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Task Interference Effects in Prospective Memory

By

Joana S. Lourenço

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology

University of Warwick, Department of Psychology

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Dedication

A special feeling of gratitude to my loving parents, Natália and Luis, and to my brother, João, whose words of encouragement and unconditional love motivate me to set higher and tenacious targets. And to my mom in particular whose eager and kind spirit and passion for life and continuous development have and will never cease to be a source of inspiration to me.

To my grandparents, Joana and Francisco, who have always taught me kindness, determination and the beauty of simple things in life.

Finally, to my (patient!) friends because without them life would not be half as fun.

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List of Abbreviations

Analysis of variance	–	ANOVA
Automated version of the operation span task	–	Aospan task
Digit Symbol Substitution task	–	DSST
Event-related potentials	–	ERPs
Functional magnetic resonance imaging	–	fMRI
Future context simulation	–	FCS
Hyperspace Analogue to Language	–	HAL
Lexical decision task	–	LDT
Mill Hill vocabulary test	–	MHVT
Preparatory attentional and memory processes theory	–	PAM theory
Prospective memory	–	PM
Response time	–	RT
Working memory	–	WM

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Declaration

I hereby confirm that I completed this thesis independently, that I have not heretofore presented this thesis to another department or university, and that I have listed all references used, and have given credit to all additional sources of assistance.

Note on Inclusion of Published Work

Experiments 5 and 6 of this thesis have been published during the period of my PhD registration, and the copyright of these papers resides with the publishers (the reproduction of the papers in this thesis is permitted under the terms of the copyright agreement). The publications are:

Lourenço, J. S., & Maylor, E. A. (2013, August 25). Is it relevant? Influence of trial manipulations of prospective memory context on task interference. *Quarterly Journal of Experimental Psychology*. Advance online publication. doi: 10.1080/17470218.2013.826257

Lourenço, J. S., White, K., & Maylor, E. A. (2013, July 8). Target context specification can reduce costs in nonfocal prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Advance online publication. doi: 10.1037/a0033702

Abstract

Prospective memory (PM), or remembering to remember, is ubiquitous in people's lives and PM misses might represent around half of daily memory failures according to recent research. In this thesis, several intention-related factors were investigated in order to clarify and elaborate our understanding of the effects of working memory (WM) and cognitive aging on prospective remembering, increase theoretical clarity regarding the dynamics of the monitoring processes in PM tasks, and investigate the interplay between two qualitatively different PM retrieval processes (i.e., spontaneous retrieval and monitoring). The overall approach was to examine how holding a particular intention affected ongoing task performance in a series of specifically devised laboratory studies of PM. The main findings of this thesis can be summarized as follows: First, encountering intention-related information boosted nonfocal PM performance for low, but not high, WM young adults, and did so without any additional cost to ongoing task performance (Experiment 1). Second, presenting intention-related information as distractor items improved PM performance for older, but not young adults (Experiments 2 and 3). The benefit was most likely due to distractor lures enhancing the salience of the target events and triggering spontaneous retrieval of the intention, or alternatively (or additionally), triggering (functional) monitoring in close proximity to the target events (Experiment 2). Third, practicing the ongoing activity prior to encoding the PM task enhanced nonfocal target detection for high WM young adults, but not for low WM young adults and older adults; practice probably allowed individuals to encode a more elaborate and detailed representation of the PM task (Experiment 4). Fourth, explicit information about target-defining features led to trial-by-trial modulations in task interference as a function of stimulus relevance for the nonfocal PM task. The effect was observed when relevant and irrelevant stimuli varied at random with no cuing (Experiments 5 and 6) and when presentation was blocked (Experiment 5), and was most likely associated with the action of top-down attentional control. Fifth, implicit information about the PM task demands also affected participants' effort and success in the PM task. Moreover, experience with the PM targets triggered local changes in attention allocation when actual demands were higher than expected (Experiment 7). And sixth, target repetition within a set boosted PM performance by stimulating retrieval through spontaneous retrieval processes, and optimized performance relative to when retrieval relied mostly on monitoring processes alone (Experiment 8). In summary, the present work uncovered several factors that have the potential to boost prospective remembering, as well as influence the extent to which monitoring processes are engaged and/or the type of processing required to support PM retrieval.

Chapter 1: An Overview of Prospective Memory

On March 16, 2003, the New York Times (Burton, 2003) reported an article entitled "The Biggest Mistake Of Their Lives" on the topic of medical errors:

"When I went home, my right breast started to increase in size. It looked like a big plum. In the emergency room, they attached pumps to my chest for drainage. But after 10 weeks, they still couldn't figure out what was wrong. I was working for I.B.M. I'd be sent home because my clothes were soaking. I could hear people whispering behind me, you know, 'She's dying; she's got cancer.' I used to wake up during the night, covered in gummy stuff, like in "Alien." Then I started growing another breast underneath my armpit. I went to a doctor. He said, 'Candy, there's something in there.' I went into surgery; they dug out this huge ball that my body formed around the gauze and sponge."

The above surgical error represents a real-world example of a prospective memory (PM) failure. PM or remembering to remember is a vital and persistent element in people's lives. PM actions can range from work-related actions to social events or health matters, such as remembering to return a call from a supplier, take medication or buy tickets for a performance that is likely to sell out. Around half of daily memory failures may be attributable to PM misses (Kliegel & Martin, 2003). Generally, these go unnoticed or are retrieved at an alternative time without great consequence. However, the failure of some PMs can also have life-threatening consequences as evident from the example above. In fact, a study published in the Annals of Surgery reported the striking figure of 12.5% of incidents involving retained sponges, needles, and instruments when 148 surgical cases were examined (Greenberg, Regenbogen, Lipsitz, Diaz-Flores, & Gawande, 2008). Such failures carry costs not only in terms of patient health as they can cause debilitating or even fatal injuries, but also bear an impact on the costs of treatments.

For instance, it is estimated that economic consequences of missed instruments (e.g., additional costs that stem from further surgery, defense costs or indemnity payments) can average the drastic amount of $24 million in the US for coronary artery bypass graft surgery alone (Egorova et al., 2008). Likewise, in aviation, PM failures can have serious consequences as revealed by the surprising figure that 1/5 of airline accidents can be attributed to intention-related failures (Dismukes & Nowinski, 2006). Not long ago two commercial airline pilots were under federal investigation because they overshot their destination by 110 miles. The pilots reported that they "lost track of time" when engaged in other ongoing activities, causing them to fail to begin their descent (Maynard & Wald, 2009).

A critical distinction between retrospective memory (for example, cued recall and free recall tests) and PM tasks is that in the latter the person must be capable of retrieving the intended action at the appropriate moment in the absence of any external prompt to remember. Additionally, the action must be retrieved while the person is involved in other ongoing activity and there must be a time difference between this retrieval opportunity and intention formation (Birenbaum, 1930; Craik, 1986; Einstein & McDaniel, 1996; Ellis & Kvavilashvili, 2000; Kvavilashvili & Ellis, 1996; Smith, Hunt, McVay, & McConnell, 2007). PM is generally classified into time-based PM and event-based PM (i.e., a particular time vs. a specific event establish the appropriate moment for performing the PM task, respectively) and it is assumed that the processes underlying prospective remembering are different between the two types of tasks (Cona, Arcara, Tarantino, & Bisiacchi, 2012; Einstein & McDaniel, 1990). This thesis focuses in particular on event-based PM, that is, situations where the intended behavior is prompted by events in the environment associated with the PM task.

Early studies of PM were mostly naturalistic and were crucial to identify the inherent characteristics of complex real-life PM behavior (see, for example, Maylor, 1990; Meacham & Leiman, 1975; Meacham, 1982; R. L. West, 1988). More recently, there has been a greater focus on investigating PM in the laboratory in order to systematically examine the underlying cognitive processes of prospective remembering and isolate the factors that affect PM successes and failures (Brandimonte, Einstein, & McDaniel, 1996; Dodhia & Dismukes, 2009; Einstein et al., 2005; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, & Shelton, 2013). In a pioneering example of laboratory PM research with young adults (see also Birenbaum, 1930, for what is most probably the first experimental study of PM), Kvavilashvili (1987) examined performance in a natural-seeming PM task. In brief, the author demonstrated that when participants were instructed to hang up a telephone receiver on the rest at the end of a 5-minute testing period (Experiment 2), increasing the importance of this PM task improved prospective remembering. Following this early, but rather complex study (see Kvavilashvili, 1987, for full details of the intricate procedure used to capture PM), most researchers in this field would agree that laboratory-based PM research particularly sprung from the introduction of an easily implementable laboratory paradigm for the study of PM in a seminal paper by Einstein and McDaniel (1990). The typical laboratory-based PM task requires participants to carry out an ongoing task, such as rating the pleasantness of words, and, additionally, to perform a designated action (e.g., press ‘T’) when a particular event or PM target (e.g., an animal word) occurs. This is intended to capture real-world situations in which individuals are typically busily engaged in performing an ongoing activity, such as getting ready to give a seminar, but must remember to interrupt their ongoing task to perform an intended action (e.g., switching the mobile phone off) when the appropriate retrieval cue (e.g., entering the seminar room) arises. The research in this thesis comprised laboratory studies of PM only and it is beyond the scope of the present work to review studies of PM conducted under naturalistic conditions or consider differences between laboratory and naturalistic studies (for an interesting discussion see Kvavilashvili, Cockburn, & Kornbrot, 2013; Phillips, Henry, & Martin, 2008; see also Kvavilashvili & Fisher, 2007).

Because of the high prevalence of delayed intentions in everyday personal and work life (Parker, Garry, Einstein, & McDaniel, 2011), and the seriousness of potential consequences of PM failures, the literature on PM has grown considerably over the last two decades and it is important that research continues to develop to improve our understanding of this type of memory (Maylor, 2008; Uttl, 2008). One essential question in the PM literature is how PM retrieval is accomplished and, in particular, whether prospective remembering can occur in the absence of resource-consuming monitoring processes. Although such a question has probably stimulated the largest amount of research in the area, the processes underlying successful retrieval are still being vigorously debated (Einstein & McDaniel, 2010; Smith, 2010). This chapter will explore the claims of the two major theories of PM retrieval and also provide a summary of the findings, approaches and ideas related to research conducted throughout the thesis. The focus of this thesis was to clarify and elaborate our understanding of how individuals modify their ongoing task processing to meet the demands of remembering different types of future intentions. This thesis identifies as well as explores several factors (intention-related information, target context specification, or target repetition within a set, among others) that have the potential to influence the extent to which monitoring processes are engaged and/or the type of processing required to support PM retrieval. A key approach for investigating the nature of the processes supporting PM retrieval that will be considered throughout this thesis is the examination of the cost to ongoing task processing from holding a PM task. Next, the main theoretical views on PM retrieval are reviewed.

Retrieval processes in PM: Theoretical approaches

A central issue in PM research is whether or not target detection always depends on processes that require attentional resources. The presence (or absence) of ongoing task costs is central to distinguish between the theoretical claims of the two major theories of PM retrieval. Specifically, contrary to the multiprocess framework (Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004), the preparatory attentional and memory processes theory (PAM; Smith, 2003; Smith et al., 2007) assumes that PM retrieval always requires capacity-demanding preparatory attentional processes to be engaged throughout the ongoing task in order to recognize PM cues as opportunities to perform the intended action. Much research has therefore focused on examining task interference (i.e., cost to the ongoing task from adding a PM task) as a way to investigate whether PM retrieval must rely on resource demanding monitoring processes.

PAM theory

According to the PAM theory, capacity-demanding preparatory attentional processes must always be employed throughout the performance interval and before the occurrence of the target(s) to support fulfillment of the PM task. These processes serve the function of mapping ongoing task stimuli onto intentions, in order to ensure that a recognition check is initiated to evaluate whether the item is an appropriate cue for performing the PM action (Smith, 2003; Smith & Bayen, 2004; Smith et al., 2007). It is proposed that PM failures can occur either due to a momentary drop in attentional processes devoted to PM performance (see also Marsh & Hicks, 1998; R. West & Craik, 1999) or due to recognition check failure. Additionally, the PAM theory assumes that preparatory attentional processes (e.g., nonautomatic monitoring, rehearsal of the PM target events) can occur outside the focus of attention or be strategic monitoring processes that are fully available to awareness but will always consume attentional resources. That is, a cost to the ongoing task should always be found as a result of having a PM task taxing the individual's limited-capacity resources. The theory also proposes that the cost should be functionally related to performance, such that better PM performance should be found in the presence of increased monitoring and thus higher ongoing task cost.

This monitoring-only theory was initially developed on the basis of the large number of studies demonstrating that holding a PM task causes significant ongoing task cost (Burgess, Quayle, & Frith, 2001; Cohen, Bayer, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Scullin, McDaniel, Shelton, & Lee, 2010; Smith, 2003; Smith et al., 2007) or that dividing attention during retrieval hinders PM performance (Einstein, Smith, McDaniel, & Shaw, 1997; Marsh, Hicks, & Bink, 1998; McDaniel, Robinson-Riegler, & Einstein, 1998; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Such research provides support to the claim that nonautomatic, resource-consuming processes are necessary for PM retrieval. It is worth mentioning that ongoing task cost is assessed on filler trials (i.e., trials where PM targets do not occur), that is, it does not reflect a cost associated with executing the prospective action.

Multiprocess view

Contrary to the PAM theory, the multiprocess view (Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004) proposes a flexible system in which PM retrieval can rely either on resource-demanding monitoring processes or on spontaneous processes. This view proposes that spontaneous retrieval can occur through two mechanisms. The reflexive associative process (Einstein & McDaniel, 1996; McDaniel, Guynn, et al., 2004) assumes that an automatic associative system can support retrieval of the intention by bringing the PM action to mind when the target event occurs. In particular, when an appropriate target stimulus is encountered, an involuntary automatic associative system would either reflexively (Guynn, McDaniel, & Einstein, 2001; McDaniel et al., 1998), or through spreading activation (Anderson, 1983), bring the PM action to mind. It is assumed that for associative retrieval to be successful, the target-action association formed at encoding needs to be strong and the target item also needs to be fully processed at retrieval. Support for this mechanism comes from studies showing that increasing the attentional demands of the ongoing task impairs PM performance when the target-intended action association is low, but not when a high association exists between the two (McDaniel, Guynn, et al., 2004).

A second spontaneous retrieval process builds on Whittlesea and Williams' (2001a, 2001b) discrepancy-attribution hypothesis, which suggests that individuals chronically evaluate the coherence of their processing and engage in an attributional process when this processing is discrepant with expectations (i.e., when the actual processing quality of a stimulus differs from the expected processing quality of that stimulus). McDaniel, Guynn, et al. (2004) advanced the discrepancy-plus-search view which assumes that when PM targets are encountered, people may notice a discrepancy with the current processing fluency (i.e., enhanced processing quality for the PM target relative to other items in that context) as a result of prior experience with the targets at encoding or due to intention planning. This would then trigger a search for the source of discrepancy in processing which can cause retrieval of the intention. Hence, it is assumed that PM retrieval can occur in the absence of devoting preparatory attentional processes before the target event occurs. Several studies have reported results consistent with the discrepancy-plus-search view by showing, for instance, that promoting extensive preexposure of nontarget filler items prior to performing the PM task (hence enhancing the discrepancy between target and nontarget words) can improve subsequent target detection (e.g., Breneiser & McDaniel, 2006; Lee & McDaniel, 2012; McDaniel, Guynn, et al., 2004).

The multiprocess view (McDaniel & Einstein, 2000, 2007) was developed in part to explain the inconsistent findings concerning age-related effects in PM. Given the decline in attentional resources associated with aging (Salthouse, 1991, 1996), it is assumed that older adults have reduced capacity for strategic processing. However, contrary to what would be expected if resource-consuming monitoring processes were always necessary for successful PM retrieval, several studies have failed to find a decline in PM performance for older relative to young adults when a single focal target[1] was used (Einstein, Holland, McDaniel, & Guynn, 1992; Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Einstein et al., 1997). By contrast, when task demands are increased, such as when the PM task is nonfocal, the ongoing task is attentionally demanding, or multiple PM targets are used, age-related deficits in PM performance arise (Einstein et al., 1992, 1997; Maylor, 1993, 1996; Park et al., 1997; see also Kvavilashvili, Kornbrot, Mash, Cockburn, & Milne, 2009; Reese & Cherry, 2002, on the importance of examining specific age bands of older participants when investigating age-related PM deficits). Results showing no age-related deficits in PM performance provide support for the multiprocess view's claim that spontaneous retrieval processes can support PM retrieval as they suggest that retrieval can take place through a relatively resource-free process when the ongoing task focuses processing on the relevant features of the target.

[1] See sub-section headed "Focal and nonfocal PM targets" below on the topic of focality of PM tasks.

It is crucial to note that the multiprocess view suggests that PM retrieval can occur in the absence of executive resources being devoted to the PM intention *prior* to the occurrence of the target event (see Kvavilashvili & Fisher, 2007, for a related point regarding prospective remembering in real-world contexts). That is, this view *does not* claim that PM retrieval will be fully automatic. It is assumed that the presence of the PM target can spontaneously initiate retrieval of the intention, but that other aspects of PM performance (e.g., coordinating execution of the PM and ongoing task responses) might require processing resources (Einstein & McDaniel, 2010; Einstein et al., 2005; McDaniel & Einstein, 2007). Moreover, the multiprocess view proposes that there is a natural tendency to rely on spontaneous retrieval processes to support PM retrieval. Given the multiple PM tasks and the considerable delays between the intention formation and execution that characterize retrieval in real-world situations, it is argued that it would not be adaptive for PM retrieval to always rely on a resource taxing process (Einstein et al., 2005; McDaniel & Einstein, 2007).

According to the multiprocess view, the characteristics of the ongoing and PM tasks as well as of the individual determine the extent to which individuals rely on automatic retrieval processes, or instead allocate attentional resources to detect the PM targets (for a thorough description of the factors that affect whether monitoring processes are required see McDaniel & Einstein, 2007). Importantly, a key assumption of this view is that the extent to which the ongoing task focuses processing on the target event will influence the processes that support PM performance (Einstein et al., 2005; McDaniel & Einstein, 2007; McDaniel, Guynn, et al., 2004). Additionally, this view assumes that strong encoding of the target cue-action association, as well as the use of a salient PM target increase the likelihood that retrieval can rely on spontaneous retrieval processes. For instance, targets that are unusual, such as low-meaningful words or perceptually salient items, may automatically capture attention leading to spontaneous retrieval of the intention (e.g., Einstein, McDaniel, Manzi, Cochran, & Baker, 2000).

Focal and nonfocal PM targets

One central assumption of the multiprocess view (Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel, Guynn, et al., 2004) is that participants rely on qualitatively different retrieval processes (i.e., spontaneous retrieval or monitoring) with focal and nonfocal targets (Einstein & McDaniel, 2005; Einstein et al., 2005; McDaniel & Einstein, 2007; McDaniel, Guynn, et al., 2004; see also Maylor, 1996, 1998, for an earlier related distinction based on task-appropriate processing). Specifically, it is assumed that attention-demanding monitoring processes need to be engaged for successful performance when the PM target is nonfocal, that is, when the ongoing task *does not* direct attention towards processing the features of the PM target initially associated with the intention. For example, during a lexical decision task (LDT) the word “tortoise” would be a focal target, whereas the category “animals” or the syllable “tor” would be nonfocal targets, because the ongoing task of deciding whether each presented item is a word or a nonword does not involve encoding of the categorical concept of animals or syllabic processing. With nonfocal PM targets, the multiprocess and PAM theories converge in their assumption that a resource-demanding process that requires allocation of limited cognitive resources toward monitoring the environment for the occurrence of PM targets must be engaged. In other words, both theories predict that significant ongoing task cost (indicative of monitoring) should be observed when the target is nonfocal. By contrast, the multiprocess view, but not the PAM theory, assumes that spontaneous retrieval processes can support PM retrieval when the PM target is focal (i.e., the pertinent features of the target are highlighted by ongoing task processing).

Overview of findings on PM retrieval and underlying processes

Following the important work of Marsh et al. (Marsh, Hicks, & Cook, 2005; Marsh et al., 2003) and Smith (2003), researchers have consistently relied on the analysis of cost to ongoing task performance to draw inferences about the processes underlying PM retrieval (Boywitt & Rummel, 2012; Einstein et al., 2005; Marsh, Cook, & Hicks, 2006b; Scullin, McDaniel, & Einstein, 2010; Smith, 2003). Although there may be some limitation to this approach (e.g., costs may reflect rehearsal of the intention, consideration about the number or location of targets, among others; cf. Einstein et al., 2005; Guynn, 2003; Marsh et al., 2005), it is generally agreed that attention to the PM task (e.g., preparatory attentional processes) can be inferred from the extent to which holding a PM task produces costs to ongoing task performance. Hence, analysis of task interference has been the primary approach to legislate between the theoretical assumptions of the multiprocess and PAM theories (Einstein & McDaniel, 2010; Einstein et al., 2005; Scullin, McDaniel, & Einstein, 2010; Smith et al., 2007). To examine the patterns of task interference produced by different types of intentions, researchers typically compare the speed of performing the ongoing task alone and with an embedded PM task. It is assumed that when a resource-demanding process is engaged for supporting successful PM retrieval, attentional resources available for performing the ongoing activity will be reduced and task interference will be observed. It is worth mentioning that, in examining ongoing task response times (RTs) to determine the presence of monitoring processes, accuracy levels must also be considered in order to rule out speed-accuracy tradeoffs (e.g., no slowing in the PM relative to the control condition at the expense of lower ongoing task accuracy for the former) (e.g., Smith, 2010). A wealth of studies have been conducted to inform the debate over the mechanism(s) underlying PM retrieval, as will be elaborated below.

Focality of targets and importance effects in PM

Across three experiments, Einstein et al. (2005) demonstrated that instructing participants to respond to a single focal PM target did not cause ongoing task cost. Furthermore, with the aim of directly testing the existence of spontaneous retrieval, Einstein et al. (2005, Experiment 4) additionally examined PM performance as a function of individual differences in ongoing task monitoring. Specifically, participants were classified on the basis of their task interference levels into either a no-cost group (i.e., individuals showing faster RTs in the PM relative to the no-PM baseline block) or a cost group. Results showed that detection of the focal PM target was nearly perfect for both groups of participants. These findings were particularly important in demonstrating that some participants may monitor for the PM target events even with a single focal target, but that with this type of PM task spontaneous retrieval processes can also support good levels of PM performance.

In addition, Scullin, McDaniel, Shelton, et al. (2010) recently demonstrated different levels of task interference in an ongoing LDT with focal and nonfocal PM tasks. Using targets that were matched for monitoring difficulty, Scullin, McDaniel, Shelton, et al. (2010, Experiment 3) showed higher overall task interference for nonfocal relative to focal targets (i.e., word and initial-letter targets, respectively). Moreover, when task interference was examined for each of the quartiles of the PM block, results revealed significant cost throughout the entire task for the nonfocal, but not for the focal condition. Importantly, with a focal PM task, changes in task interference across quartiles were not accompanied by changes in PM performance, with target detection always being at a high level. By contrast, with a nonfocal PM task, target detection was worse for quartiles where the amount of ongoing task slowing was reduced, suggesting that performance suffered when fewer resources were being devoted to monitoring for the nonfocal target. Results are therefore consistent with the multiprocess view that qualitatively different retrieval processes are responsible for prospective remembering with the two types of targets, such that spontaneous retrieval processes can trigger retrieval with a focal, but not a nonfocal, target.

Finally, Einstein et al. (2005, Experiment 1) also examined how focality and importance of the PM task affect ongoing task processing and PM target detection. Results showed that both nonfocal intentions and instructions that emphasized the importance of the PM task caused participants to devote attentional resources to monitoring for the target events as indicated by significant task interference. By contrast, when the PM task was focal and the importance of the PM task was not emphasized, there was no evidence of ongoing task cost. Moreover, emphasizing the importance of the PM task improved target detection with a nonfocal, but not with a focal intention. The high level of PM performance in the absence of task interference when the target was focal and no emphasis was placed on the PM task, suggests that spontaneous retrieval processes supported PM retrieval. In line with Einstein et al.'s (2005) findings, Kliegel, Martin, McDaniel, and Einstein (2004; see also Loft, Kearney, & Remington, 2008; Smith & Bayen, 2004) have also shown that increasing the relative importance of the PM relative to the ongoing task can cause participants to monitor for the presence of the PM target and influence the size of the task interference effect. Moreover, they additionally showed that emphasizing the importance of the ongoing task in relation to the PM task lowered PM performance (relative to the high PM importance condition) with nonfocal but not with focal targets.

Aging effects in PM

As mentioned earlier in this chapter, the pattern of age-related effects is mixed such that while for some tasks a substantial age-related decline in PM performance has been demonstrated, for others age-related sparing has been found (see McDaniel & Einstein, 2007, for a review). Recent meta-analyses of PM and aging (Henry, MacLeod, Phillips, & Crawford, 2004; Kliegel, Jäger, & Phillips, 2008) have documented and tried to address the wide variability in age effects in PM tasks. These studies provide suggestive evidence for the multiprocess view that retrieval in focal and nonfocal PM tasks can rely on qualitatively different processes. Specifically, the authors reported that age-related differences in PM performance were substantial with nonfocal PM targets, but considerably reduced with focal targets. Kliegel et al. (2008) argued that their results were consistent with a weaker prediction of the multiprocess framework (i.e., greater deficits for nonfocal than for focal PM tasks). (The strong prediction was that deficits would be absent altogether for focal PM tasks.) A caveat to this conclusion was the fact that most of the studies examined in the meta-analysis did not measure ongoing task cost. As discussed by Einstein, McDaniel, and Scullin (2012), it is possible that young adults (who have greater availability of attentional resources) engaged in monitoring processes even when performance could rely on spontaneous retrieval processes, and that relying on both processes gave them a performance advantage relative to older adults.

In addition, there has been evidence to suggest that one reason for the discrepancies between studies is that comparisons are made using an older adult sample with a wide age range (Ellis & Kvavilashvili, 2000; Kvavilashvili et al., 2009). Specifically, previous research has shown that age differences in attention-demanding PM tasks are more pronounced among the old-old (71-80 years) than the young-old (61-70 years) (Kvavilashvili et al., 2009; Maylor, 1998; Shelton et al., 2011). These studies suggest that monitoring processes may be relatively uncompromised in the young-old, such that age-related differences in PM might at times be subtle or nonexistent in the young-old. Furthermore, research suggests that health or educational background differences between young and older adults may contribute to the pattern of inconsistencies. Specifically, smaller deficits have been found for older adults with high educational achievement and verbal abilities (Cherry & LeCompte, 1999) and higher fluid intelligence (Cockburn & Smith, 1991) than for those with lower abilities.

In sum, for older adults who have compromised resources there is a large body of empirical evidence to support the existence of a deficit on PM performance with attention-demanding tasks (Einstein et al., 1992, 1997; Maylor, 1993, 1996; Park et al., 1997; Vogels, Dekker, Brouwer, & de Jong, 2002). Importantly, our everyday lives are replete with PM demands, and, particularly for older adults, forgetting intentions – such as taking medication at scheduled times – can threaten independent living. Thus, it appears critical to explore ways to boost PM performance for this age group and, at the same time, to examine the mechanisms underlying any age-related improvement in PM. Such lines of research will be important for further development of effective strategies for promoting behavioral change in the real world. This issue is returned to at the end of this chapter upon summarizing the empirical work presented in this thesis.

Suspending the PM task demands

Einstein et al. (2005, Experiment 5) introduced a procedure for studying the existence of spontaneous retrieval in PM tasks that consisted of examining processing of the PM targets when the intention had been suspended. Einstein et al. (2005) showed slowing for target relative to filler words (i.e., items that had no association with the previously encoded intention) when these items were presented during a LDT performed while the PM task was suspended. Moreover, RTs to filler trials in the PM condition were identical to those in a condition where a retrospective memory task had been suspended instead. This result shows that participants were not engaging in resource consuming monitoring processes when the intention was suspended. Moreover, it suggests that slowing for the PM targets was caused by spontaneous retrieval of the intention when these items were encountered.

More recently, Scullin, Einstein, and McDaniel (2009) extended Einstein et al.'s (2005) findings by showing slowing to target words when the PM task was suspended, but not when participants had been instructed that the PM task was finished. This allays concerns that slowing to PM targets could be due to a simple familiarity-based process, as opposed to spontaneous retrieval of the intention upon encountering the targets. Furthermore, Scullin et al. (2009) replicated the finding that target words were receiving additional processing in the suspended condition in the absence of preparatory attentional processes. Finally, in this study, participants were given the suspended/finished instructions after performing the PM task, thereby ruling out concerns that Einstein et al.'s (2005) procedure represented a Zeigarnik task. It is assumed that the need to interrupt and postpone the execution of a task can cause participants to maintain the task in a higher state of activation and ultimately benefit performance (Zeigarnik effect; Zeigarnik, 1939). Although the PAM theory focuses on retrieval in the designated performance interval, the Einstein et al. (2005) and Scullin et al. (2009) studies provide at least indirect evidence for the involvement of spontaneous retrieval processes in PM tasks.

Proximal cost and task interference across the ongoing task

Scullin, McDaniel, and Einstein (2010) recently introduced a new approach for examining the extent to which resource-consuming monitoring processes are necessary for PM retrieval with focal and nonfocal targets. Scullin, McDaniel, and Einstein (2010) proposed that overall ongoing task cost might not be the most appropriate measure to determine whether or not monitoring processes are always necessary for PM performance. For instance, even if attention has momentarily waned before a PM target is presented, such that monitoring is not occurring proximal to the target (cf. Loft et al., 2008; McDaniel, Einstein, & Rendell, 2008; R. West & Craik, 1999), averaging RTs across the entire set of ongoing task trials could still yield significant levels of task interference. Instead, Scullin, McDaniel, and Einstein (2010) argued that it is important to examine proximal cost (i.e., cost on the (five) trials immediately preceding each target event) to determine whether ongoing task cost is functionally related to PM performance (see also Loft & Yeo, 2007; McNerney & West, 2007).

To examine whether cost was functional for PM, Scullin, McDaniel, and Einstein (2010) presented participants with a cue to the PM task several trials prior to each PM target. Cues were words semantically associated with the focal target (Experiment 1) or color screens linked with the occurrence of the targets and associated with the focal/nonfocal PM task during instructions (Experiment 2). Results showed that cues caused ongoing task slowing, suggesting that these items triggered monitoring for the target events, or at least caused awareness of the PM task. Moreover, Experiment 1 showed that with a focal PM task, ongoing task slowing was not sustained for long periods of time, such that proximal cost was observed when the semantic lure was presented 6 but not 21 items away from the target (proximal and distal conditions, respectively). Interestingly, although cost immediately preceding the focal PM targets was observed only for the proximal condition, PM performance in this condition was high and similar to that in the distal condition. Scullin, McDaniel, and Einstein (2010) interpreted these results as evidence that spontaneous retrieval processes can support PM retrieval for focal PM tasks as proposed by the multiprocess view.

In addition, Scullin, McDaniel, and Einstein (2010, Experiment 2) showed that nonfocal PM performance was higher in the cued than in the uncued condition. Crucially, there was no difference in overall cost between conditions. Rather a difference was obtained for proximal cost such that color screens stimulated monitoring proximal to nonfocal target events when participants were aware that screens could precede PM targets (i.e., cued condition). Moreover, a more detailed analysis according to PM success revealed that participants in the cued condition who did not show slowing following the color screens displayed lower PM performance than those who showed evidence of proximal cost. Findings from Scullin, McDaniel, and Einstein (2010, Experiment 2) are particularly important in demonstrating a functional relationship between monitoring and nonfocal PM performance, such that monitoring close to target events was crucial for successful target detection with a nonfocal PM task.

Additionally, Scullin, McDaniel, and Einstein (2010) showed a decrease in task interference across the ongoing task with a nonfocal PM task, a finding that converges with results from previous studies (Einstein et al., 2005; Loft et al., 2008). Moreover, such a decrease is in line with Smith's (2003) proposal that monitoring is a nonautomatic, resource consuming process and with Bargh and Chartrand's (1999) view that individuals have a limited capacity to sustain controlled processes. Importantly, decreased monitoring in the Scullin, McDaniel, and Einstein (2010) study was associated with declines in PM performance in the nonfocal but not in the focal condition, a result that is predicted by the multiprocess view only.

Can a cost be found with focal PM tasks?

As just reviewed above, the strong assertion of the PAM theory (Smith, 2003; Smith et al., 2007) that resource-consuming preparatory attentional processes are always necessary for PM retrieval has been challenged by a number of studies. Despite the support for the multiprocess view's proposal (McDaniel, Guynn, et al., 2004) that PM retrieval may rely on multiple processes when the PM task is focal, a few exceptions remain. Consistent with the PAM theory, Smith (2003; see also Burgess et al., 2001; Smith & Bayen, 2004) found a 200 to 300 ms increase in LDT RTs when participants had to additionally perform a focal PM task. This suggests that attentional resources were devoted to monitoring for the target events, causing a reduction in the amount of resources available for ongoing task performance as a result. Moreover, there was a positive relationship between cost and PM performance such that participants who displayed greater ongoing task slowing also showed superior target detection. These results are consistent with the PAM theory's claim that preparatory attention is functionally related to PM performance (but see Einstein et al., 2005; Loft & Yeo, 2007; Marsh et al., 2005; McNerney & West, 2007; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, et al., 2010, for studies showing that cost levels are not always related to PM performance).

There is one potential source of discrepancy between Smith's (2003) study and previous research showing no ongoing task cost with focal PM tasks, namely, Smith (2003) used a PM task that consisted of six target words. As argued by Einstein et al. (2005), the inconsistencies between findings may reside in the complexity of the demands of the PM task (i.e., number of targets used). Thus, Smith (2003) asked participants to respond to six different target words, whereas previous studies finding no task interference have used one or two target words (e.g., Cohen, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; Harrison & Einstein, 2010). Consistent with this proposal, research has shown that when the size of a set of PM targets increases, so does the extent to which processing resources are taxed (as indexed by task interference). Specifically, Cohen, Jaudas, et al. (2008) showed that task interference was observed when participants were instructed to respond to multiple target events, but not when a single focal target word was used, suggesting that number of PM targets can affect the processes involved in PM retrieval.

Note, however, that Cohen, Jaudas, et al. (2008) did not report accuracy data for the ongoing task. Recently, Smith (2010) proposed some considerations regarding aspects to take into account when examining whether high levels of PM performance can be observed in the absence of ongoing task cost. Specifically, the author pointed out that failing to consider both speed and accuracy on the ongoing task (e.g., Cohen, Jaudas, et al., 2008), and failing to analyze performance separately for different types of ongoing trials (e.g., Scullin, McDaniel, & Einstein, 2010; see also Chapter 5 in this thesis), among others, can be problematic as they have the potential to eliminate evidence for significant ongoing task costs that would otherwise be obtained. In addition, Smith et al. (2007) argued that some studies (e.g., Cohen, Jaudas, et al., 2008; Einstein et al., 2005) might be underpowered for detecting the presence of significant task interference (but see Einstein & McDaniel, 2010, for a counterargument).

Notwithstanding, the PAM theory has clearly gained some opposition since its original introduction (Smith, 2003); however, this theory remains to be discredited. Moreover, the PAM theory has been slightly modified recently. The most recent (and flexible) version of the theory (Smith et al., 2007) claims that preparatory attentional processes can be stimulated by the salience of the target cue. That is, it is argued that salient stimuli can capture attention and stimulate the engagement of preparatory attentional processes leading to recognition of the stimulus as a target and increased PM performance (but see Einstein & McDaniel, 2010, for a discussion of how this mechanism might be akin to the discrepancy-plus-search process assumed to support spontaneous retrieval).

More recently, however, Smith et al. (2007) conducted a study using conditions that, according to the multiprocess view (McDaniel & Einstein, 2007), encourage spontaneous retrieval. The authors hypothesized that successful PM performance, together with no evidence for disruptions to ongoing task performance, would disprove the PAM theory and provide support for the multiprocess view. Across four experiments, Smith et al. (2007) showed significant task interference (by an average of 86 ms relative to a no-PM control condition) when participants additionally performed the focal PM task of responding to a highly salient target word. Hence, Smith et al. (2007) concluded that engaging in preparatory attentional processes was necessary for successful PM retrieval. Nevertheless, such results contrast with several studies showing high PM performance and no ongoing task cost with a single focal target (e.g., Cohen, Jaudas, et al., 2008; Einstein et al., 2005; Marsh et al., 2003; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, et al., 2010).

In contrast to Smith et al. (2007), Harrison and Einstein (2010) proposed that the presence of significant ongoing task costs with a single focal target (e.g., Smith et al., 2007) only demonstrates that participants were allocating attention to the PM task, and cannot be used to argue that resource-consuming monitoring processes are always required for PM retrieval. According to Harrison and Einstein (2010), parameters of the ongoing and PM tasks, such as the nature of the task instructions (e.g., Einstein et al., 2005; Loft et al., 2008; Smith & Bayen, 2004), frequency of target presentation or ongoing task duration (e.g., Einstein et al., 2005; Loft et al., 2008; Scullin, McDaniel, Shelton, et al., 2010), influence the extent to which participants engage in costly monitoring processes. Harrison and Einstein (2010) argued that these factors can result in attentional resources being allocated to the PM task even when they are not necessary for successful retrieval. Hence, Einstein, McDaniel and their colleagues (Einstein &

McDaniel, 2010; Einstein et al., 2005; Harrison & Einstein, 2010; Scullin, McDaniel, & Einstein, 2010) have claimed that in order to examine whether spontaneous retrieval can support prospective remembering, it is important to examine performance under conditions that discourage engaging in preparatory attentional processes (i.e., when task interference has been eliminated). It is under such conditions that the predictions from the multiprocess and PAM theories concerning the levels of PM performance differ.

In an attempt to examine PM performance when task interference was absent, Harrison and Einstein (2010) strongly emphasized the importance of ongoing task performance and used a single focal PM target that was presented only in the last quarter of the LDT and after multiple ongoing task trials. When the importance of the ongoing task had been emphasized, results showed significant task interference for the first quarter of the ongoing task only. That is, slowing was not observed for the following quartiles, such that there was no evidence for task interference in the trials proximal to the PM target. By contrast, when the importance of the PM task was emphasized, higher levels of task interference were observed. Crucially, results additionally showed that task interference declined across the ongoing task and that, similar to the ongoing task emphasis condition, there was no evidence of slowing before the PM target in the PM-emphasized condition (despite the high levels of PM performance). Hence, Harrison and Einstein's (2010) findings add to those of Scullin, McDaniel, and Einstein (2010), who also showed high levels of PM performance with a focal target in the absence of cost proximal to target events, and provide support for the multiprocess view.

Critically, Harrison and Einstein's (2010) results (see also Scullin, McDaniel, & Einstein, 2010) highlight the importance of assessing task interference throughout the ongoing task (and before the PM target in particular), and using an ongoing task with sufficient duration when examining whether PM retrieval can rely on spontaneous retrieval processes. As noted by Harrison and Einstein (2010, p. 866), "the target event in the corresponding Smith et al. (2007) experiment always occurred relatively early (task interference in all four of their experiments was measured within the first 64 trials)" and a target event occurred every 10 trials. Thus, results such as those of Smith et al. (2007) suggest that it is hard to discourage monitoring in laboratory tasks and that length of the ongoing task and the frequency of target presentation are important aspects of the procedure. These can influence the perceived task demands and the extent to which monitoring processes are observed (Einstein & McDaniel, 2010; Harrison & Einstein, 2010; Loft & Yeo, 2007; Marsh, Cook, et al., 2006b). Finally, several authors have highlighted the importance of conducting more fine-grained examinations of task interference by analyzing cost throughout the ongoing task as monitoring processes can decrease across time and overall ongoing task cost may reflect initial concern with the PM task (Einstein & McDaniel, 2010; Loft et al., 2008; Scullin, McDaniel, & Einstein, 2010; R. West, Krompinger, & Bowry, 2005).

Nonfocal PM and the effect of intention-related material

Nonfocal PM targets have been extensively investigated and the consensus in the literature is that nonfocal PM performance relies on resource-consuming monitoring processes (e.g., Einstein & McDaniel, 2005; Einstein et al., 2005; McDaniel & Einstein, 2007; McDaniel, Guynn, et al., 2004; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, et al., 2010; Smith & Bayen, 2004). Curiously, an important, but understudied, area in the PM literature is the (potential) benefit of intention-related material for nonfocal prospective remembering. Only a few studies to date have examined the role of intention-related material on PM performance, and while most studies support the idea that this material can benefit performance (Guynn & McDaniel, 2007; Scullin, McDaniel, & Einstein, 2010; Taylor, Marsh, Hicks, & Hancock, 2004; see also Dewitt, Hicks, Ball, & Knight, 2012), other studies have found only limited evidence for such a benefit (Mäntylä, 1993; Meier, Zimmermann, & Perrig, 2006; Penningroth, 2005). In particular, Mäntylä (1993) showed that generating instances of a target category prior to the PM task improved young adults' detection of atypical, but not typical instances of the target category. In addition, Meier et al. (2006, Experiment 1) found that intention-related material benefited PM performance only under certain conditions. Specifically, the authors asked participants to give a PM response to words from the category of musical instruments while performing a short-term memory task. On each trial, a drawing of an easy-to-name object was presented together with an unrelated noun; the ongoing task consisted of reading each word aloud while memorizing the object for a later recall. Meier et al. showed that presenting picture lures (e.g., a drawing of a "conductor"), but not word lures (e.g., the word "conductor"), improved PM performance relative to a no-lures condition. The inconsistency of findings regarding the benefit of intention-related material on PM performance is particularly relevant to the present thesis because it suggests the need for further research. Moreover, earlier studies were limited in several ways including the lack of control over the intention-related material (e.g., Mäntylä, 1993; Penningroth, 2005), or the use of procedures that probably confounded the effect of intention-related material with that of increasing the importance of the PM task (e.g., Guynn & McDaniel, 2007; Taylor et al., 2004). Additionally, research investigating the effect of intention-related material on PM performance has neglected the examination of task interference (e.g., Guynn & McDaniel, 2007; Mäntylä, 1993; Penningroth, 2005; Taylor et al., 2004). This can be seen as somewhat problematic because, as indicated throughout this chapter, examining costs to ongoing task processing can provide valuable insight into the nature of the processes underlying performance.

Furthermore, research has shown that nonfocal PM performance is negatively affected by aging (e.g., Henry et al., 2004; Kliegel et al., 2008) and can also vary as the result of individual differences in WM capacity (Brewer, Knight, Marsh, & Unsworth, 2010; Smith & Bayen, 2005). In particular, there is considerable evidence to suggest that low WM individuals are more susceptible to task-unrelated thoughts and have less efficient attentional control, which can impair their ability to succeed at attention and memory tasks (e.g., McVay & Kane, 2010; Unsworth, 2007). Hence, it may be fruitful to expand the focus of research to include examination of factors such as aging and individual differences in WM capacity. Will the effect of intention-related information on PM performance be qualitatively distinct between individuals who differ in their use of controlled attention? Hitherto, no study has considered how WM capacity might modulate the effect of intention-related material on nonfocal PM performance in young adults, and only Mäntylä (1993) has used a sample of both young and older adults. It is proposed here that a more complete understanding of the effects of intention-related material on nonfocal PM will be fostered by the systematic examination of ongoing task processing (and in particular cost proximal to the intention events), as well as by focusing on individuals with differing ability to rely on resource-demanding strategies.

Considering both young and older adults, as well as individual differences in WM capacity, will allow examination of the capacity requirements of the (potential) benefit of intention-related material on PM performance, and of the circumstances in which such benefit might be found. Extending research on the topic of intention-related material and nonfocal PM is an issue not only of theoretical importance, but also of considerable practical concern. As argued by Bargh and Chartrand (1999), individuals have a limited capacity to maintain controlled processes such as monitoring. Given that independent everyday functioning often depends on efficient execution of intentions, determining whether individuals with reduced attentional capacity can rely on environmental cues to optimize performance when intentions involve a high degree of strategic processing is worthy of further investigation. Previous studies examining the effect of intention-related material on PM performance and research on individual differences in WM capacity will be considered in detail in Chapter 2.

Nature of the monitoring processes supporting PM retrieval

It is assumed that task interference reflects the division of the limited pool of attentional resources between the ongoing and PM tasks, and, as such, an increase in monitoring for target events should produce greater levels of task interference (Hicks, Marsh, & Cook, 2005; Marsh et al., 2005). Something of a consensus has developed around the idea that monitoring is dependent on the prefrontal cortex (Burgess et al., 2008; Burgess, Gonen-Yaacovi, & Volle, 2011; Burgess et al., 2001; Volle, Gonen-Yaacovi, Costello, Gilbert, & Burgess, 2011) and on WM capacity (Brewer et al., 2010; McDaniel, Guynn, et al., 2004; Smith & Bayen, 2005; Smith et al., 2007). That said, more research is needed to further our understanding about the nature of monitoring processes in PM. Most importantly with respect to this thesis, much of the PM research has focused on determining whether preparatory attentional processes are necessary for PM retrieval in order to legislate between the theoretical predictions of the multiprocess and PAM theories. By contrast, very little attention has been given to examining the nature of the resource-demanding processes that give rise to task interference (Boywitt & Rummel, 2012; Einstein & McDaniel, 2010; Smith, 2010). This gap in the PM literature underscores the importance of examining in more detail the nature and function of the cognitive processes underlying ongoing task cost. Doing so was one of the main goals of the present thesis. Previous research that has contributed to the topic is discussed next.

Guynn (2003) proposed a two-process model of strategic monitoring which assumes that the cost associated with monitoring is the result of maintaining a retrieval mode (i.e., keeping the cognitive system ready to perform the future action) and of checking for target events (i.e., deploying attention to stimuli in the context where the PM target is likely to occur to check whether they are a cue to perform the intended action). Marsh and colleagues (Hicks et al., 2005; Marsh, Cook, et al., 2006b; Marsh et al., 2005) also proposed that task interference is the result of both a global attention allocation policy and more local attention allocation policies. They argued that participants set a distribution of attentional resources between the ongoing and PM tasks based on their beliefs about their PM abilities and their expectations about the PM context and the difficulty of the PM task (Einstein & McDaniel, 2008; Meeks, Hicks, & Marsh, 2007). Crucially, the local attention allocation policy is assumed to be more dynamic in that attention varies according to the relevance of the material being processed and due to natural fluctuations over time. Marsh, Cook, et al. (2006b) argued that the nature of the local/specific task interference effect is what distinguishes between theirs and Guynn's accounts of task interference.

In an attempt to disentangle the two views, Marsh, Cook, et al. (2006b) examined whether task interference can be material-specific (i.e., reduced for material that is not relevant to the intention). According to their view, when the type of stimulus about to be processed can be predicted, participants should be able to process stimuli irrelevant for the intention more quickly (i.e., reduced task interference for these stimuli should be observed). However, when the ongoing task involves the random presentation of two different materials and/or judgments, the uncertainty regarding the nature of the upcoming trial and the need to randomly switch between two types of judgments should tax central executive resources (e.g., Duncan, 1995; Marsh, Hancock, & Hicks, 2002) and give rise to a general interference effect instead. By contrast, according to Guynn's (2003) view, item-level changes in task interference would be expected even when stimuli vary at random and the nature of the upcoming trial cannot be predicted because target checking (i.e., poststimulus processing) is one of the components giving rise to task interference.

In brief, Marsh, Cook, et al. (2006b) instructed participants to perform an ongoing task consisting of reading words and naming pictures, and to give a PM response to furniture words (pictures in a counterbalanced condition); the two types of material were then either presented randomly or blocked in groups of trials (Experiments 1-2). Results showed that task interference for stimuli not relevant to the PM task (e.g., picture trials when the intention was to perform an action to furniture words) was reduced when presentation of word and picture trials alternated in groups of trials (Experiment 1B), as well as when the two types of trials were presented randomly but the nature of the upcoming stimulus was cued at the start of the trial (Experiment 2; see also Experiment 3 for a conceptual replication). By contrast, when stimulus presentation alternated randomly without warning (Experiment 1A), there was no material-specific reduction in task interference. In other words, in line with their view, when the type of material about to be processed could not be predicted, results showed no evidence of differences in ongoing task slowing between word and picture trials. Importantly, Marsh, Cook, et al.'s (2006b) results contrast with more recent findings suggesting that trial-by-trial changes in task interference when intention-relevant and irrelevant stimuli are presented at random with no cuing can be observed at least under some circumstances (Cohen, Jaudas, et al., 2008; Cohen, Jaudas, Hirschhorn, Sobin, & Gollwitzer, 2012; J. B. Knight, Ethridge, Marsh, & Clementz, 2010). This literature, as well as relevant research on task switching that may help to understand the pattern of inconsistent findings, is reviewed in more detail in Chapter 5. In this chapter, the nature of the resource demanding monitoring processes is examined in more detail by focusing on trial-by-trial changes in the allocation of attention as a function of ongoing task stimuli relevance to a nonfocal intention.

Thesis overview

The overall aim of the thesis was to clarify and understand how individuals modify their ongoing task processing to meet the demands of different PM tasks. More specifically, this thesis identifies as well as explores several intention-related factors that have the potential to further our knowledge about the effects of WM and cognitive aging in prospective remembering, increase theoretical clarity regarding the dynamics of the monitoring processes in PM tasks, and develop our understating about the type of processes that can support PM retrieval.

Chapter 2 investigates whether presenting intention-related material (i.e., words semantically related to the PM target) can improve performance in a nonfocal PM task. Additionally, this chapter aims to elucidate whether participants' WM capacity modulates the effect of intention-related material on PM performance. Considering that low WM individuals have impoverished ability to flexibly control attentional resources and that the ability to engage in effortful monitoring is essential for nonfocal PM performance (e.g., Einstein et al., 2005; Scullin, McDaniel, Shelton, et al., 2010; Smith, 2003), this chapter addresses whether intention-related material can compensate (e.g., by stimulating the maintenance of the attention towards the PM task) for PM deficits in low WM individuals. Moreover, examination of processing in the ongoing LDT at the exact time the intention-related words were presented and in the trials that followed their presentation allowed investigation of the processes underlying changes to PM performance.

The effect of exposure to intention-related material was also investigated in older adults (Chapter 3). Given the weight of evidence suggesting that aging increases the susceptibility to distractor information (Campbell, Hasher, & Thomas, 2010; Gopie, Craik, & Hasher, 2011; Healey, Campbell, & Hasher, 2008), the interactive effects of age and exposure to intention-related events presented as distractor information on PM performance were investigated in Chapter 3. Presentation of intention-related events as distractor information was achieved by asking individuals to perform an n-back task to pictures superimposed with to-be-ignored strings of letters. Words semantically associated with the categorical PM task were then presented as some of the to-be-ignored strings. The first of the two experiments in this chapter constitutes the first study to date to offer insight into the effect of encountering intention-related distractor information on older adults' ability to carry out future intentions. The second experiment was designed to allow examination of ongoing task processing and assessed the effect of intention-related distractor information on young adults' PM performance more systematically.

Chapter 4 explores a factor that similarly to intention-related material (Chapters 2 and 3) has also been shown to improve prospective remembering, but that unlike the former is assumed to exert its effect primarily during the encoding (instead of the retrieval) phase of the PM task. Thus, recent evidence suggests that mental simulations of future events can also benefit PM performance (Brewer, Knight, Meeks, & Marsh, 2011; Brewer & Marsh, 2010; Papies, Aarts, & de Vries, 2009). Future context simulation (FCS) can be achieved through exposure to the prospective context before intention encoding (e.g., Brewer & Marsh, 2010) and is thought to benefit PM performance by allowing participants to encode a more detailed representation of the intention (Schacter, Addis, & Buckner, 2008). Again, the approach was to examine performance with a nonfocal PM task across individuals who differ in their controlled-attention capabilities.

Hence, in Chapter 4, individual differences in WM capacity and aging were considered in relation to the effect of FCS on PM performance. It was hypothesized that if FCS improves PM by enhancing retrieval context familiarity and decreasing the attentional demands of the intention, a benefit should be observed for both older adults and low WM capacity individuals. Alternatively, if controlled attention is particularly advantageous under FCS conditions (e.g., to strategically plan intention execution and optimize deployment of resources to monitor for the nonfocal target), the benefit of exposure to the retrieval context should be limited to high WM young adults only.

In Chapters 5 and 6, the focus was shifted from factors that can improve prospective remembering to the processes that underlie PM retrieval. Specifically, much of the research on PM has centered on the extent to which prospective remembering relies on monitoring processes (e.g., Einstein & McDaniel, 2010; Einstein et al., 2005; Smith, 2010). Chapter 5 aims to address an equally important but severely understudied issue, that is, the nature of the resource demanding monitoring processes. This chapter comprises two experiments; the overarching aim was to determine whether there can be trial-by-trial changes in task interference as a function of stimulus relevance to a nonfocal intention. In the first experiment, the PM task was associated with one of the colors of ongoing stimuli and occurrence of the target's color (random vs. predictable in eight-trial blocks) was manipulated. In the second experiment, target context specification was manipulated by explicitly associating the PM target with a subset of ongoing stimuli (word trials) for some of the participants. Both experiments comprised a single ongoing task in order to avoid the reduction of attention resources associated with task switching paradigms. Three main questions were addressed in Chapter 5. Firstly, can task interference in a nonfocal PM task change on a trial-by-trial basis when intention-relevant and irrelevant stimuli vary at random with no cuing? Secondly, will blocked presentation of relevant and irrelevant trials affect the dynamics of cost throughout the sequence of intention-irrelevant trials? For instance, will cost be fully eliminated on these trials? And if not, will cost be equally reduced for all trials or will task interference be modulated as a function of the item's proximity to the relevant trials? Thirdly, will explicitly informing participants about the target context impact the extent to which limited attentional resources are allocated to intention-related processing throughout ongoing task trials? That is, can individuals optimize their attention allocation at an item level (by reducing costs to irrelevant items without compromising PM performance) in accordance with their expectations about the target context?

Chapter 5 examines whether there can be trial-by-trial changes in the allocation of attention according to explicit information about the relevance of the ongoing items for the intention. Chapter 6 complements this approach by investigating whether the amount of attention allocated to a nonfocal intention can also be adjusted according to implicit information about the PM demands. Specifically, it was examined whether exposure to target exemplars (atypical vs. typical animals) during encoding can affect participants' effort and success in a nonfocal PM task. Furthermore, this chapter also investigates whether participants can adjust their attention allocation strategies when the cognitive effort required to successfully fulfill the PM task is higher than expected.

Chapter 7 investigates the interplay between strategic monitoring and spontaneous retrieval processes and introduces a novel approach for testing whether target detection can rely on multiple processes. The rationale for the experiment in this chapter stemmed from the premise that relying on both monitoring and spontaneous retrieval processes should augment the functional value of these processes and ultimately benefit PM performance (Einstein &

McDaniel, 2010; Einstein et al., 1997; Scullin et al., 2013). A PM task consisting of responding to multiple target words was used. Target experience at retrieval (i.e., whether each target occurrence consisted of a different target or whether one of the targets in the set of encoded targets was repeatedly presented) was then manipulated. Rather than examining performance when cost-inducing monitoring processes were absent (cf. Einstein et al., 2005; Scullin, McDaniel, & Einstein, 2010), the approach was to manipulate target repetition within a set. This was done with the aim of creating conditions for which successful PM performance can rely on processes that utilize minimal cognitive resources. It is proposed that the presence of spontaneous retrieval processes can be inferred from target repetition boosting PM performance at no extra cost to ongoing task performance.

Finally, Chapter 8 outlines the conclusions that may be drawn from the studies comprising this thesis. An overview of the main findings from the eight experiments is provided first. This is followed by consideration of the impact of the present results on both theoretical and practical issues, as well as a discussion of interesting avenues for future research.

Chapter 2: The Role of Intention-Related Events in PM

During the course of a day, most individuals establish and have to accomplish multiple PM tasks. However, individuals are typically exposed to a variety of information before they can perform their intention(s). For instance, one might form the intention to divert from the usual route home in order to collect theater tickets. Meanwhile, information that is somewhat related to this PM task might be encountered, such as chatting with a friend about a great play s/he recently viewed, listening to the entertainment news on the radio, seeing a theater advertisement on the way home, etc. This chapter examines whether presentation of intention-related material (i.e., words semantically related to the PM target) can improve PM performance with an attentionally demanding, nonfocal PM task. In addition, ongoing task processing (at the exact time the intention-related material was presented and following the presentation of this information) was also investigated in order to illuminate the nature of the process(es) underlying potential changes in PM performance.

Intention-related material and PM

To date, only a few studies have examined the influence of intention-related material on PM performance. Moreover, not only have the approaches used in each study varied greatly, there has also been surprisingly little focus on processing of the intention-related items and surrounding ongoing task items.

In an early study, Mäntylä (1993) asked participants to perform a PM task to instances of target categories. The author showed that when a category-fluency task using the target categories was performed prior to receiving the PM instructions, an improvement in PM performance was observed. Mäntylä (1993) argued that the benefit was due to an increase in activation of the intention representation in memory at the time of encoding, which subsequently facilitated PM retrieval. However, the exact nature of the processes underlying the activation-related PM benefit could not be determined as there were no measures of ongoing task processing. More recently, Penningroth (2005) conducted a similar study but additionally manipulated ongoing task demands. Interestingly, she failed to find a consistent benefit on PM performance from the preexposure of target categories. Penningroth (2005) proposed that the inconsistent results might be due to a difference in the categories used in the two studies. Thus, data from Mäntylä (1993) and Penningroth (2005) highlight the limited effect of encoding-related factors, such as preexposure of target categories, on PM performance and suggest that the extent to which a benefit is found might depend on the specific material used.

More recently, Guynn and McDaniel (2007) investigated whether negative effects of demanding ongoing conditions on PM performance can be overcome by preexposing words later designated as PM targets. Participants performed an ongoing word rating task and had to additionally respond to two different PM targets. Results showed that target preexposure benefited PM performance relative to a no-target-preexposure condition and eliminated the negative effect of divided attention on target detection. In addition, participants in the preexposure group showed no cost on the secondary digit detection task relative to a no-PM control group. By contrast, a cost was found for participants in the no-preexposure group suggesting that PM retrieval in the two conditions relied on qualitatively different processes. Moreover, target preexposure enhanced participants' ability to retrieve the action associated with the intention (i.e., recall the correct response word upon encountering each of the PM targets). Guynn and McDaniel (2007) proposed that preexposure promoted the encoding of a strong target-action association, reducing the need to rely on resource-demanding preparatory attentional processes and benefiting PM performance through relatively automatic reflexive retrieval processes (Guynn, McDaniel, & Einstein, 1998; McDaniel, Guynn, et al., 2004; McDaniel et al., 1998).

A distinctive aspect of Guynn and McDaniel's (2007) procedure was that target words were preexposed by presenting participants with six word fragments and six anagrams for each of the two targets before receiving the PM instructions. Importantly, such exclusive and extensive processing of the targets might have caused these items to stand out during PM instructions and increased the perceived importance of successfully performing the PM task in the preexposure condition. As shown by previous studies (Einstein et al., 2005; Kliegel et al., 2004), emphasizing the importance of the PM task at encoding causes an increase in monitoring for the target events (as indexed by costs to ongoing task processing). Unfortunately, ongoing task RTs were not reported in Guynn and McDaniel's (2007) study and, as such, interference to the ongoing task from holding an intention could not be examined. Note that although secondary-task digit detection was better for the preexposure than no-preexposure condition (suggesting that more resource-consuming processes were being devoted to the PM task in the latter case), without ongoing task RTs it is not possible to determine whether this result was due to a speed-accuracy tradeoff (i.e., greater ongoing task slowing in the preexposure condition).

In addition, Dewitt et al. (2012, Experiment 2) recently examined whether encountering items (cues) previously paired with the PM targets can improve performance in a categorical PM task. Items were paired by asking participants to complete a paired associate learning task (comprising cue-target pairs) after encoding the PM instructions. Results showed that encountering words previously paired with items from the target category improved PM performance. However, the benefit was only observed when cues and targets were presented in close proximity (i.e., 3, but not 6 or 9, items away from each other). In addition, results revealed that slowing was present for the two trials that immediately followed the cues, but gradually dissipated throughout the following trials. Dewitt et al. (2012) suggested that consciously retrieving the intention upon encountering the cues was beneficial, but only to the extent that the intention was maintained in a heightened state of activation. According to the authors, the need to continuously process information in the ongoing task likely limited individuals' ability to sustain the heightened activation. Thus, results suggest that paired-associate cues can improve performance with a categorical intention but only to the extent that cues and targets are presented in close temporal proximity. It is interesting to note that, in addition to finding that the paired-associate cues triggered slowing only for the immediately succeeding trials, Dewitt et al. (2012, Experiment 2) found no lure interference (i.e., slowing for the cue items; cf. Taylor et al., 2004). Together these results suggest that paired-associate cues might serve only as weak covert reminders of the intention.

More relevant to the present thesis are two other studies that have examined how PM performance is affected by presenting items semantically associated with the targets. In the first, Meier et al. (2006, Experiment 1) asked participants to give a PM response to words from the category of musical instruments while performing a short-term memory task. On each trial, a line drawing of an object together with an unrelated word was presented; the ongoing task consisted of reading each word aloud while memorizing the object for a later recall. Results showed that picture lures (e.g., a drawing of a "conductor") improved PM performance relative to a no-lures condition. Although task interference was not assessed, participants' subjective reports indicated that retrieval experience differed between the lures and the no-lures conditions, such that presentation of lures increased the number of *pop up* experiences (i.e., reports of remembering the intention because it just popped into mind). The authors interpreted these results as evidence that lures enhanced the accessibility of the PM task and benefited performance due to spontaneous retrieval processes. Note, however, that Meier et al.'s (2006) approach has some limitations as assessing retrieval experience will likely increase participants' awareness about the experimenter's interest in the PM task and influence their attention allocation to the PM task (cf. Meier, von Wartburg, Matter, Rothen, & Reber, 2011).

In the second of these studies, Taylor et al. (2004, Experiments 1 and 2) examined whether presentation of partial-match cues (i.e., items that only partially fulfill the requirements for prospective responding) can benefit performance on a categorical PM task. The authors showed that when participants were instructed to give a PM response to animal words beginning with 'L', presenting semantic partial-match cues (i.e., animal words not beginning with 'L') improved target detection. Moreover, slowing was found for semantic partial-match cues relative to filler words on the ongoing word rating task, suggesting that these cues led to conscious retrieval of the intention. Taylor et al. (2004) proposed that semantic cues could have served as explicit reminders (cf. Guynn et al., 1998; McDaniel, Guynn, et al., 2004; McDaniel et al., 1998; Vortac, Edwards, Fuller, & Manning, 1993) or as episodes of retrieval practice, and, ultimately, heightened the retrieval sensitivity (i.e., the ease with which a target is noticed as associated with a PM task). It is important to point out that in Taylor et al.'s (2004) study, partial-match cues were highly frequent (e.g., 18% of the ongoing task items in Experiment 1), which might increase the importance of the PM task and cause a concomitant increase in monitoring for target events (e.g., Einstein et al., 2005). Moreover, RTs were not reported for the no-cues PM condition, nor was the comparison between filler word RTs in the no-cues relative to the semantic partial-match cues condition. Thus, whether enhanced PM performance for the partial-match cues condition was also accompanied by a general increase in ongoing task slowing, or enhanced monitoring following the semantic cues, cannot be determined on the basis of the available data.

Thus, although research on the effect of intention-related material on prospective remembering mostly suggests that there can be a benefit to performance, there have been a few studies that failed to find evidence for such a positive effect. Also, as discussed above, several of the studies used methods that likely confounded the effect of lures with that of increasing the importance of the PM task. Importantly with respect to this thesis, most studies failed to conduct a thorough analysis of processing on the ongoing task (see Dewitt et al., 2012, for an exception), which causes difficulties in terms of determining the processes that underlie the effect of intention-related material on PM performance. Finally, a generalized stance that intention-related material can improve nonfocal PM performance may be unwarranted without examining first how any benefit might be affected by factors such as WM resource availability, which has been shown to affect PM success (e.g., Brewer et al., 2010; Smith & Bayen, 2005).

Before moving on to discuss research examining the relationship between WM capacity and nonfocal PM, it is worth considering one last study. To determine the extent to which resource-consuming monitoring processes are necessary for PM retrieval, Scullin, McDaniel, and Einstein (2010, Experiment 2) examined PM performance under two different cueing conditions. Specifically, the authors inserted color screens five trials before each PM target, and then either informed participants that these screens might precede the PM targets (cued condition), or gave participants no such information (not-cued condition). Results showed that detection of nonfocal (target syllable) targets was higher in the cued than in the not-cued condition. More importantly, there was no overall cost difference between conditions. Instead, superior PM performance in the cued condition (i.e., when participants were aware of the relationship between the presentation of color screens and the occurrence of the target) was due to color screens stimulating monitoring proximal to nonfocal target events. These findings are particularly important in demonstrating a functional relationship between monitoring and nonfocal PM performance, such that monitoring close to target events was critical for successful detection of nonfocal targets. Furthermore, although the authors' aim was not to examine whether cueing improves PM performance (hence the lack of a no-cues PM condition), their study provides preliminary evidence for the positive effect of cues on prospective remembering. That is, PM performance benefited from the color screens' presentation when participants were explicitly instructed about the presence of such cues and about their temporal proximity to the PM targets. Finally, it is important to point out that the nature of the cueing effect probably differs when color screens as opposed to words semantically related to the PM targets are used. That is, because screens are completely unrelated to the PM targets, when color screens are used participants need to be explicitly informed about the association between the presentation of cues and the occurrence of the PM targets (see Guynn et al., 1998; Vortac et al., 1993, on the use of explicit reminders). By contrast, semantic lures have the potential to elicit awareness of the PM task in the absence of any instruction regarding either the inclusion of these items or their relationship with target occurrence.

Working memory and PM

Working memory (WM) capacity reflects the ability to maintain task-relevant representations active in the face of distraction and depends critically on the ability to flexibly control attentional resources (Engle & Kane, 2004; Kane, Bleckley, Conway, & Engle, 2001; Norman & Shallice, 1986). Consistent with the claim that low WM participants have poorer attentional control and are more susceptible to internal and external distraction, a number of studies have shown that individual differences in WM capacity are related to performance success in several tasks where task goals have to be maintained in the face of distraction. Specifically, low WM individuals are more likely to experience periodic cognitive failures than high WM individuals and show performance deficits in tasks like the antisaccade, Stroop, and various vigilance tasks (e.g., Kane et al., 2001; Kane & Engle, 2003; Unsworth & Spillers, 2010). Likewise, research shows that individuals low in WM are more susceptible to mind wandering and task unrelated thoughts (e.g., Kane et al., 2007; McVay & Kane, 2009).

Researchers investigating PM have also shown that high WM participants outperform low WM in PM tasks when these tasks require high levels of attentional resources either due to the high demands of the ongoing task or due to the demanding nature of the particular PM task (Brewer et al., 2010; Cherry & LeCompte, 1999; Marsh, Hancock, et al., 2002; Marsh et al., 1998; Smith & Bayen, 2005; R. West & Bowry, 2005; R. West, Bowry, & Krompinger, 2006). Due to their poorer attentional processes, low WM participants are presumably less able to sustain controlled attentional processes towards intention-related processing in order to support successful target detection (Smith & Bayen, 2005; R. West et al., 2006). The experiment in this chapter aimed to examine the extent to which intention-related material can compensate for the decreased ability of low WM individuals to succeed on nonfocal PM tasks.

Experiment 1

The present study addressed several issues. First, it examined whether presentation of intention-related material (i.e., words semantically related to the PM target) can improve performance in a nonfocal PM task. It is important to point out that although the PM target was nonfocal, a paradigm was devised that allowed not only the use of semantic lures, but also the presentation of the latter in the focus of attention. This was done to maximize the likelihood that participants would process the intention-related material and, as a result, display a benefit in PM performance. Second, the extent to which presenting intention-related material affects cognitive processing on the ongoing task (at the exact time the material was presented and in the trials that followed its presentation) was examined in order to illuminate the nature of the process(es) underlying changes to PM performance. A LDT was used as the ongoing task because of its emphasis on response speed and its suitability for investigating the activation level of the material being processed (e.g., Einstein et al., 2005; Marsh et al., 1998). Third, the present experiment examined whether the effect of intention-related material presentation on target detection would be modulated by participants' WM capacity. In nonfocal PM tasks, the ability to engage in capacity-consuming monitoring processes is critical for efficient task performance. It was reasoned that presenting intention-related material might reduce attention failures in low WM individuals by encouraging these individuals to maintain their attention focused on the PM task (i.e., by compensating for their higher susceptibility to task-unrelated thoughts and less efficient attentional control).

Method

Design and participants. The study employed a between-subjects design with PM condition (lures, no-lures) as the variable. Participants were undergraduate students from Warwick University.

Eighty-two participants (38 male) aged 18-33 years (*M* = 19.5, *SD* = 2.2) were randomly assigned to the lures (*n* = 40), and the no-lures (*n* = 42) conditions. Two participants in the no-lures condition were excluded as detailed in the Results section. Testing took place individually in sessions lasting approximately 60 min, and participants were either paid £6 for participation or given course credit (the number of participants receiving each type of compensation was similar for the two experimental conditions). During the session, participants completed the Digit Symbol Substitution task (DSST; Wechsler, 1981) and the multiple-choice part of the Mill Hill vocabulary test (MHVT; Raven, Raven, & Court, 1988), used as measures of perceptual-motor processing speed and crystallized intelligence, respectively. In addition, participants' WM capacity was assessed using an automated version of the operation span task (Aospan; Unsworth, Heitz, Schrock, & Engle, 2005) where individuals were required to solve a series of math operations while trying to remember a set of unrelated letters. Scores on the measures of cognitive ability for participants in each of the PM conditions can be found in Table 1 (see Appendix 1 for a full description of these measures). Independent samples *t* tests revealed no differences between the lures and the no-lures conditions for the DSST, $t < 1$, MHVT, $t(78) = -1.56$, $p = .123$, or Aospan task ($t(78) = 1.35$, $p = .181$ and $t(78) = 1.58$, $p = .119$, for the absolute and total scores, respectively), indicating that participants randomly assigned to each PM condition were well matched with respect to all the measures collected.

Table 1: *Scores on the Mill Hill Vocabulary Test (MHVT), Digit Symbol Substitution Task (DSST) and Automated Operation Span Task (Aospan) for Participants in Each of the Prospective Memory (PM) Conditions*

	PM Condition			
	Lures		No-lures	
	M	*SD*	*M*	*SD*
DSST	72.8	11.6	71.1	10.3
MHVT	18.4	3.2	19.5	2.9
Aospan				
Absolute	53.3	14.1	49.0	14.4
Total	65.5	7.6	62.7	8.2

Materials and procedure. A LDT task that allowed the presentation of PM cues as focal items and PM targets as nonfocal items was devised. Specifically, in each trial four items (two words, two nonwords) were simultaneously presented on the screen. One of these items (red font item) required a lexical decision whereas the other three items (black font items) were distractors. The items were always presented at the same four locations (center-top, center-bottom, left and right of the screen) and the item in red appeared approximately the same number of times in each of the four possible locations (see Figure 1, upper panel). Participants were first given instructions for the LDT where they were told that on each trial four strings of letters (1 red, 3 black) would be presented on the screen and that they had to decide as quickly and accurately as possible whether the red string was a word or not; a sample screen was provided. They were told to press the key marked with a tick (‘M’ key) with their right index finger if the red string was a word and the key marked with a cross (‘Z’ key) with the left index finger if it was not a word. It was added that after each decision, a *waiting* message would appear on the screen and that they should press the spacebar with one of their thumbs to see the next four items. Participants were then given the PM instructions stating that whenever they saw the word *sheep* they should press the ‘T’ key after they made their lexical decision or as soon thereafter as they could. It was added that the word *sheep* could appear either as the item in red or as one of the items in black. Participants were asked to repeat the instructions to the experimenter, and any questions or misunderstandings were resolved before continuing. They then completed 10 practice trials (5 words, 5 nonwords as the red items). A delay of approximately 10 min between PM instructions and the start of the ongoing task was created by asking participants to complete a subset of 10 experimental trials from Engle, Tuholski, Laughlin, and Conway’s (1999) counting span task. This task required participants to count aloud the number of target circles (presented among distractors) and remember the count total for later recall. Because this task was only intended as a distractor task, participants were not asked to complete the full set of 24 experimental trials.

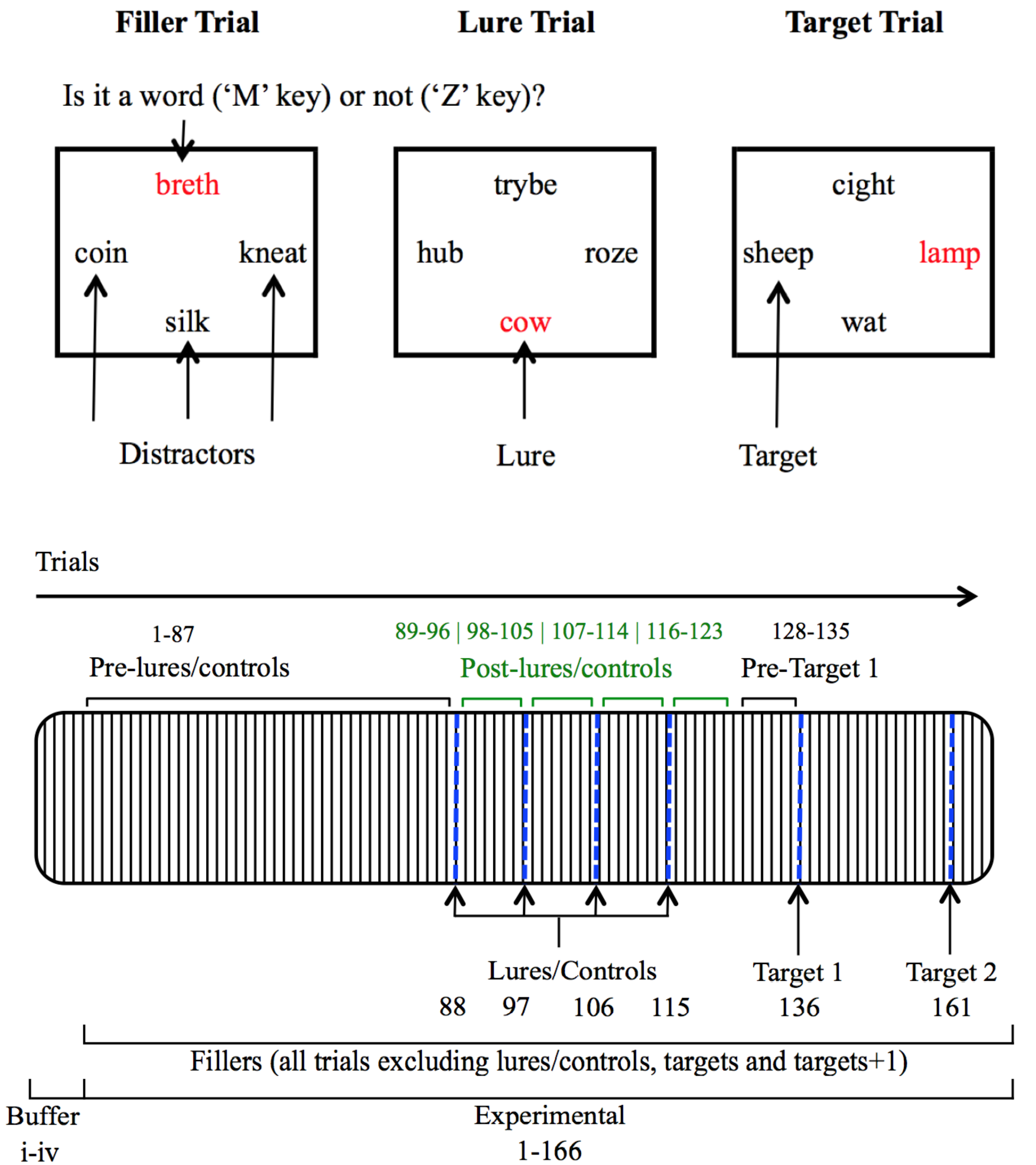

Figure 1: Illustrative examples of ongoing lexical decision task trials (upper panel) and overview of the trial sequence (lower panel) in Experiment 1.

Next, participants performed the ongoing LDT that included four buffer trials at the start of the task and 166 experimental trials. In half of the trials the red string that required a lexical decision was a word; in the other half it was a nonword. The experimental trials included two occurrences of the PM target *sheep* and four semantic lures (or, in the no-lures condition, control words unrelated to the target word). The PM target was always presented nonfocally as one of the strings in black, and occurred once at the top and once at the left location (location of the first target presentation was counterbalanced across participants within each condition). The target was presented on Trials 136 and 161. In the lures condition, semantic lures were nine trials apart and always occurred before the first PM target occurrence. The fourth lure word was presented 21 trials before the target. Specifically, semantic lures (or, in the no-lures condition, control words matched with lures on number of letters and mean log-transformed Hyperspace Analogue to Language (HAL) frequency; Balota et al., 2007) appeared on Trials 88, 97, 106, and 115 (see Figure 1, lower panel). The semantic lures (selected from Battig & Montague, 1969) were the words *cow*, *lamb*, *goat* and *mule*, always appearing in that order. In contrast to the PM target, semantic lures/control words were always presented focally as the strings in red that required a lexical decision. Filler words were selected to closely match the lures/controls, such that they had a mean length of 4.1 letters, consisted of 1.1 syllables on average, and had a mean HAL frequency of 9.1 according to Balota et al. (2007). None of these filler items was forwardly associated with the target word *sheep* (according to the Nelson et al., 1998, norms). Filler nonwords were all pseudohomophones selected from the ARC Nonword Database (Rastle, Harrington, & Coltheart, 2002).[2] The words/nonwords presented in black font and presented as distractors were selected from the same sources.

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[2] Joordens and Becker (1997) argued that because pseudohomophones are more wordlike foils, they increase the processing needed to distinguish between words and nonwords. Accordingly, all nonword stimuli in the LDT were

All items appeared in lowercase letters in 20-pt font with a height corresponding to approximately 0.9° viewing angle at a distance of 50 cm. Each trial started with a 500-ms fixation cross, followed by a screen with the four strings of letters, and finally the *waiting* message, the latter two presented until the participant responded or 5000 ms had elapsed. At the end of the LDT, participants answered a post-experiment questionnaire to check their memory for the PM task. They were asked to recall the instructions for the task and all were able to correctly recall the PM instructions. Participants were then asked to perform the Aospan task (Unsworth et al., 2005). Before the end of the experimental session, participants completed the DSST (Wechsler, 1981), the MHVT (Raven et al., 1988), and a demographic questionnaire.

Results

In this experiment, and in all subsequent experiments in this thesis, the probability of a Type I error was set at .05, and estimates of effect size (η_p^2) for significant and marginally significant effects are reported. One participant in the no-lures PM condition who was more than 2.5 *SD*s from his group's mean scores on the Aospan task was removed; another participant in this condition was excluded due to a software error in recording the data.

PM task performance. A PM response was scored as correct if the participant pressed the 'T' key during the target trial or within the next trial, and this captured all PM responses. An independent samples *t* test showed that presenting intention-related information (i.e., words semantically associated to the PM target) benefited prospective remembering, $t(78) = 2.11$, $p = .039$, such that the proportion of correctly detected targets was higher for the lures ($M = .64$, $SD = .42$) than for the no-lures PM condition ($M = .44$, $SD = .43$).

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pseudohomophones in order to enhance the level of semantic processing of ongoing task items.

Next, it was examined whether the effect of semantic lures on PM performance was influenced by WM capacity. A post hoc split of participants into low and high WM capacity was conducted using the median of absolute (*Mdn* = 53) and total (*Mdn* = 67) scores. Only the analyses based on total scores will be presented here.[3] There were 40 low WM participants (17 in the lures PM condition and 23 in the no-lures PM condition) and 40 high WM participants (23 in the lures PM condition and 17 in the no-lures PM condition). Proportion correct on the PM task was included in a 2 x 2 analysis of variance (ANOVA) with PM condition (lures, no-lures) and WM (low, high) as the between-subjects factors. Results showed a significant effect of WM, $F(1, 76) = 4.77$, $MSE = 0.16$, $p = .032$, $\eta_p^2 = .06$, such that PM performance was higher for high ($M = .65$, $SD = .43$) than for low ($M = .43$, $SD = .42$) WM participants. More important, this effect was qualified by a significant PM condition by WM interaction, $F(1, 76) = 5.60$, $MSE = 0.16$, $p = .021$, $\eta_p^2 = .07$. As illustrated in Figure 2, PM performance was higher in the lures than no-lures condition for participants with low WM, $t(38) = 3.23$, $p = .003$, but there was no difference in PM performance between conditions for participants with high WM capacity, $t < 1$.[4] In other words, presenting intention-related material benefited PM performance for participants with low WM capacity only.

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[3] Absolute and total scores in the Aospan task were highly correlated, $r(80) = .93$, $p < .001$, and results were qualitatively similar when absolute scores, instead of total scores, were used.

[4] Furthermore, this pattern of results was evident for both Target 1 ($M_{\text{low WM}} = .65$ and $M_{\text{high WM}} = .61$ in the lures condition; $M_{\text{low WM}} = .22$ and $M_{\text{high WM}} = .76$ in the no-lures PM condition) and Target 2 ($M_{\text{low WM}} = .65$ and $M_{\text{high WM}} = .65$ in the lures condition; $M_{\text{low WM}} = .30$ and $M_{\text{high WM}} = .59$ in the no-lures PM condition).

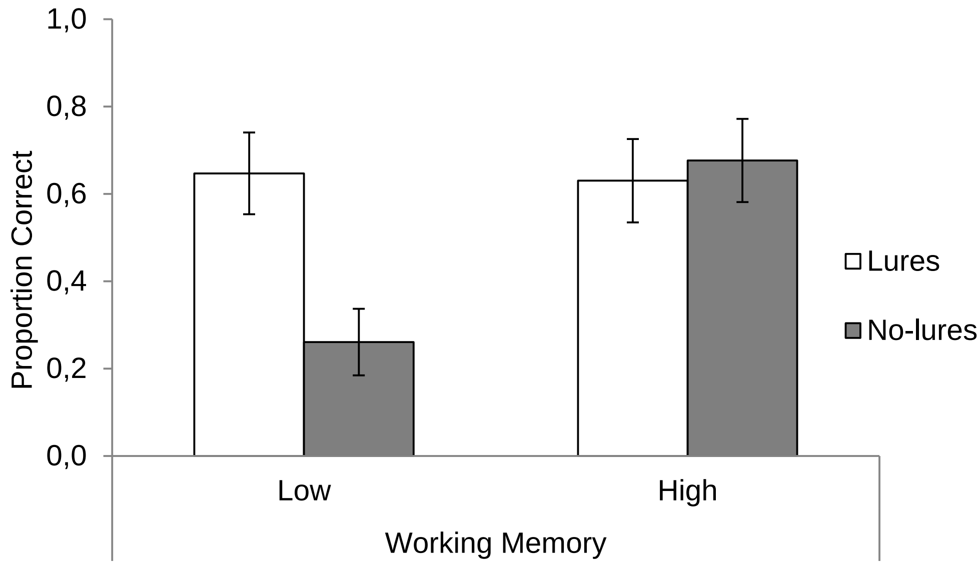


Figure 2: Mean proportion correct for the prospective memory (PM) task as a function of working memory (low, high) and PM condition (lures, no-lures). Error bars represent ± 1 standard error.

Ongoing task performance. In line with previous studies examining task interference in the context of LDTs (e.g., Brewer et al., 2010; Hicks et al., 2005; Loft et al., 2008; Smith et al., 2007), performance on word trials was the primary dependent variable for ongoing task performance. Accuracy on the LDT was examined first. An independent-samples t test on the proportion of correctly identified words showed no significant difference between the lures (M = .92, SD = .04) and no-lures (M = .91, SD = .04) PM conditions, $t < 1$.

For RTs on the LDT, filler trials were trimmed to include only correct responses to word trials that were less than 2.5 *SD*s away from each participant's mean (e.g., J. B. Knight et al., 2011). The trial immediately following each PM target was excluded to avoid potential bias from slowing associated with target-related processes. Trimming resulted in the elimination of 2.5% of correct RTs. An analysis examining processing of intention-related material is reported first. Lure interference was assessed by contrasting average RTs for the four semantic lure trials (or control words in the no-lures condition) with average RTs for filler word trials. For an overview of the trial sequence, see Figure 1 (lower panel). RTs were included in a 2 x 2 x 2 mixed ANOVA with PM condition (lures, no-lures) and WM (low, high) as the between-subjects factor and trial type (lures/controls, fillers) as the within-subjects factor (see Table 2). There was a significant interaction between PM condition and trial type, $F(1, 76) = 4.34$, $MSE = 17{,}772.96$, $p = .041$, $\eta_p^2 = .05$. As expected, the difference between lures/controls and fillers (i.e., lure interference) was larger in the lures than in the no-lures PM condition. In addition, there was a main effect of WM, $F(1, 76) = 4.98$, $MSE = 121{,}088.54$, $p = .029$, $\eta_p^2 = .06$, such that low WM participants were faster than high WM ones (*M*s = 1138 and 1262 ms, respectively). There were no other significant effects (all *p*s > .251). These results suggest that participants in the lures condition noticed the lure words as intention-related, and that such a noticing effect was independent of their WM capacity.

Table 2: *Means and Standard Deviations for Response Times in Milliseconds on Non-Target Word Trials as a Function of Prospective Memory (PM) Condition (Lures, No-Lures) and Working Memory (WM; Low, High)*

	PM Condition							
	Lures				No-lures			
	Low WM		High WM		Low WM		High WM	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Lures/controls	1211	349	1292	304	1069	270	1216	270
Fillers	1160	176	1267	197	1112	249	1274	260
Lure interference	51	239	25	192	-44	110	-58	211
Pre-lures/controls	1181	185	1290	209	1155	273	1306	275
Post-lures/controls	1149	193	1239	202	1069	275	1231	252
Pre-Target 1	1092	199	1217	220	1059	192	1252	304

Note. Lure interference reflects lures/controls RTs – filler words RTs.

The results above suggest that participants in the PM lures condition noticed the association between the lure words and the PM task. Next, it was examined whether presentation of intention-related information affected subsequent processing on the ongoing task. Towards this end, mean RTs were computed for pre-lures/controls (i.e., word trials preceding the first lure/control word), and for post-lures/controls (i.e., eight trials that followed each of the lure/control words; see Figure 1, lower panel). Data can be found in Table 2. A 2 x 2 x 2 mixed ANOVA with PM condition (lures, no-lures) and WM (low, high) as the between-subjects factors and trial type (pre-lures/controls, post-lures/controls) as the within-subjects factor revealed a significant main effect of trial type, $F(1, 76) = 25.00$, $MSE = 5,836.31$, $p < .001$, $\eta_p^2 =$

.25. Namely, participants sped up from the trials preceding to those succeeding the lure/control words by an average of 61 ms. The PM condition by trial type interaction failed to reach significance, $F(1, 76) = 2.61$, $p = .111$, but the trend was in the expected direction of less speeding up in the lures condition than in the no-lures condition (41 vs. 81 ms, respectively). Thus, there is at least tentative evidence that in the lures condition, lure words caused some additional slowing for the trials that immediately followed the presentation of the intention-related material. Other than a main effect of WM similar to the one reported above, $F(1, 76) = 5.99$, *MSE* = 106,658.79, $p = .017$, $\eta_p^2 = .07$, there were no other significant effects (all *p*s > .531).

Next, a similar analysis was conducted to examine differences between conditions for the trials preceding the first PM target occurrence. Towards this end, mean correct RTs for the eight word trials preceding the first PM target were averaged (cf. Scullin, McDaniel, & Einstein, 2010) and these data were submitted to a 2 x 2 x 2 mixed ANOVA with PM condition (lures, no-lures) and WM (low, high) as the between-subjects factor and trial type (pre-lures/controls, pre-Target 1) as the within-subject factor. There was only a main effect of trial type, $F(1, 76) = 19.15$, *MSE* = 12,403.38, $p < .001$, $\eta_p^2 = .20$ (*M*s = 1233 and 1155 ms, for pre-lures/controls and pre-Target 1, respectively), and a main effect of WM, $F(1, 76) = 8.39$, *MSE* = 97,568.52, $p = .005$, $\eta_p^2 = .10$, with these effects being similar to those found for the post-lures/controls. There were no other significant effects (all *p*s > .419). Thus, there was no evidence of additional slowing in the pre-Target trials for the lures relative to the no-lures condition.

Finally, correlational analyses further revealed that there was a significant positive correlation between filler-word RTs and PM performance for the no-lures condition, $r(40) = .594$, $p < .001$, suggesting that longer RTs in the ongoing task were positively associated with

PM performance. This finding is in line with past research showing that devoting attention towards the PM task aids detection of nonfocal targets (e.g., Einstein et al., 2005; Smith, 2003; Smith & Bayen, 2004). In contrast, filler-word RTs were unrelated to PM performance in the lures condition, $r(40) = .137$, $p = .398$. This is consistent with the effect of intention-related material on PM performance, and indicates that presentation of lure items attenuated the relationship between ongoing task slowing and PM performance. Furthermore, results also showed that the correlation between lure interference and PM performance was significant for the lures condition, $r(40) = .327$, $p = .040$, but not for the no-lures condition, $r = -.186$, $p = .250$. This suggests that the extent to which participants noticed the lures (i.e., slowing for the lures relative to filler trials) was related to PM success.

Discussion

Results showed that encountering words semantically related to the PM target improved performance with a nonfocal PM task. Crucially, this effect was modulated by individuals' WM capacity, such that presenting intention-related information benefited PM performance for low, but not high, WM participants. Furthermore, ongoing task latencies did not differ between low WM participants in the lures and no-lures conditions, suggesting that participants in the two groups were allocating similar amounts of attentional resources to support target detection despite the clear differences in PM performance between the two. It is proposed that intention-related events might stimulate thoughts about the intended action and compensate for low WM individuals' higher susceptibility to task-unrelated thoughts and impoverished ability to sustain controlled attentional processes to support prospective remembering.

In the present paradigm, focal processing of the lure words was assured by presenting these items in red font, such that they were part of the set of items requiring a lexical decision in the ongoing task. By contrast, the PM target was nonfocal as it was presented as one of the black font distractor items that, on any given trial, were irrelevant for ongoing task performance. In line with Taylor et al. (2004), results showed slowing for intention-related material in the lures condition, suggesting that participants noticed the association between these items and the PM task. This finding, together with the observation that the degree of slowing for lure words was associated with PM success, is consistent with the enhanced PM performance in the lures relative to the no-lures PM condition. It is important to point out that, due to the nature of the present manipulation, participants in the lures condition were presented with lure words whereas those in the no-lures condition were presented with control words (i.e., items unrelated to the PM target). Thus, it could be claimed that the different pattern of lure interference in the two PM conditions (i.e., slowing for lures, but not controls, relative to filler words) was due to differences between the items. Such a possibility seems unlikely because lure and control words were carefully matched in mean length, syllables and frequency, and past studies show that comparing words related to the intention and control-matched words is a valid approach (e.g., Marsh et al., 2003; Scullin, Bugg, & McDaniel, 2012; Scullin et al., 2009). Moreover, if anything, data from Balota et al.’s (2007) English Lexicon Database would suggest that in the absence of any experimental manipulations RTs should be slower for control relative to lure words (626 vs. 585 ms, respectively).

Most importantly, the findings from the present study yield new evidence on the role of intention-related material in nonfocal target detection. It was shown that presenting events related to the intention benefits PM performance for low WM participants and eliminates target detection differences between high and low WM individuals. One possibility is that presentation of intention-related material benefited prospective remembering by stimulating the engagement of additional cognitive resources following the lures and up to the target presentation (e.g., Guynn, 2003; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, et al., 2010; Smith, 2003). If intention-related material triggered monitoring on the ongoing task, then ongoing task RTs should have been inflated following the presentation of the lure words in the lures condition. Results showed that although the speeding up from the trials preceding the lure/control words to those following these items was numerically smaller in the lures than in the no-lures condition, the difference did not reach statistical significance. It is possible that the lack of any strong evidence for slowing following the lure words is due to the short-lived nature of the post-lure slowing effect (e.g., Scullin, McDaniel, & Einstein, 2010[5]). Alternatively, or additionally, it could be reasoned that lack of a significant post-lure slowing in the lures condition may be the result of the amount of attention allocated to the PM task already being high (RTs of approximately 1200 ms on average) due to the nonfocal nature of the intention. Although this is speculative (because of the absence of a no-PM control condition), several studies using a LDT as the ongoing task have yielded RTs ranging between 500 and 1300 ms (Einstein et al., 2005; Smith, 2003). Furthermore, research suggests that participants generally exhibit an a priori awareness of the difficulty of detecting nonfocal targets and the amount of resources allocated to the PM task is typically well adjusted (Einstein & McDaniel, 2008; Meeks et al., 2007). Equally relevant, however, was the analysis of RTs immediately preceding the PM target, since the fourth and final lure word occurred 20 trials away from the first PM target occurrence. As mentioned earlier, findings from Scullin, McDaniel, and Einstein (2010) demonstrated that it is important to examine cost in the trials proximal to the target events to investigate the nature of the processes that are being engaged to support retrieval. Crucially,

[5] Note that results from Scullin, McDaniel, and Einstein (2010, Experiment 1) suggest that presenting words semantically associated with a focal PM target can trigger ongoing task slowing. Most importantly, their findings also suggest that the slowing effect has a short-lived nature, such that it is not sustained for several trials.

there was no visible difference in ongoing task RTs for the trials immediately preceding the PM target between the lures and the no-lures conditions. Likewise, RTs were highly similar for low WM participants in the lures and the no-lures conditions despite enhanced PM performance for the former. Together, the present evidence suggests that the allocation of additional resources to the PM task cannot explain the benefit of intention-related material on PM observed for low WM participants.

Alternatively, intention-related material might compensate for low WM individuals' greater susceptibility to fluctuations in the efficiency of executive control over time and reduced ability to maintain an integrated representation of the entire task set (i.e., ongoing and PM task demands) in an activated or easily accessible state. The present data are consistent with this possibility. Specifically, low WM participants in the lures and no-lures conditions did not differ in their ongoing task RTs (both overall and preceding the PM target), despite clear differences in the level of PM success. This strongly suggests that the difference in the detection of nonfocal targets between participants in the lures and no-lures conditions reflects differences in the efficiency of cognitive attentional control. It is proposed that for individuals with low WM, presentation of intention-related material may compensate for deficits in the efficiency of attentional control by stimulating thoughts about the PM task and mitigating against the occurrence of irrelevant thoughts and attentional lapses. This idea is elaborated next.

Research shows that there can be fluctuations in the efficiency of executive control processes over time resulting in relatively brief periods where maintenance of a course of goal-directed action is operating below optimal levels (e.g., Unsworth, Brewer, & Spillers, 2012). Additionally, as discussed above, there are individual differences in the efficiency of executive control processes. Studies have shown that individuals low in cognitive control (e.g., low WM individuals) are more likely than those high in cognitive control to experience lapses of attention (e.g., Unsworth & Spillers, 2010) and mind-wandering (e.g., Kane et al., 2007). Similarly, low WM individuals are less able than high WM individuals to maintain the PM task demands in a highly activated state (Smith & Bayen, 2005; R. West et al., 2006). This is in line with Smith's (2003) view that monitoring is a nonautomatic, capacity-consuming process and with Bargh and Chartrand's (1999) view that individuals' capacity to sustain controlled processing is limited. In the present study, multiple words semantically related to the PM target preceded the (first) nonfocal target. It is proposed that presentation of intention-related material could have compensated for deficits in the efficiency of executive control processes for low relative to high WM individuals. Thus, superior performance on nonfocal PM tasks for high relative to low WM individuals has been associated with differences in the ability to efficiently and continuously allocate attentional resources toward the PM task (e.g., Brewer et al., 2010; Smith & Bayen, 2005). Repeated presentation of intention-related information probably stimulated periodic thoughts about the PM task and promoted the maintenance of attention towards the PM task, which should be especially beneficial for low WM individuals. In other words, presentation of lure words could have increased low WM participants' thoughts about the intention (reducing the occurrence of distractor thoughts or mind-wandering) and increased the efficiency with which they could retrieve task-relevant representations that had been temporarily displaced by distraction (cf. Unsworth, 2007).

Additionally, it is possible that presenting intention-related information strengthened the representation of the intention in memory and thus increased cue accessibility (i.e., amount of processing required to activate the mental representation of the intention to a level of awareness sufficient to support retrieval of the PM action). This could lead individuals to overcome some of their PM failures by counteracting momentary lapses of attention. Specifically, it has been proposed that PM failures reflect momentary lapses of attention (i.e., moments where the intention fails to reach awareness) due to natural fluctuations in the efficiency of executive control processes over time (Craik & Kerr, 1996; R. West & Craik, 1999; R. West, Murphy, Armilio, Craik, & Stuss, 2002; see also R. West & Alain, 2000). Consistent with the proposal that PM failures can result from momentary lapses of attention, Maylor (1996) demonstrated that participants' ability to detect PM targets fluctuates throughout the ongoing task and that performance is worst for participants with diminished attention control. Specifically, she showed that the likelihood of forgetting (i.e., failure to detect a target following successful PM performance) was greater for older adults relative to middle-aged adults, whereas the opposite was true for the likelihood of recovering (i.e., success following a failure to perform the intended action). This aligns well with the present findings showing that a benefit of intention-related material on PM performance was found for low WM individuals, that is, individuals who display increased difficulty in sustaining attention toward cue-focused processes. It is also consistent with the proposal that presenting intention-related events allowed low WM individuals to more efficiently control attention and retrieval processes (particularly critical to efficient performance with nonfocal PM tasks).

In sum, the present study provides original evidence that presenting intention-related material can compensate for PM performance deficits in low relative to high WM individuals. Furthermore, results suggest that intention-related events might benefit performance by reducing momentary lapses of attention and stimulating low WM participants to maintain attention toward the PM task.

Chapter 3: The Role of (Relevant) Distraction in PM

Like the previous chapter, the role of intention-related material in PM performance is addressed here. However, a new factor is considered, as the role of encountering distractor information that is associated with the PM task is explored in relation to age-related deficits in PM performance. An essential aspect of cognitive functioning is the need to minimize or otherwise ignore environmental distraction that interferes with successful concentration on the task at hand. Distractions can come from various sources and be of different types, but it is generally assumed that distraction can disrupt performance, such as when trying to read this thesis in a noisy environment or during office hours with students coming in and out. Similarly, in PM scenarios, it is often the case that people are presented with multiple sources of information and must focus on the one that is relevant to their current goals.

The notion explored here is that some environmental distractions may hold more relevance than others, such that some of the ignored information might, at times, be of interest to the person's future intentions and aid PM target detection. For example, while you are engaged in browsing information on a topic that caught your attention at a seminar you attended early in the day, concurrent irrelevant information such as advertisements or email alerts might cause distraction. However, the sight of incoming messages might also remind you to send an email to a restaurant confirming table numbers for the evening meal, before you leave for a meeting that you have to attend shortly. Research examining PM performance in the face of task-irrelevant information is scarce and, so far, has neglected the influence of aging. The experiments in this chapter investigated whether presenting distractor information can benefit PM when this information is related to the intention. Furthermore, based on research showing older adults' increased susceptibility to distractor information, it was examined whether there are age-related differences in the potential benefit from distractor information on prospective remembering.

PM and distraction

PM research has typically focused on examining how PM performance is disrupted by distraction caused by demanding ongoing activities. A number of studies have shown that increasing the cognitive demands or processing requirements of the ongoing task can reduce PM performance (e.g., Guynn & McDaniel, 2007; Marsh, Hancock, et al., 2002; Marsh & Hicks, 1998; McDaniel, Guynn, et al., 2004). Although this line of research has resulted in important practical and theoretical contributions, these studies do not address effects of distraction caused by material that individuals are told to ignore and, particularly relevant here, what effects intention-related distractor information has on PM performance.

The only study that has experimentally manipulated exposure to intention-related material in the to-be-ignored stream did so to examine if noticing of this material would occur and was limited to young adults. Specifically, Marsh, Cook, Meeks, Clark-Foos, and Hicks (2007, Experiment 1) instructed participants to perform a PM task of responding to animal words in the context of an ongoing task requiring pleasantness ratings to visually presented words. In addition, participants were explicitly told to ignore words that would be concurrently presented in the auditory channel during the ongoing task. Critically, intention-related material (i.e., animal words) was presented auditorially as to-be-ignored information and awareness for this material was examined in a subsequent recognition test for the words in the auditory stream. Results showed higher recognition memory for intention-related words compared to words from a control category. Marsh et al. (2007) suggested that forming a categorical intention would heighten the category's activation and likely bias attention towards to-be-ignored information that was related to the intention. Moreover, the authors showed that when the intention was linked to a distal context, such that the intention was no longer active during the pleasantness-rating task, recognition memory for the intention words in the ignored channel no longer differed from memory for the control words.

Thus, results support the claim that having an intention can cause intention-related distractor material presented during the performance interval to be noticed and differentially processed. Furthermore, as pointed out by Marsh et al. (2007), whether an attentional bias towards intention-related distractor information can result in a benefit for PM performance certainly merits clarification from future research. As reviewed in the previous chapter, research suggests that when participants are given a nonfocal PM task, presenting words semantically related to the intention (i.e., semantic lures) during the ongoing task can improve PM performance relative to a condition with no lures (e.g., Experiment 1, Chapter 2 in this thesis; Taylor et al., 2004). Analogously, presenting intention-related information as distractor material might benefit PM performance; however, to date this has not been examined. Moreover, previous research has not addressed the effect of aging on PM performance when distraction is related to the intention.

Distraction and aging

Much prior work has examined how attention to information that is irrelevant to the task at hand interferes with cognitive performance (e.g., Healey et al., 2008; Rowe, Valderrama, Hasher, & Lenartowicz, 2006). Most relevant to the present investigation, several studies have focused on age-related differences in the susceptibility to distractor information. Results generally reveal that performance in a multitude of cognitive tasks is disproportionately affected by concurrent irrelevant information in older relative to young adults. For instance, it has been shown that older adults' reduced ability to ignore irrelevant information leads to performance deficits in processing speed tests (Lustig, Hasher, & Tonev, 2006), the Simon task (e.g., Proctor, Pick, Vu, & Anderson, 2005), speech comprehension and reading (e.g., Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Koivisto & Revonsuo, 2007), problem-solving (May, 1999), and episodic retrieval (Thomas & Hasher, 2012). Hasher and colleagues' inhibition theory assumes that older adults have reduced inhibitory control, including reduced ability to prevent irrelevant information from gaining access to attention/WM (see Hasher, Lustig, & Zacks, 2007; Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Lustig et al., 2006). Thus, the proposal is that a primary determinant of age-related differences in cognitive abilities is older adults' impoverished capacity to efficiently regulate distraction.

However, whereas the focus of much research in aging and distraction has been on the negative effects of decreased attention regulation in older adults, more recently interest in positive effects has arisen. In particular, several studies have shown that when distractor information becomes relevant in a subsequent implicit memory task, a benefit is often seen in older but not young adults (e.g., Biss, Ngo, Hasher, Campbell, & Rowe, 2013; Gopie et al., 2011; Healey et al., 2008). For example, Kim, Hasher, and Zacks (2007) showed that reading stories that included distractor words that were solutions to a problem-solving task performed subsequently in the session increased the number of problems solved in older, but not young, adults. More recently, it was shown that implicit transfer of previously distracting information can also improve older adults' free recall performance (Thomas & Hasher, 2012).

Of particular relevance here is a study on the positive effects of distraction in older adults (Rowe et al., 2006) using a paradigm first developed by Rees, Russell, Frith, and Driver (1999) to investigate inattentional blindness in young adults. In Rees et al.'s study, participants were presented with rapid streams of pictures containing superimposed letter strings (words or random letters) and asked to detect immediate repetitions of pictures. In addition to no advantage for distractor words in comparison to never-presented words, in a subsequent recognition test, functional magnetic resonance imaging (fMRI) data showed that cortical activation for words was similar to that found when the superimposed strings were random letters. Moreover, this was in clear contrast with the word-related activation observed when participants were instructed to attend to the letter-strings stream instead. Thus, results are consistent with inattentional blindness for words presented in the attended location in young adults, such that no differential processing was observed for words compared with random letters presented as to-be-ignored information. Rowe et al. (2006) adapted this paradigm to examine implicit memory for distractor words in young and older adults. Results showed increased completion of word fragments in older compared with young adults when the solutions matched previous distractive information in the 1-back task to pictures. Thus, findings were consistent with a performance advantage in older adults that follows from their poor attention regulation for irrelevant information.

PM and aging

As reviewed in Chapter 1, evidence for age-related deficits on PM performance is mixed. On the assumption that older adults have reduced attentional resources (Craik, 1986; Salthouse, 1991), it has been suggested that inconsistent findings might be the result of variations across studies in the level of strategic demands imposed by the tasks. Results from two meta-analyses showing that age-related deficits in PM are especially pronounced with more demanding nonfocal tasks (relative to focal PM tasks) are consistent with this proposal (e.g., Henry et al., 2004; Kliegel et al., 2008).

Interestingly, recent evidence suggests that valence of PM targets can exert a positive effect on target detection in a PM task that poses attentional demands (i.e., responding to six target words). Specifically, in a study investigating the effect of emotional valence on PM performance, Altgassen, Phillips, Henry, Rendell, and Kliegel (2010) showed worse PM performance for older relative to young adults with neutral but not with emotionally valenced targets. The authors argued that emotional valence increased the salience of the targets. According to Altgassen et al. (2010), salient targets might increase prospective remembering by facilitating involuntary capture of attention.

Experiment 2

The main questions addressed in this experiment were whether presenting distractor information that is intention-related can lead to a PM improvement, and whether aging will influence the contribution of the distractor material to PM performance. Rees et al.'s (1999) paradigm, in which a 1-back task was performed on target pictures superimposed with to-be-ignored strings of letters, was adapted. Specifically, the task of giving a PM response to pictures of animals was embedded in the 1-back ongoing task. To examine whether intention-related distractor information would lead to a PM benefit, for half of the participants some of the distractor strings occurring before the PM targets were animal words. Given the age-related differences in the susceptibility to distractor information, it was hypothesized that presentation of intention-related distractor words should be advantageous to PM performance for older but not young adults. Considering research suggesting that aging can pose additional challenges to the ability to successfully carry out PM tasks, and on the assumption that attentional resources decline with aging (Craik, 1986; Salthouse, 1991), the aim was to determine if older adults' increased susceptibility to irrelevant information can serve a compensatory role when distractor information holds relevance to their future intentions.

Method

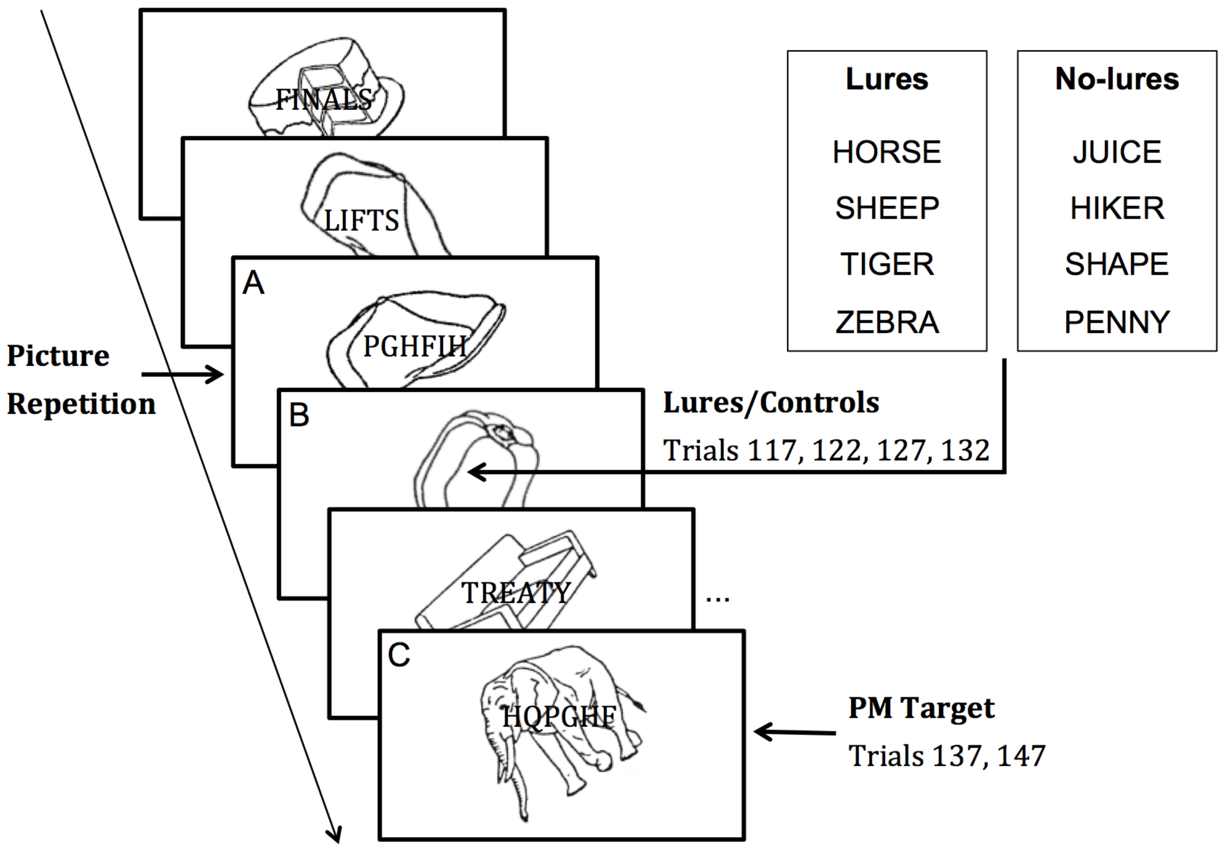
Design and participants. The experiment was a 2 x 2 between-subjects design, with age (young, older) and PM condition (lures, no-lures) as factors. Fifty-seven young adults (26 female) aged 18-28 years and 59 healthy older adults (34 female) aged 58-83 years took part in the experiment. Young participants were undergraduate students from Warwick University who volunteered in exchange for course credit or were paid £4 for their participation. Community-dwelling older adults were recruited from the University of Warwick Age Study volunteer panel that was populated by local advertisements, and received £10 towards their travel expenses. All participants reported being in good health and all had normal or corrected to normal vision (self-reported). Within each age group, participants were randomly assigned to the lures and no-lures conditions (see Table 3). Data from one young and one older participant in the lures condition and two older participants in the no-lures condition had to be discarded as detailed in the Results section, leaving 28 participants in each of the four cells of the design.

Table 3: *Means and Standard Deviations for Demographic Information and Tasks Performed During the Testing Session for Each Age Group and Condition*

	Age Group							
	Young				Older			
	Lures		No-lures		Lures		No-lures	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age (years)	21.2	2.4	20.6	3.1	71.2	5.8	72.1	5.9
Mill Hill vocabulary score	20.6	3.9	19.3	3.9	25.4	4.1	24.4	3.5
Simon Task – Mean correct response time in milliseconds								
Congruent	420	86	407	81	529	88	516	75
Incongruent	457	97	449	75	604	93	590	70
Digit Span								
Forward	9.5	2.1	9.5	1.7	8.2	2	8.8	2.1
Backward	7.0	1.2	7.8	2.0	7.0	1.8	7.4	2.0
Pictures Task								
Hit rate	.89	.08	.94	.07	.83	.11	.84	.12

Participants were tested individually in sessions lasting 40 to 50 min. The multiple choice part of the MHVT (Raven et al., 1988) was administered as a measure of crystallized intelligence. The results were consistent with the literature (e.g., Salthouse, 1991, 2010) with young participants scoring significantly lower than older participants, $p < .001$. There was neither a main effect of PM condition nor an interaction between age and PM condition suggesting that, within each age group, participants in the lures and no-lures conditions were well matched in terms of vocabulary. Two further cognitive tasks were administered to ensure that expected age differences were evident and that there were no differences in either age group between participants assigned to the lures and no-lures conditions. The first was a Simon task, which measures the degree of interference from task-irrelevant spatial information on responses to task-relevant nonspatial information (see Lu & Proctor, 1995). Speeded responses with the left/right hand were required on the basis of the direction of left-/right-pointing arrows that appeared on the left/right side of the screen. Responses were both faster and more accurate on congruent than on incongruent trials (Simon effect). For mean correct RTs, older adults showed a significantly larger Simon effect than did young adults, both in absolute and proportional terms (cf. Bialystok, Craik, Klein, & Viswanathan, 2004; Van der Lubbe & Verleger, 2002). However, there were no main effects or interactions involving lures, indicating that within each age group, those randomly assigned to the lures and no-lures condition were equivalent on at least one indicator of inhibitory functioning. The second cognitive measure was the digit span subtest from the Wechsler Adult Intelligence Scale (Wechsler, 1981), which requires the immediate repetition of digit sequences of increasing length in the exact order presented (forward span) or in the reverse order (backward span). As expected, young participants significantly outperformed older participants, especially for forward span. Again, there were no main effects or interactions involving lures, indicating that within each age group those randomly assigned to the different conditions were equivalent in terms of short-term/WM. Results from the several tasks for participants in each condition can be found in Table 3.

***Materials and procedure*.** Participants were first given instructions about the 1-back visual WM task (referred to as the “pictures” task). They were presented with a rapid stream of individual pictures superimposed with either random letters or words. Participants were instructed to ignore the random letters/words and to press the spacebar whenever two consecutive pictures were identical. It was explained that the pictures could appear rotated, but that a correct response should be made even if the repeated picture was oriented differently. An example of a repeated picture presentation was then given and participants were informed that auditory feedback would be provided such that correct detection of picture repetitions would be followed by a bell sound and missed detections would be followed by a buzz sound (see Rees et al., 1999). Finally, participants were additionally given the PM instructions stating that if they ever saw a picture of an animal they should press the ‘B’ key (see Figure 3). Following encoding, participants were asked to explain the instructions to the experimenter and any omissions or mistakes were corrected. On each trial, the picture and letters pair was presented for 1000 ms, followed by a 500-ms blank screen. In addition, on consecutive picture trials, auditory feedback (i.e., bell or buzz) was added during the blank screen. Before performing the pictures task, participants carried out the digit span task, which served as a delay between the PM task instructions and the beginning of the pictures task.



Note: The ongoing task consisted of pressing the spacebar whenever two consecutive pictures were identical (A), while ignoring the strings of letters superimposed over each picture. The prospective memory (PM) task consisted of pressing the 'B' key whenever a picture of an animal (C) was presented. Lure/control words were presented before Target 1 (B) according to the PM condition. Each picture-letters pair was presented for 1000 ms, followed by a 500-ms blank screen.

Figure 3: Schematic diagram of the 1-back pictures task that was used as the ongoing task in Experiment 2.

For the pictures task, 129 line drawings were selected from Snodgrass and Vanderwart (1980) such that only two were pictures of animals (i.e., the PM targets). Drawings were presented in the center of the screen and superimposed with either uppercase random letters or uppercase word strings. The strings had a length of 5 or 6 letters and were distinct for all trials (total of 90 random-letter strings and 60 word strings). Words were generated from the Balota et al. (2007) lexicon database, were 1–2 syllables in length, and had a log-transformed HAL frequency between 6 and 10. The strings were presented in a font size of 24 pt, subtending a visual angle of approximately 8º x 1.5º with a viewing distance of 50 cm. The pictures were presented with a maximum visual angle of approximately 12º x 12º.

The pictures task was composed of three blocks, with each block comprising 50 trials, 7 of which were picture repetitions (150 trials with 21 repetitions in total). Before the start of each block, a screen with the block number was displayed for 2000 ms. The lag between consecutive pictures ranged from 2 to 7 intervenient pictures. In order to increase task demands, pictures were rotated 30º clockwise or counterclockwise from their natural axis and pictures had different orientations within any repeated pair (see Rees et al., 1999). Within each block of 50 trials, 8 pictures with random letters superimposed were followed by 42 pictures with either random letters (22 in total) or words (20 in total) superimposed. PM targets and lures always consisted of no-repetition trials and were only presented during the third block as described next. There were two PM target pictures presented on Trials 137 and 147 (an *elephant* and a *mouse*, respectively). In addition, in the lures condition, four of the superimposed words were animal words, presented on Trials 117, 122, 127, and 132 (*HORSE*, *SHEEP*, *TIGER*, and *ZEBRA*, respectively). In the no-lures condition, the animal words were replaced by control words (*JUICE*, *HIKER*, *SHAPE*, and *PENNY*; see Figure 3) that were matched with the lures on number of letters, syllables, and mean HAL frequency.

Before the end of the experimental session, participants answered a post-experiment questionnaire to test their recall for the PM task as well as awareness for the animal lures presented as distractor words in the lures condition. Specifically, participants were asked to repeat the full instructions for the pictures task and memory for the PM task was checked. Then participants were asked if they noticed any animal words during the pictures task and, whenever they answered yes, participants were asked to list the animal words they remembered seeing.

Next, participants performed a standard LDT comprising 240 experimental trials, which was not relevant to the main aims of the present experiment, followed by the Simon task. They then completed a demographic questionnaire and the MHVT before being debriefed.

Results and discussion

When queried about the PM task during the post-experiment questionnaire, one young and three older participants had no memory for the PM target/action and so their data were not included due to their failure in encoding and retaining the instructions.

PM performance. PM performance was scored as the proportion of target pictures for which the participant pressed the ‘B’ key during the presentation of the target or within the next two trials. Ninety-six percent of the PM responses occurred during these periods. The overall means are shown in Figure 4. A 2 x 2 ANOVA with age (young, older) and PM condition (lures, no-lures) as between-subjects factors revealed a significant main effect of PM condition, $F(1, 108) = 11.88$, $MSE = 0.15$, $p = .001$, $\eta_p^2 = .10$, such that target detection was better in the lures than in the no-lures condition. Thus, although participants were told to ignore the letter strings superimposed on the drawings, there was a benefit to PM performance when some of these strings were intention-related (i.e., animal words). The main effect of age was not significant, $F < 1$, and the interaction between age and PM condition failed to reach significance, $F(1, 108) = 2.18$, $p = .143$. Still, examination of Figure 4 reveals that the benefit of intention-related words was largely limited to older adults, $t(54) = 3.52$, $p = .001$. For young adults, there was little difference as a function of the presence or absence of intention-related material, $t(54) = 1.38$, $p = .174$. These findings are consistent with research showing an age-related increase in the susceptibility to irrelevant information (e.g., Kim et al., 2007).

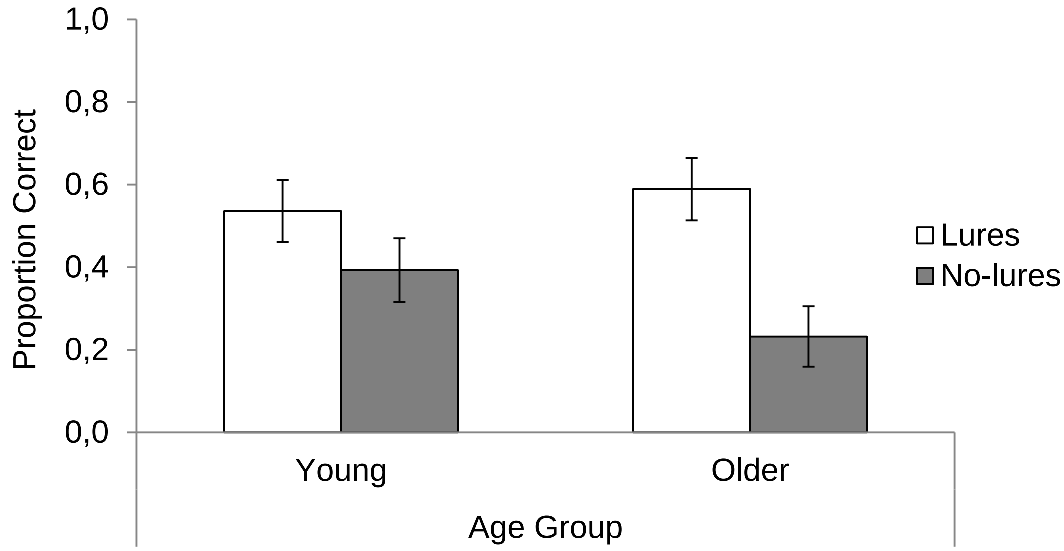


Figure 4: Mean proportion correct for the prospective memory task across conditions. Error bars represent ± 1 standard error.

Additionally, because multiple PM observations may not be independent as practice effects can occur across trials (see Maylor, 1996, 1998), the processes involved in trials other than the first PM target might obscure interesting effects. Therefore, and in line with the use of this approach in previous research (e.g., McDaniel, Guynn, et al., 2004), it was examined if the effect of intention-related distractor material was more prominent on the first trial by conducting a 2 x 2 (Age x PM condition) ANOVA on responses only to the first PM target. In this case, the age by PM condition interaction reached significance, $F(1, 108) = 5.02$, $MSE = .24$, $p = .027$, $\eta_p^2 = .04$. Again, intention-related distractor words benefited PM performance for older adults ($M = .61$, $SD = .50$ with lures, and $M = .25$, $SD = .44$ with no lures, $t(44) = 3.37$, $p = .002$), but not young adults ($M = .41$, $SD = .49$ with lures, and $M = .46$, $SD = .51$ with no lures, $t < 1$). There were no other significant effects. These results provide original evidence that presenting intention-related material as distractor information can improve PM performance, but only for older, and not young, adults. It is noteworthy that the present findings converge with studies demonstrating that older adults' reduced distraction control can benefit performance in retrospective memory tasks (e.g., Healey et al., 2008; Kim et al., 2007; Rowe et al., 2006).

Next, mean PM success was examined when the young and older adult samples in the lure condition were composed solely of participants with no explicit memory for the intention-related distractor words (i.e., excluding participants who, during the post-experiment questionnaire, could recall at least one animal word and had, therefore, noticed the presence of lures in the distractor stream[6]). A 2 x 2 ANOVA with age (young, older) and PM condition (lures, no-lures) revealed a main effect of PM condition, $F(1, 91) = 5.17$, $MSE = 0.14$, $p = .025$, $\eta_p^2 = .05$, that was qualified by a significant age by PM condition interaction, $F(1, 91) = 5.40$, $MSE = 0.14$, $p = .022$, $\eta_p^2 = .06$. As before, presentation of intention-related words improved target detection for older adults ($M = .60$, $SD = .37$ with lures, and $M = .23$, $SD = .37$ with no lures, $t(54) = 2.84$, $p = .006$), but not for young adults ($M = .39$, $SD = .37$ with lures, and $M = .39$, $SD = .39$ with no lures, $t < 1$). Thus, for participants with no explicit memory for the distractor lure words, a benefit was observed for older, but not young, adults. This replicates the pattern observed both for mean PM and PM performance for the first target.

It is interesting to note, however, that although the method used in the present study greatly discouraged processing of the information presented in the distractor stream, at least some older and a few more young adults recalled seeing intention-related distractor information. This implies that at least on some proportion of the trials a few participants failed to ignore the lure words. Although, at first, the present results might appear contradictory with those of Rees et al. (1999), it is important to note that their paradigm was expanded in several critical ways

[6] Ten young adults and seven older adults in the lures condition noticed the presence of distractor animal words and were therefore not included in the analysis.

including embedding a PM task. In brief, Rees et al. reported behavioral and fMRI data in young adults consistent with inattentional blindness for words presented in the attended location as to-be-ignored information. However, the authors presented each picture-letters pair in the pictures task for only 500 ms. With older adults in mind, and similar to Rowe et al. (2006) study using the pictures task to examine distraction control in older adults, a duration of 1000 ms was used here. This probably caused changes in the demands posed by the 1-back task in comparison to Rees et al.'s task. As argued by the authors, incidental processing of lexical properties of the word stimuli may occur under task conditions that impose a lower load than the one created by the task parameters used in their study. Thus, it is possible that stimulus presentation time in the present study played an important role in allowing occasional processing of letter strings.[7]

Ongoing task performance. The proportion of picture repetitions correctly detected (hit rate) was computed, and included in a 2 x 2 x 3 ANOVA with age (young, older) and PM condition (lures, no-lures) as between-subjects factors, and block (first, second and third) as the within-subjects factor (see Table 3). There was a main effect of block, $F(1, 216) = 3.50$, $MSE = 0.17$, $p = .032$, $\eta_p^2 = .03$, such that hit rate was lower in the first ($M = .85$, $SD = .17$) than in the second ($M = .89$, $SD = .15$) and third ($M = .89$, $SD = .12$) blocks. The only other significant effect was a main effect of age, $F(1, 108) = 17.30$, $MSE = 0.03$, $p < .001$, $\eta_p^2 = .14$, such that hit rate was higher for young ($M = .91$, $SD = .08$) than for older ($M = .84$, $SD = .12$) participants. Thus, older adults were performing worse on the 1-back ongoing task than were young adults. It seems likely that age-related differences in performance occurred as the result of older adults

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[7] Research has also shown that conscious attention can modulate the processing of task-irrelevant stimuli, such that a stimulus semantically congruent with an attended category is easier to detect than an incongruent stimulus. It is assumed that the effect is the result of a decrease in the detection threshold for category members due to attention directed to the attended category (semantic congruency effect; Koivisto & Revonsuo, 2007, 2009). Importantly, in contrast with the present study and research on age-related distraction control, the previous findings were observed when presentation of the irrelevant stimulus was unexpected and limited to a single occurrence.

being less able to perform the 1-back visual WM task due to their reduced attentional resources (e.g., Altgassen, Henry, Bürgler, & Kliegel, 2011; Craik & Jennings, 1992; Hertzog, Dixon, Hultsch, & MacDonald, 2003; Park et al., 1996).

One final aspect deserves mention. Participants were asked to perform the nonfocal PM task of responding to pictures of animals.[8] As discussed in Chapter 1, nonfocal tasks generally yield age-related deficits on PM performance (e.g., Kliegel et al., 2008). However, there was no significant difference between young and older adults in mean target detection. Nevertheless, it was found both that results were in the direction of a reduction, and that older adults performed worse than young adults in the ongoing task, with an accuracy of 84% (compared with 91%) for the detection of picture repetitions. Thus, it is possible that older adults maintained PM performance at the expense of greater costs to the ongoing task. In line with this notion, McDaniel et al. (2008) showed that older adults can sometimes perform at similar levels to young adults in nonfocal PM tasks by trading off performance on the ongoing task. Regardless, the results show that presenting intention-related distractor information during the ongoing task benefited the PM performance of older, but not young adults.

Experiment 3

The results from Experiment 2 suggest that presenting intention-related material as distractor information improved PM performance for older, but not young adults. Notice that response latencies on the ongoing pictures task were not collected in Experiment 2. Consequently, RT costs in the ongoing task could not be considered when interpreting the effects of lure presentation. Experiment 3 used a procedure that was, essentially, very similar to that of

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[8] The task is considered nonfocal (or "task-inappropriate"; Maylor, 1996) because processing the pictures for the 1-back ongoing task does not require encoding of their category (Einstein & McDaniel, 2005).

Experiment 2, but that allowed the collection of RT data. One of the main goals of Experiment 3 was to replicate the finding that presenting distractor lure words does not benefit young adults' PM performance. More important, ongoing task RTs were measured to examine cognitive processing in the ongoing task, and, in particular, to determine whether young adults would show the same pattern of RTs across the different types of ongoing task trials (i.e., intention-related vs. neutral). Such a finding would bolster the proposal that the impact of distractor lure words on PM performance was due to age-related differences in the efficiency of distraction control.

Method

Design and participants. The study was a single-factor, between-subjects design with condition (no-PM control, PM lures, PM no-lures) as the variable. Participants aged 18–26 years (M = 20.6 years, SD = 1.4) were undergraduate students from Warwick University and were an opportunity sample. Ninety participants (37 male) were randomly assigned to the no-PM control (n = 30), PM lures (n = 29), and PM no-lures (n = 31) conditions. One participant in the PM lures condition was excluded as detailed in the Results section. Testing took place individually in sessions lasting approximately 25 min. During the session, participants completed the DSST (Wechsler, 1981), used as a measure of perceptual-motor processing speed, as well as paper versions of the Stroop task (Golden, 1978; Stroop, 1935) and Trail Making test (Reitan, 1992). Scores on the measures of cognitive ability for participants in each of the PM conditions can be found in Table 4 (for a description of the tasks see the Procedure section). ANOVA revealed no main effect of condition for the DSST, $F(2, 86) = 1.22$, $p = .300$, Stroop task, $F(2, 86) = 1.52$, $p = .225$, or Trail Making B test, $F < 1$, indicating that participants randomly assigned to the different conditions were equivalent on all the measure of cognitive ability used.

Table 4: Scores on the Digit Symbol Substitution Task (DSST), Stroop Task and Trail Making B Test for Participants in Each Condition

	Condition					
	No-PM control		PM lures		PM no-lures	
	M	*SD*	*M*	*SD*	*M*	*SD*
DSST	71.3	12.4	68.0	12.1	72.8	12.1
Stroop task	49.4	13.0	52.0	12.1	54.8	11.5
Trail Making B test	44.2	15.7	43.9	16.1	41.7	15.5

Materials and procedure. The procedural details of this experiment were similar to Experiment 2, with several important exceptions as follows. First, a practice phase of 10 pictures was included and the number of experimental trials was increased to 235 pictures (220 fillers, 3 PM targets, and 12 buffers half of which were presented at the start and half at the end of the ongoing task). The experimental trials comprised a total of 47 repetitions and 188 non-repetitions. The PM targets were pictures of a *squirrel*, a *pig*, and an *elephant*, presented on Trials 127, 178, and 229, respectively. Additionally, all line drawings selected from Snodgrass and Vanderwart (1980) were colored red.

Second, nine animal words (*BEAR*, *COW*, *DEER*, *GOAT*, *HORSE*, *LION*, *MOUSE*, *RABBIT*, *and TIGER*) selected from Van Overschelde, Rawson, and Dunlosky (2004) were used. The order of appearance of these nine distractor lure words was randomized between participants; they were presented on Trials 112, 117, 122, 163, 168, 173, 214, 219, and 224, resulting in three animal lures being presented before each PM target (see Figure 5). Lure items (as well as targets) always occurred in non-repetition trials. Whereas participants in the PM lures condition were presented with these nine animal words, in the PM no-lures condition these items were replaced by nine control words, unrelated to the target category and matched with the lure words on mean length, syllables, and frequency. In the no-PM control condition, half of the participants were presented with the lure words, whereas the other half was presented with the control-matched words. For all participants, a delay of approximately 5 minutes between instructions and the start of the pictures task was created by asking them to complete the DSST (Wechsler, 1981) and to fill in a demographic questionnaire. Additionally, the set of distractor filler words were selected to match the animal lures on several lexical characteristics, such that they had a mean length of 4.4 letters, consisted of 1.2 syllables on average, and had a mean HAL frequency of 9.2 according to Balota et al. (2007).

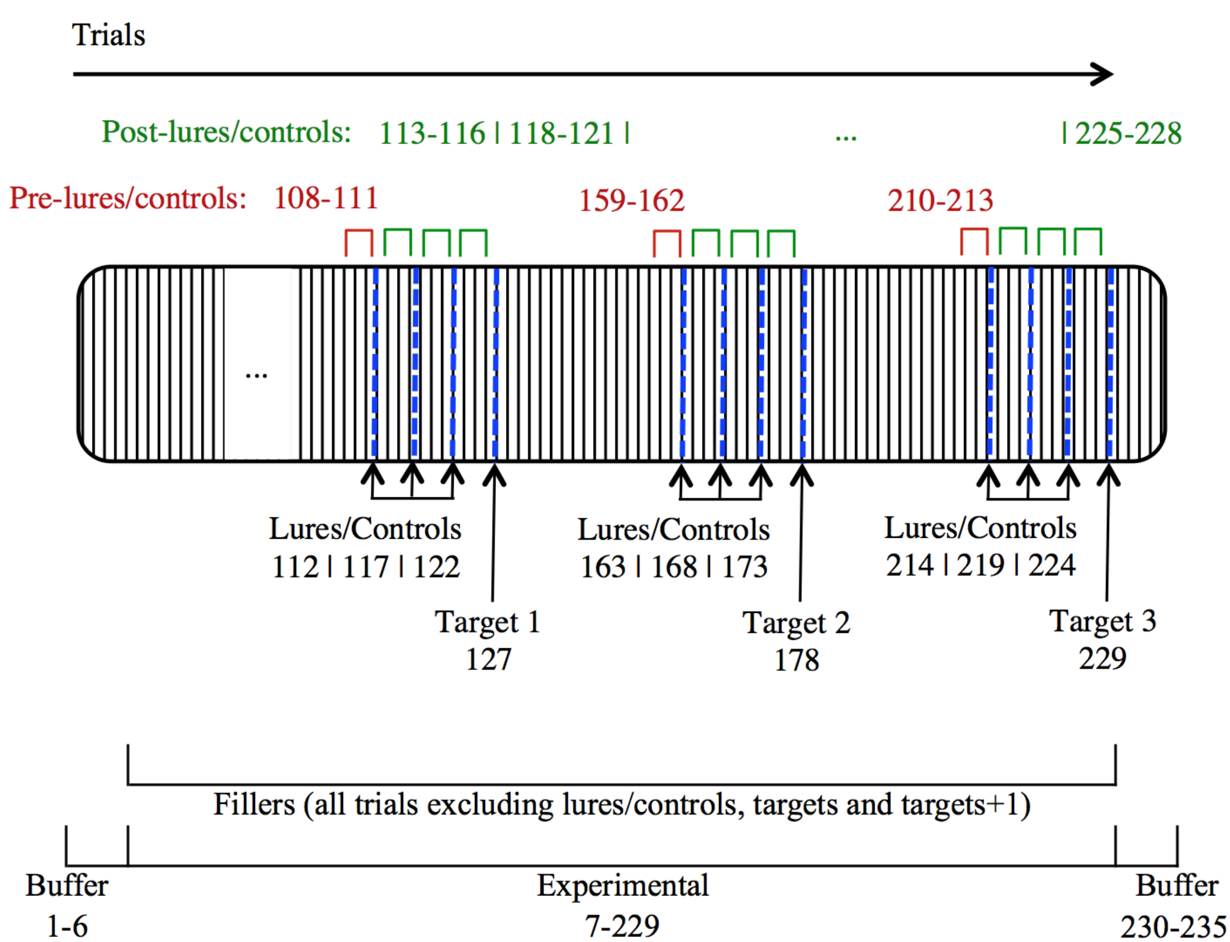

Figure 5: Overview of the trial sequence in the 1-back pictures task that was used as the ongoing task in Experiment 3.

Third, the ongoing task was the same as in Experiment 2 in that, for each trial, participants had to decide whether or not the picture was an immediate repetition of the picture presented in the immediately preceding trial. However, in order to collect performance measures (accuracy and RTs) for all trials in the ongoing task, instructions for the pictures task were modified such that participants were told to press the key labeled ‘Y’ (‘J’ key) with their right index finger and ‘N’ (‘F’ key) with their left index finger to indicate a *yes* and *no* response, respectively; for the PM task the target key was changed to ‘T’. As mentioned above, a practice phase was added and this took place immediately after the instructions for the ongoing pictures task and before instructing participants about the PM task. Each picture-word pair was presented at the center of a computer screen for 1000 ms followed by a 500-ms blank screen; there was no auditory feedback regarding the detection of the picture repetitions.

Fourth, because of the interest in examining task interference (i.e., cost to ongoing task processing from holding a PM task), a no-PM control condition was added. This condition was identical to the PM conditions in all respects except for the lack of PM instructions.

Fifth, and finally, because of the interest in examining whether the effect of presenting lure words as distractor information was related to inhibitory control, measures of inhibition and executive control were administered. In line with previous PM studies (e.g., Scullin et al., 2012; Scullin, Bugg, McDaniel, & Einstein, 2011), the Stroop task and the Trail-Making test were used. These tasks were performed after participants had answered the post-experiment questionnaire that followed the pictures task. The Trail-Making test was the final task participants performed before being debriefed as the testing session no longer included the

Simon task and the MHVT (Raven et al., 1988). The Stroop task (Golden, 1978; Stroop, 1935) consisted of three phases: (a) reading the names of color words printed in black ink; (b) naming the ink color of strings of X's printed in red, blue or green ink; and (c) naming the ink color of words independently of the (incongruent) written color word (e.g., "green" rather than "red" when the word "red" was printed in green ink). Participants were given 45 seconds to correctly respond to as many items as possible in each of the three phases. Number of items correctly responded to during the final phase (i.e., when reading of the incongruent word had to be suppressed) was used as the index of inhibition. Participants then completed both components of the Trail-Making test (Reitan, 1992). In Trail-Making A, participants drew lines to connect circles (numbered 1 to 25) in ascending order and as quickly as possible. In Trail-Making B, both numbers and letters appeared on the page, and participants had to draw lines connecting circled numbers and letters alternately (i.e., 1-A-2-B-3-C, etc.). The index of inhibition was the time to complete Trail-Making B, as performance in this component of the test is thought to reflect goal maintenance, task switching, and the ability to inhibit currently irrelevant goals (Langenecker, Zubieta, Young, Akil, & Nielson, 2007).[9] In all other respects pertaining to the experimental session, the procedure was identical to that used in Experiment 2.

Results and discussion

All participants were able to accurately recall the ongoing and PM instructions during the post-experiment questionnaire.

PM performance. PM performance was scored as the proportion of target pictures for which the participant pressed the 'T' key during the presentation of the target or within the next

[9] Note that, while other indexes of inhibition could have been used, Experiment 3 uses exactly the same composite measure of inhibition–executive functioning as described in Scullin et al. (2011). This measure combines the average *Z* scores for the third phase of the Stroop task and the B component of the Trail Making test (see the Results and discussion section for details on the calculation of the composite measure, termed Z-inhibition).

two trials and this captured all PM responses. An independent samples *t* test showed that there was no difference in the percentage of targets detected between the PM lures (*M* = .63, *SD* = .41) and PM no-lures (*M* = .67, *SD* = .35) conditions, $t < 1$.[10] Therefore, Experiment 2's finding that presenting intention-related distractor words does not benefit PM performance for young adults was replicated.

In addition, the relationship between PM performance and participants' inhibition scores was examined. Following Scullin et al. (2011), a composite measure of inhibition–executive functioning (Z-inhibition) was used. First, Z scores for the third phase of the Stroop task and the Trail Making B test (multiplied by -1 so that lower values equaled worse performance, similar to Stroop) were calculated for each participant; these scores were moderately correlated, $r(89) = 0.43$, $p < .001$. Then, a Z-inhibition measure was calculated for each participant by averaging the two Z-scores. There was a positive correlation between Z-inhibition and PM performance for both the PM lures, $r(28) = .41$, $p = .032$, and the PM no-lures, $r(31) = .43$, $p = .017$, conditions. That is, participants with higher inhibitory–executive functioning performed better on the PM task, which is in line with the proposal that performing a nonfocal PM task requires attentional resources.

Ongoing task performance. Accuracy on the 1-back pictures task was examined by including the proportion of picture repetitions correctly detected in a 3 x 2 ANOVA with condition (no-PM control, PM lures, PM no-lures) as the between-subjects factor, and trial type (repetition, non-repetition) as the within-subjects factor (see Table 5). There was a main effect of trial type, $F(1, 86) = 86.60$, $MSE = 0.01$, $p < .001$, $\eta_p^2 = .50$, such that accuracy was lower for repetition (.84) than for non-repetition (.96) trials. There was no effect of condition, $F(2, 86) =$

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[10] A similar comparison for the first target presentation only also revealed no effect of condition (*M* = .50 and .65, for the lures and no-lures conditions, respectively, $t(57) = -1.12$).

2.24, *MSE* = 0.01, $p = .113$, although the trend was for somewhat higher accuracy in the no-PM control condition (.92) than in the PM conditions (.88 and .90 with lures and no lures, respectively). The interaction was not significant, $F < 1$.

For RTs, filler trials were trimmed to include only correct responses that were less than 2.5 *SD*s away from each participant's mean. Trimming was done separately for repetition and non-repetition trials. The trial immediately following each target was excluded to avoid potential bias from slowing associated with target-related processes. Trimming resulted in the elimination of 1.1% of correct RTs. Data were analyzed with a 3 x 2 (Condition x Trial type) ANOVA (see Table 5). There was a main effect of trial type, $F(1, 86) = 23.59$, *MSE* = 1,515.33, $p < .001$, $\eta_p^2 = .22$, such that RTs were longer for repetitions ($M = 588$ ms) than for non-repetitions ($M = 560$ ms). There was also a main effect of condition, $F(1, 86) = 3.16$, *MSE* = 7,328.51, $p = .047$, $\eta_p^2 = .07$, such that RTs were shorter in the no-PM control condition (551 ms) than in the PM conditions (586 and 585 ms, for lures and no-lures, respectively). This result is in line with previous research showing that slowing is observed with nonfocal (categorical) PM tasks (e.g., Marsh et al., 2003). The condition by trial interaction was not significant, $F < 1$.

Table 5: *Means and Standard Deviations for Accuracy (Proportion Correct) and Response Times (RTs) for Non-Target Trials of the Pictures Task as a Function of Condition*

	Condition					
	No-PM control		PM lures		PM no-lures	
	M	*SD*	*M*	*SD*	*M*	*SD*
Accuracy						
Repetition	0.87	0.09	0.81	0.14	0.83	0.10
Non-repetition	0.96	0.03	0.94	0.10	0.96	0.04
RTs						
Repetition	567	58	602	80	596	51
Non-repetition	536	77	570	71	573	59
Lures/Controls	523	90	558	99	551	77

Responses for trials with intention-related distractor words (i.e., trials where animal words were presented as the to-be-ignored letter strings) were examined next. Lure interference was defined as the average latency to make a picture repetition/non-repetition decision on the nine lure trials in the PM lures condition (or control trials in the PM no-lures condition) minus the average latency to make the same decision in non-repetition filler trials. There were no differences in lure interference across conditions, $F < 1$ (*M*s = -13, -13, -22 ms and *SD*s = 45, 62, 51, in the no-PM control, PM lures, and PM no-lures conditions, respectively). In addition, planned comparisons were also conducted to determine if the lure interference levels in each condition were significantly different from zero. The results demonstrated that lure interference was significantly different from zero in the PM no-lures condition, $t(30) = -2.45$, $p = .020$. Importantly, lure interference was not significantly different from zero in the no-PM control, $t(29) = -1.54$, $p = .134$, and PM lures, $t(27) = -1.08$, $p = .289$, conditions. Moreover, when the sample of participants in the lures condition was composed solely of individuals who reported seeing at least one animal word (*M* = -6 ms, *SD* = 64)[11], results again revealed no differences in lure interference across conditions, $F < 1$. Lure interference was again not significantly different from zero in the PM lures condition, $t < 1$. These data show that RTs were similar for trials comprising filler words and lure items and strongly suggest that the two types of items were not differently processed. Furthermore, an independent samples *t* test showed that there was no difference in the percentage of targets detected between participants in the PM lures condition who reported seeing at least one animal word (*M* = .58, *SD* = .41) and those who did not (*M* = .69, *SD* = .42), $t < 1$. The data presented next further strengthen the proposal that presenting lure words did not affect young adults' performance.

RTs for the trials before and after lures/lure controls were compared. Given that there was no evidence of lure interference, finding no differences across conditions for the trials that followed the lure words would strengthen the conclusion that these items were not generally noticed. Accordingly, the four trials preceding the first (out of three) lure/control trials presented before each PM target (pre-lures/controls) were averaged and compared to the four trials immediately succeeding each of the nine lures/controls (post-lures/controls), while excluding only incorrect responses; see Figure 5 for an overview of the trial sequence. A 3 x 2 (Condition x Trial type) ANOVA revealed a main effect of trial type, $F(1, 86) = 7.55$, $MSE = 913.27$, $p = .007$, $\eta_p^2 = .08$, such that there was a practice effect from pre-lures (*M* = 561 ms, *SD* = 75) to post-lures (*M* = 548 ms, *SD* = 71) trials. More important, as expected, there were no significant effects involving condition (both *p*s > .271). Similar results were obtained when this analysis

[11] When asked whether they remembering seeing any animal words during the pictures task in the post-experiment questionnaire, 15 young adults replied yes. These participants were asked to identify the animals they recalled seeing from a list of 18 words (comprising the 9 animal lures and 9 other animal foils not presented during the ongoing task); recognition of the lure words was very low at only 1.53 on average (*SD* = .92).

was repeated while restricting the sample of participants in the lures condition to only individuals who reported seeing at least one animal word.

Finally, an important aspect of the present procedure was the fact that to-be-ignored letter strings could be either words or strings of random letters. A 3 x 2 ANOVA with condition (no-PM control, PM lures, PM no-lures) as the between-subjects factor, and trial type (words, random letters) as the within-subjects factor revealed that there were no significant effects involving trial type (ps > .783). In fact, RTs were identical for trials where the distractor strings of letters were words (M = 564 ms, SD = 67) as opposed to when they were random letters (M = 564 ms, SD = 66). The importance of this finding is that it shows that lexicality of the distractor strings did not affect the ongoing task processing (cf. Rees et al., 1999), and it strongly suggests that the present methodology was effective in discouraging the processing of the information presented in the distractor stream for young adults.

General discussion

The primary goal of the present chapter was to examine if the presentation of intention-related material as distractor information differentially impacts PM performance in young and older adults. The present findings provide the first evidence that presenting intention-related distractor information during an ongoing task is particularly advantageous in enhancing target detection in older, but not in young adults. Moreover, data suggest that the PM benefit shown for older adults was not the sole result of these participants noticing the lure words, as an improvement was observed even for those who had no explicit memory for the intention-related words.

The present research establishes that a benefit of intention-related material on PM performance can be observed even when this material is presented as information that is irrelevant to the task currently being performed. Importantly, results further suggest that the benefit from intention-related distractor words on PM performance is limited to older adults. That is, results showed that PM performance was significantly higher when distractor lure words were presented (relative to a condition with no lures) in older but not in young adults.[12] Moreover, analysis of ongoing task accuracy in Experiment 2 revealed that the benefit was found in the absence of performance differences between the lures and no-lures conditions for each age group. Furthermore, Experiment 3 replicated the lack of a PM benefit from distractor lure words in young adults. Also, on the basis of RT data and participants' reports, it can be argued that incidental processing of the intention-related words and, more generally, of the lexical properties of the ongoing stimuli, was minimal (i.e., observed for a small proportion of trials and/or for a limited number of participants only). That is, data revealed no evidence of differential processing of words relative to random letters, lures relative to other word items, or of post-lure slowing in the PM lures condition.

Notably, findings from the present research showing that intention-related distractor information can facilitate older adults' PM performance converge with results demonstrating an age-related benefit of poorer distraction control. In particular, previous research suggests that older adults' reduced inhibitory control (Hasher et al., 2007; Hasher & Zacks, 1988; Hasher et al., 1999; Lustig et al., 2006) can benefit their performance when distractor information becomes relevant in a subsequent implicit memory task (e.g., Healey et al., 2008; Kim et al., 2007; Rowe et al., 2006). For example, Rowe et al. (2006) showed that exposure to target pictures with to-be-ignored superimposed words improved the performance of older, but not young adults, in a

[12] In Experiment 2, the pattern of results was similar for mean PM performance and performance to the first target only (i.e., performance that is independent of success to previous target occurrences). And although the lure by age interaction did not reach significance for mean PM performance, planned comparisons confirmed that a benefit was present for older but not young adults.

subsequent word fragment completion task when the solutions had appeared as the distractor words. Thus, the findings from the present chapter align well with research on distraction control showing that older adults' performance is more likely to be influenced by distractor information than that of young adults. Importantly, this chapter extends those findings to the area of PM, which has been associated with age-related declines in performance.

When distractor lure words were presented, older adults' PM performance not only improved but also reached a similar level to that observed for young adults. In the present research, what intention-related processes might have been facilitated by the inclusion of intention-related distractor words? Prior findings of an age-related benefit of distractor information have been mostly linked with an effect of implicit knowledge on performance (e.g., Kim et al., 2007; see also Thomas & Hasher, 2012). For instance, Campbell et al. (2010) showed that, after participants performed a 1-back task to target pictures with distractor words superimposed, using preserved picture-word pairs in a paired-associates memory task improved older but not young adults' performance. Notably, the authors showed that this differential transfer of distraction in older compared to young adults was observed even though participants showed no explicit memory for the picture-word pairs. Accordingly, of further interest in Experiment 2 was the pattern of PM performance in the lures condition for those participants who reported no memory for the distractor lure words. Importantly, higher target detection was found for these participants than for those presented with control words, and the benefit on PM performance was again limited to older adults.

Consistent with the assumption that older adults have reduced attentional resources (Craik, 1986; Salthouse, 1991), an important finding that has arisen in the memory and aging literature is that older adults are less penalized when performance can rely on preserved cue-driven retrieval processes (Jennings & Jacoby, 1997; McDaniel & Einstein, 2011; Schmitter-Edgecombe, 1999). Likewise, in the PM literature it has been suggested that minimal age-related impairments in PM should be found when successful performance can rely on stimulus-triggered or spontaneous retrieval processes (e.g., McDaniel & Einstein, 2000; McDaniel, Guynn, et al., 2004; Scullin, McDaniel, & Einstein, 2010). It is suggested here (on the basis of Experiment 2) that presentation of lure words as distractor information might have enhanced the processing quality or salience of the targets (relative to other ongoing task items), and enhanced older adults' PM performance through a mechanism akin to the discrepancy plus search process (Breneiser & McDaniel, 2006; McDaniel, Guynn, et al., 2004). It is worth pointing out a somewhat related finding by Altgassen et al. (2010; see also Hashimoto, Umeda, & Kojima, 2011), who found that emotionally salient targets can eliminate age-related differences in PM performance. According to the authors, the effect was obtained because salience facilitated capture of attention and decreased the need for resource demanding processes.

Importantly, research has shown that low cognitive control is associated with more lapses of attention (e.g., Unsworth, 2007; Unsworth & Spillers, 2010). In line with this research, it is argued that presenting intention-related material mitigated against older adults' increased susceptibility to momentary lapses of attention (R. West & Craik, 1999). Specifically, enhanced PM performance for older adults in the lures condition suggests that their reduced ability to inhibit irrelevant information led to the processing of the intention-related information.[13] This probably caused the representation of the intention to be strengthened in memory, and facilitated noticing of the targets by boosting cue accessibility. Such a boost might be particularly crucial for older adults, given that previous research suggests that the efficiency of the noticing

[13] Although reliant only on indirect evidence about the participants' awareness of intention-related distractor words, results suggest that processing was mostly implicit. Specifically, for the majority of older adults, the distractor lure words were processed and led to a PM benefit, even though they failed to be consciously perceived.

component of prospective remembering is negatively influenced by age (Cohen, West, & Craik, 2001). Additionally, or alternatively, presentation of intention-related information might have triggered periodic thoughts about the PM task and stimulated monitoring for the target events during critical points of the PM task (i.e., in close proximity to the target events; Scullin, McDaniel, & Einstein, 2010; Chapter 2 of this thesis). Admittedly, the exact nature of the age-related benefit from intention-related material cannot be determined on the basis of the current data alone. However, complementing the results of Experiment 3 by additionally testing a sample of older adults would surely be a promising approach to disentangle the processes underlying the positive effect of distractor lures on older adults' PM performance. Regardless, the present findings suggest that when distractor information holds relevance to intentions it can serve a compensatory role in prospective remembering in older adults.

Chapter 4: The Effect of Task Experience and WM on PM

In Chapter 2 it was demonstrated how the positive effect of (relevant) intention-related material in nonfocal PM performance is modulated by individual differences in WM capacity. Additionally, Chapter 3 showed that older adults' reduced attentional resources can lead to an age-related benefit in PM performance when intention-related events are presented as distractor information. This chapter shifts the focus to another manipulation that can also lead to an improvement in nonfocal PM performance, but that is assumed to exert its influence during the encoding phase of the intention. The approach was again to examine whether the extent to which a PM benefit is found depends on differences in controlled-attention capacities, and to focus on ongoing task processing to inform the processes that underlie the changes in prospective remembering.

As Klein, Robertson, and Delton (2010, p. 14) stated, "an evolved capacity to imagine and plan for personal future contingencies, especially plans not tied to current drives and needs, confers an enormous selective advantage on its possessor". Research on PM suggests that planning and monitoring might be particularly relevant for successful prospective remembering (e.g., Dobbs & Reeves, 1996; Marsh & Hicks, 1998). For instance, intention formation-related processes such as planning are an important strategy when dealing with complex intentions (Kliegel, Martin, McDaniel, & Einstein, 2002; Kliegel, Martin, McDaniel, Einstein, & Moor, 2007). In addition, recent evidence has pointed out the importance of more implicit manipulations that can also affect encoding of the intention representation in memory (Brewer & Marsh, 2010; Papies et al., 2009). Specifically, Brewer and Marsh (2010, Experiment 2) demonstrated that manipulating the degree of experience with an ongoing task (before encoding the intention) affected performance in a categorical PM task. Their study showed that detection of the nonfocal targets was enhanced when participants were given the opportunity to practice the ongoing task before encoding the PM task relative to a condition where there was no ongoing task practice before PM encoding. The authors argued that people use episodic memory about the ongoing task to encode the intention and simulate the future context in which the PM targets will be encountered. That is, according to Brewer and Marsh (2010), participants in the practice condition were able to use episodic information about the ongoing task to simulate a more elaborate representation of the prospective context and boost PM performance. In the present chapter, these findings are extended by examining the relationship between individuals' WM capacity and the extent to which PM performance can benefit from FCS (i.e., exposure to the prospective context before intention encoding).

WM and the role of FCS in PM tasks

As considered in Chapter 2, WM capacity reflects the ability to flexibly control attentional resources (Engle & Kane, 2004; Kane et al., 2001). It is assumed that individual differences in WM capacity will affect intention retrieval whenever control processes (e.g., preparatory attentional processes) are necessary for successful cue detection (e.g., Einstein et al., 2005; Smith, 2003). Consistent with this proposal, Brewer et al. (2010) showed that participants with high WM capacity perform better on nonfocal PM tasks than those with low WM. It is assumed that detection of nonfocal targets (e.g., a syllable "tor" when the ongoing task involves semantic processing of words rather than of individual syllables) requires the engagement of additional attentional resources and more target-focused processing to carry out extra monitoring (Einstein & McDaniel, 2005). Increased WM capacity may facilitate the efficient and continuous allocation of attentional resources that serves to maintain an attentive state and support the detection of nonfocal targets (e.g., Smith & Bayen, 2005). In line with this idea, it has been found that individuals with high WM abilities are less susceptible to task-unrelated thoughts and both more capable of keeping representations active in the focus of attention as well as retrieving representations that have temporarily been displaced by distraction (Brewer et al., 2010; Unsworth, 2007; R. West et al., 2005).

Given that high success levels with nonfocal PM tasks require continuous recruitment of attentional resources, an intriguing question is whether familiarizing individuals with the ongoing activity (i.e., FCS) will help them to maximize the efficiency of attentional allocation throughout the task. For instance, FCS might increase participants' awareness that the ongoing task will not direct attention towards the information relevant for detecting the PM targets, potentially highlighting the need to plan intention retrieval in order to increase the probability of success. Crucially, the benefit of FCS on PM performance may differ as a function of individual differences in WM capacity if resources are required to encode a more detailed representation of the intention and/or simulate intention retrieval (cf. Craik, 1986; Moscovitch, 1992; Moscovitch & Winocur, 1992).

Alternatively, FCS might benefit PM performance in low WM young adults. Research has shown that low WM individuals are more likely to experience mind-wandering during challenging tasks than high WM individuals (Kane et al., 2007). Interestingly, although stimulus-independent thought has been typically associated with performance decrements (e.g., McVay & Kane, 2010), research has recently highlighted that mind-wandering is sometimes associated with goal-related content. For instance, Mason et al. (2007; see also Christoff, Gordon, Smallwood, Smith, & Schooler, 2009) reported evidence from fMRI showing increased activation in neural regions associated with both future simulation and mind-wandering when individuals performed a well-practiced, goal-directed task as opposed to a novel task.

In addition to examining differences as a function of WM capacity, the present research also investigated whether a positive effect of FCS on PM performance can be found for older adults. Aging has been associated with a decrease in the efficiency of executive control over time as reflected, for example, by an increase in lapses of intention and a diminished ability to sustain attention toward cue-focused processes (R. West, 2004; R. West et al., 2002). In line with the age-related decline in attentional resources (Craik, 1986; Craik & Jennings, 1992; Salthouse, 1991), studies typically report poorer PM performance for older relative to young adults when nonfocal targets are used (e.g., Einstein & McDaniel, 2005; Henry et al., 2004; Maylor, 1996; R. West & Craik, 2001). FCS could improve older adults' PM performance by serving the important and adaptive function of allowing access to information that can be used in the service of intention planning. Hence, if participants can spontaneously use ongoing task experience to optimize PM performance (i.e., capacity is not required to use practice with the ongoing task to plan intention execution), FCS should compensate for the age-related decline in nonfocal PM task performance; it should similarly compensate for the PM deficit for low relative to high WM individuals. However, to the extent that FCS relies on WM and executive resources, a benefit of FCS should be observed for high WM young adults only.

Experiment 4

The present study investigated two related issues. First, the relationship between individuals' WM capacity and the extent to which PM performance can benefit from FCS was examined. Second, it was investigated whether the positive effect of FCS on PM performance is affected by aging. It was hypothesized that to the extent that FCS relies on WM and executive resources, a benefit of FCS should not be observed for either older adults or low WM young adults. By contrast, the opposite would be expected if participants spontaneously use familiarity with ongoing events to plan intention retrieval and/or increase the effectiveness of monitoring for target events.

Method

***Design and participants*.** The main design was a 2 x 2 x 2 mixed factorial, with age group (young, older) and condition (FCS, no-FCS) as the between-subjects factors, and LDT phase (first, second) as the within-subjects factor. A median split was employed to create groups of young participants with low and high WM capacity on the basis of their performance on the Aospan task (Unsworth et al., 2005). Young adults aged 18-27 years (M = 21.0, SD = 1.8) were mainly undergraduate students from Warwick University and were an opportunity sample. Older adults aged 64-89 years (M = 72.8, SD = 6.0) were self-reported healthy volunteers who lived independently within the community and were recruited using flyers and posters at several locations in Warwickshire (The University of Warwick Arts Centre, The University of the Third Age in Coventry, the Age UK Coventry Craft and Computer Centre), and personal contacts. Eighty-six young adults (37 female) and 50 older adults (30 female) were randomly assigned to the two conditions. Four young adults (3 FCS and 1 no-FCS) and three older adults (3 no-FCS) were excluded as detailed in the Results section. This resulted in a total of 39 young and 25 older adults in the FCS condition and 43 young and 22 older adults in the no-FCS condition. During the session, participants completed the DSST (Wechsler, 1981) as a measure of processing speed, and the multiple-choice part of the MHVT (Raven et al., 1988) as a measure of crystallized intelligence. Young adults scored higher than older adults on the DSST (Ms = 66.0 and 45.2; SDs = 10.9 and 11.7, respectively), $t(127) = 10.12$, $p < .001$, but lower on the MHVT (Ms = 19.5 and 22.1; SDs = 3.0 and 4.4, respectively), $t(127) = -4.98$, $p < .001$. Before the end of the experimental session, young adults also completed the Aospan task (Unsworth et al., 2005), used as a measure of WM capacity. Testing took place individually in sessions ranging from 20 min (older adults) to 45-60 min (young adults).

***Materials and procedure*.** Participants were first given the LDT instructions where they were instructed that a string of letters would appear on the screen and that they would need to decide as quickly and as accurately as possible if the string was a word or not. They were told to press the key labeled ‘Y’ (‘J’ key) with their right index finger if the string was a word and the key labeled ‘N’ (‘F’ key) with their left index finger if it was not a word. The main distinction between conditions was whether participants were given the PM instructions after practicing the ongoing task (FCS) or immediately after the LDT instructions (no-FCS). Specifically, in the FCS condition, the LDT instructions were followed by the first LDT phase (i.e., 40 practice trials). This was then followed by the PM instructions stating that they should press the ‘T’ key after making their lexical decision (or as soon thereafter as they could) whenever they encountered a word starting with the letter ‘g’. By contrast, in the no-FCS condition, the LDT instructions were followed immediately by the PM instructions. All participants were asked to summarize the instructions and the experimenter corrected any misunderstandings or omissions. In each condition, PM instructions were followed by a delay of approximately five minutes created by asking participants to complete the DSST (Wechsler, 1981) and fill in a demographic questionnaire.

The delay was followed by the LDT task comprising 172 trials (second LDT phase) for the FCS condition and 212 trials (first and second LDT phases presented seamlessly) for the no-FCS condition. There were four target words (*galleries*, *generous*, *glancing*, and *grooming*) presented every 40 trials during the second LDT phase; the order of appearance of these four PM targets was randomized between participants. LDT stimuli were obtained from the English

Lexicon Database (Balota et al., 2007) and consisted of 106 words and 106 nonwords. Words were on average 8.3 letters in length and 2.5 syllables, with a mean log-transformed HAL frequency of 7.3. The ‘g’ words were matched with filler words on mean length, syllables and frequency. Nonwords were selected from the same source and were also 8.3 letters in length.

After the LDT, participants were given a post-experiment questionnaire to check their memory for the PM task. They were also asked to indicate whether or not they reminded themselves of the PM task before the start of the ongoing task and how often they thought about the intention throughout the ongoing task on a scale of 1 (never) to 5 (very frequently). Participants then completed the MHVT (Raven et al., 1988) before being debriefed. For young adults (but not older adults) the MHVT was additionally followed by the Aospan task (Unsworth et al., 2005).

Results

Four young and three older participants were excluded from analysis due to low accuracy on the ongoing LDT (more than 2.5 *SD*s from their age group’s mean).

PM performance. A PM response was considered correct if ‘T’ was pressed on the target trial or within the next two trials (less than 1% of the responses occurred outside these periods). Proportion correct was examined using a 2 x 2 ANOVA with age group (young, older) and condition (FCS, no-FCS) as between-subjects factors (see Figure 6). There was a significant main effect of condition, $F(1, 125) = 4.22$, $MSE = 0.12$, $p = .042$, $\eta_p^2 = .03$, such that target detection was better in the FCS condition ($M = .69$, $SD = .35$) than in the no-FCS condition ($M = .55$, $SD = .36$). Although the interaction failed to reach significance, $F < 1$, independent samples *t* tests revealed higher target detection in the FCS relative to the no-FCS condition for young adults, $t(80) = 2.70$, $p = .008$, but not for older adults, $t(45) < 1$. The main effect of age was also not significant, $F(1, 125) = 2.73$, $p = .101$. However, within the context of examining age-related declines in PM, it has been found that older adults with higher verbal abilities (Cherry & LeCompte, 1999) and higher fluid intelligence (Cockburn & Smith, 1991) tend not to be as impaired as those with lower abilities. Hence, an analysis of covariance was conducted using age group (young, older) as the between-subjects factor and MHVT score (an index of crystallized intelligence) as the covariate. The effect of the covariate was significant, $F(1, 126) = 3.97$, $MSE = 0.13$, $p = .048$, $\eta_p^2 = 0.03$, and when MHVT scores were controlled for there was a main effect of age, $F(1, 126) = 4.88$, $MSE = 0.13$, $p = .029$, $\eta_p^2 = 0.04$. These data are consistent with previous findings (e.g., Kliegel et al., 2008) indicating poorer detection of nonfocal targets for older relative to young adults.

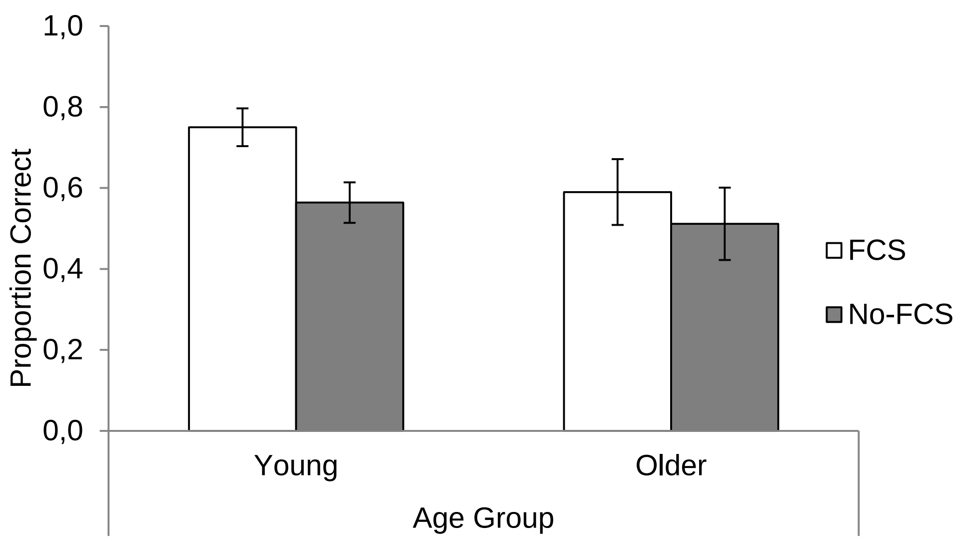

Figure 6: Mean proportion correct for the prospective memory task as a function of age group (young, older) and condition (future context simulation (FCS), no-FCS). Error bars represent ± 1 standard error.

Next it was examined whether the effect of FCS on PM performance for young adults was affected by WM performance (one participant withdrew from the WM task and his data were therefore excluded from this analysis). A split of young participants into low and high WM capacity was conducted using the median of absolute (*Mdn* = 47) and total scores (*Mdn* = 62). Total score was used for all the analyses involving WM.[14] There were 40 low WM participants (18 in the FCS condition and 22 in the no-FCS condition) and 41 high WM participants (21 in the FCS condition and 20 in the no-FCS condition). Proportion correct on the PM task was included in a 2 x 2 ANOVA with condition (FCS, no-FCS) and WM (low, high) as the between-subjects factors. Results showed a significant effect of condition, $F(1, 77) = 7.30$, $MSE = 0.10$, $p = .008$, $\eta_p^2 = .09$, that was qualified by a marginally significant WM by condition interaction, $F(1, 77) = 3.87$, $MSE = 0.10$, $p = .053$, $\eta_p^2 = .05$. As illustrated in Figure 7, FCS benefited PM performance relative to the no-FCS condition for high WM, $t(39) = 3.22$, $p = .003$, but not for low WM young adults, $t(38) < 1$.

[14] Absolute and total scores in the Aospan task were highly correlated, $r(81) = .90$, $p < .001$, and results were qualitatively similar when absolute scores, instead of total scores, were used.

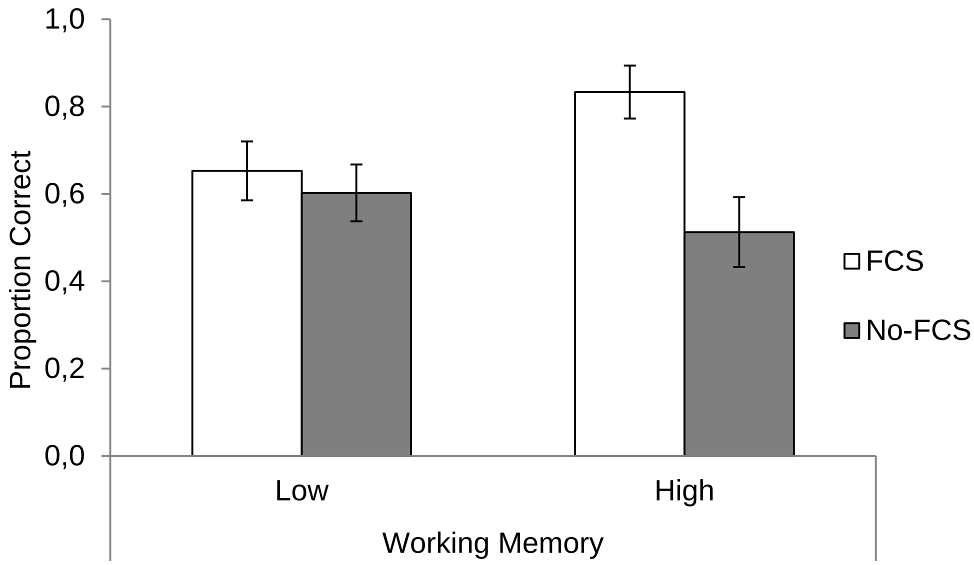

Figure 7: Mean proportion correct for the prospective memory task (young adults only) as a function of working memory (low, high) and condition (future context simulation (FCS), no-FCS). Error bars represent ± 1 standard error.

Finally, participants' responses on the post-experiment questionnaire were examined using a 2 x 2 ANOVA with age group (young, older) and condition (FCS, no-FCS) as between-subjects factors. Results showed that participants in the FCS condition were more likely to report that they reminded themselves of the PM task before the start of the ongoing task than those in the no-FCS condition (*M*s = .89 and .76; *SD*s = .31 and .43, respectively), $F(1, 125) = 3.99$, $MSE = 0.14$, $p = .048$, $\eta_p^2 = .03$. The interaction was not significant ($F < 1$), but there was a trend for more young than older adults reminding themselves about the PM task (*M*s = .87 and .75; *SD*s = .34 and .44, respectively), $F(1, 125) = 3.47$, $MSE = 0.14$, $p = .065$, $\eta_p^2 = .03$. In addition, young adults reported more thoughts about the intention throughout the ongoing task than did older adults (*M*s = 3.59 and 3.19; *SD*s = 0.95 and 1.35, respectively), $F(1, 125) = 4.03$, $MSE = 1.24$, *p*

= .047, η_p^2 = .03. Neither the main effect of condition nor the interaction was significant (both *F*s < 1).

Ongoing task performance. It was first examined if having a PM task affected the accuracy of performing the ongoing LDT. It is worth mentioning that whereas only the second LDT phase was conducted with a PM load for FCS participants, both the first and second LDT phases were conducted with a PM load for no-FCS participants. Proportion correct on word trials was analyzed in a 2 x 2 x 2 ANOVA with age group (young, older) and condition (FCS, no-FCS) as the between-subjects factors, and LDT phase (first, second) as the within-subjects factor (see Table 6). There was a significant effect of LDT phase, $F(1, 125) = 27.37$, $MSE = 0.001$, $p < .001$, $\eta_p^2 = .18$, such that accuracy was higher in the first than in the second phase (.97 vs. .94, respectively), and there was a significant main effect of age group, $F(1, 125) = 25.88$, $MSE = 0.002$, $p < .001$, $\eta_p^2 = .17$, such that accuracy was higher for older than for young adults (.97 vs. .94, respectively). There was also a marginally significant LDT phase by age group interaction, $F(1, 125) = 3.55$, $MSE = 0.001$, $p = .062$, $\eta_p^2 = .03$, and a significant three-way interaction, $F(1, 125) = 4.90$, $MSE = 0.001$, $p = .029$, $\eta_p^2 = .04$. Note from Table 6 that whereas young and older adults in the FCS condition showed a similar decrease in accuracy from the first to the second phase, young adults in the no-FCS condition showed a greater decrease from the first to the second phase than did older adults. There were no other significant effects (*p*s > .210).

Table 6: *Means and Standard Deviations for Accuracy (Proportion Correct) on Word Filler Trials in Each Phase of the Lexical Decision Task as a Function of Age Group (Young, Older) and Condition (Future Context Simulation (FCS), No-FCS)*

	Age Group			
	Young		Older	
Condition	*M*	*SD*	*M*	*SD*
FCS				
Phase 1	0.95	0.05	0.98	0.03
Phase 2	0.93	0.04	0.96	0.04
No-FCS				
Phase 1	0.97	0.04	0.97	0.03
Phase 2	0.93	0.04	0.97	0.03

Next RTs on word trials in the LDT were examined. Based on previous PM research (e.g., J. B. Knight et al., 2011), RTs were trimmed to include only correct responses that were less than 2.5 *SD*s away from each participant's mean. Trimming was done separately for the first and second LDT phases (PM targets, as well as the trial immediately following each of the PM targets, were excluded) and resulted in the elimination of 3.1% of correct RTs. The overall means can be found in Table 7. Data were examined using a mixed 2 x 2 x 2 ANOVA with age group (young, older) and condition (FCS, no-FCS) as the between-subjects factors, and LDT phase (first, second) as the within-subjects factor. There was a main effect of condition, $F(1, 125) = 4.73$, $MSE = 104{,}233.63$, $p = .032$, $\eta_p^2 = .04$, such that RTs were longer in the no-FCS condition than in the FCS condition (*M*s = 1044 ms and 953 ms, respectively), as well as a main effect of age, $F(1, 125) = 69.33$, $MSE = 104{,}233.63$, $p < .001$, $\eta_p^2 = .36$, with longer RTs for older than for young adults (*M*s = 1173 and 825 ms, respectively). In addition, there was a main effect of LDT phase, $F(1, 125) = 37.65$, $MSE = 15{,}283.67$, $p < .001$, $\eta_p^2 = .23$, that was qualified by an interaction between LDT phase and age group, $F(1, 125) = 12.32$, $MSE = 15{,}283.67$, $p = .001$, $\eta_p^2 = .09$. This interaction was obtained because speeding up from the first to the second phase was more pronounced for older than for young adults (154 vs. 42 ms). Finally, there was an interaction between LDT phase and condition, $F(1, 125) = 13.78$, $MSE = 15{,}283.67$, $p < .001$, $\eta_p^2 = .10$, indicating a greater RT decrease from the first to the second LDT phase for the no-FCS than for the FCS condition (158 vs. 39 ms). Thus, there was evidence that the PM task caused significant ongoing task interference, which was similar in magnitude across young and older adults as indicated by the absence of a three-way interaction, $F < 1$. It can be noted that there was no evidence of any speed-accuracy tradeoff. That is, the absence of a three-way interaction for the RT data indicates that the lack of a reduction in accuracy from the first to the second phase for older adults in the no-FCS group was not accompanied by less pronounced speeding up from the first to the second phase for this group of participants.

Table 7: *Means and Standard Deviations for Response Times in Milliseconds on Word Filler Trials in Each Phase of the Lexical Decision Task as a Function of Age Group (Young, Older) and Condition (Future Context Simulation (FCS), No-FCS)*

	Age Group			
	Young		Older	
Condition	*M*	*SD*	*M*	*SD*
FCS				
Phase 1	740	141	1205	332
Phase 2	748	140	1120	358
No-FCS				
Phase 1	951	201	1295	415
Phase 2	860	162	1071	249

Finally, RTs on word trials in the LDT for young adults were examined as a function of WM performance. A mixed 2 (WM: high, low) x 2 (condition: FCS, no-FCS) x 2 (LDT phase: first, second) ANOVA was conducted (see Table 8). There was a main effect of condition, $F(1, 77) = 22.93$, $MSE = 44{,}432.93$, $p < .001$, $\eta_p^2 = .23$, such that RTs were longer in the no-FCS condition (904 ms) than in the FCS condition (745 ms). There was also a main effect of LDT phase, $F(1, 77) = 7.20$, $MSE = 10{,}030.97$, $p = .009$, $\eta_p^2 = .09$, that was qualified by an interaction with condition, $F(1, 77) = 9.18$, $MSE = 10{,}030.97$, $p = .003$, $\eta_p^2 = .11$. Whereas participants in the no-FCS condition sped up from the first to the second LDT phase, those in the FCS condition did not (90 ms vs. -6 ms). Crucially, there was no main effect of WM or any interactions involving WM (all other *p*s > .195).

Table 8: *Means and Standard Deviations for Response Times in Milliseconds on Word Filler Trials in Each Phase of the Lexical Decision Task as a Function of Working Memory (Low, High) and Condition (Future Context Simulation (FCS), No-FCS)*

	Working Memory			
	Low		High	
Condition	*M*	*SD*	*M*	*SD*
FCS				
Phase 1	772	162	712	116
Phase 2	753	145	743	140
No-FCS				
Phase 1	983	208	915	198
Phase 2	877	166	841	163

Discussion

Brewer and Marsh (2010) showed that FCS can benefit PM performance and proposed that access to information about the retrieval context provides participants with the opportunity to encode a more detailed representation of the intention. Importantly, the present results suggest that with an attentionally demanding PM task, such as when nonfocal targets are used, the benefit of FCS may rely on some optimal level of attentional resources. Specifically, a benefit of FCS for nonfocal PM performance was found for high WM young adults, but not for participants with reduced processing resources (i.e., low WM young adults and older adults). Furthermore, results showed that target detection in the FCS condition was worse for low relative to high WM individuals, even though the two groups of young participants allocated the same amount of attentional resources to the PM task (as revealed by similar levels of task interference).

The lack of a PM benefit from FCS in older adults[15] and low WM young adults suggests that central executive control processes, such as planning and monitoring, are required for a benefit to be observed with nonfocal tasks. In particular, in a task that requires efficient allocation of attentional resources, high cognitive functioning might be important in the generation and use of internal organizational strategies to optimize intention-related behavior. Critically, it has been proposed that older adults may be less able to engage in elaborate memorial processing due to an age-related decline in controlled processes associated with frontal dysfunction (Craik, 1986; Moscovitch, 1992; Moscovitch & Winocur, 1992). Moreover, research suggests that young adults with limited encoding resources may also be less able to add richness to their encoding (e.g., Gopie et al., 2011). Such deficits in strategy utilization may underlie the present lack of a benefit from FCS on PM performance in low WM young adults and older adults. Moreover, several PM studies support the idea that planning ability might benefit PM performance (Burgess, Veitch, de Lacy Costello, & Shallice, 2000; Fortin, Godbout, & Braun, 2002; Kliegel, Stock, Martin, Ramuschkat, & Zimprich, 2003; Shallice & Burgess, 1991). It is argued that individuals with reduced processing resources will be less likely to spontaneously use their experience with the upcoming ongoing task to encode a more detailed representation of the PM task and plan subsequent intention execution when there are no explicit instructions stressing the benefit of doing so.

In this experiment, task interference was revealed by the presence of an interaction for RTs between LDT phase and condition. (Recall that whereas in the no-FCS condition participants had to maintain both the PM and LDT demands during Phase 1, those in the FCS performed the LDT only during this phase.) More interesting, however, was the lack of any

[15] Because the interaction between age group and condition failed to reach significance, this result has to be treated with some caution and awaits replication.

effects for ongoing task cost involving WM capacity in young adults. That is, FCS improved PM performance for high relative to low WM individuals in the absence of any significant task interference differences between the two groups. This suggests that differences in attentional control, rather than overall amount of attention, were responsible for the performance benefit. Importantly, this finding is consistent with the proposal that individual differences in WM capacity reflect not the absolute amount of resources available to the individual but, instead, the ability to direct attention in a flexible manner (Conway & Kane, 2001).

In addition, detection of nonfocal PM targets was enhanced for high WM relative to low WM young adults in the FCS condition, but not in the no-FCS condition. This finding is somewhat surprising because a positive relationship between PM performance and WM capacity has been reported by previous studies (Brewer et al., 2010; Einstein et al., 2000; Reese & Cherry, 2002). However, it is interesting to note that in these studies participants were exposed to the prospective context before the start of the ongoing task (i.e., practice with the ongoing task was provided either before or immediately after PM encoding). Crucially, no such opportunity to practice the ongoing task was provided in the present no-FCS condition. Successful retrieval with a nonfocal task must rely on the ability to continuously monitor for the targets, and on the capacity to inhibit the ongoing activity at the appropriate time to execute the intended action. It is suggested here that individuals with high executive processing skills, such as high WM individuals, might be particularly effective at doing so if they are provided with episodic information at encoding that allows them to anticipate and plan for the future. This information may increase their awareness about the need to continuously monitor for the targets while minimizing disruptions from distractor events (e.g., task-unrelated thoughts) in order to successfully perform both the ongoing and the PM task.

When the PM task is cognitively demanding, such as when nonfocal targets are used, an age-related decline in PM performance is typically observed (e.g., Cherry et al., 2001; Dobbs & Rule, 1987; Henry et al., 2004; Kliegel et al., 2008; Mäntylä & Nilsson, 1997; Maylor, 1993, 1996; Park et al., 1997; Rendell, McDaniel, Forbes, & Einstein, 2007; R. West & Covell, 2001). Worse PM performance for older adults was not observed in Experiment 4. However, older participants in the present study were healthy, community-dwelling individuals with high verbal abilities and when MHVT score (an index of crystallized intelligence) was controlled for, an age-related deficit in PM performance emerged. This is in line with research showing that age-related differences in PM performance tend to be reduced or even eliminated for high functioning older adults (e.g., Cherry & LeCompte, 1999; Cockburn & Smith, 1991). Moreover, Experiment 4 used a PM target corresponding to a letter at the start of a word. Importantly, Scullin, McDaniel, Shelton, et al. (2010) have shown that instructing participants to respond to words starting with a particular letter is a less cognitively demanding nonfocal PM task than responding to words containing a particular syllable. Hence, future studies may benefit from using a nonfocal task that requires more attentional resources and places heavier demands on WM capacity to strengthen the effect of aging and/or FCS on PM performance.

Before closing, it is important to address some potential limitations of the present study. First, PM instructions were given in isolation for the FCS, but not the no-FCS condition. Some research suggests that memorability of events may be increased by the temporal separation of events at encoding (temporal distinctiveness hypothesis; Brown, Neath, & Chater, 2007) and that items become less distinguishable when encoded temporally closer together (Bjork & Whitten, 1974; Crowder, 1976). To examine whether the benefit of FCS could be accounted for by the methodological difference between conditions (also existent in Brewer & Marsh, 2010, Experiment 2), an additional group of 13 young participants was tested. These participants received the LDT instructions followed by a 60-seconds pictorial Spot-the-Difference distractor task and finally by the PM instructions in isolation. Thus, similarly to the no-FCS condition, participants in this additional control condition performed Phases 1 and 2 seamlessly and were given no practice with the ongoing task alone; however, in contrast with no-FCS participants, they encoded the PM instructions in isolation (similarly to FCS participants). An analysis examining PM performance for young adults in the three between-subjects conditions revealed a significant difference between conditions, $F(2, 92) = 5.34$, $MSE = 0.11$, $p = .006$, $\eta_p^2 = .10$. Posthoc analysis using a Bonferroni test revealed that target detection was higher in the FCS condition than in both the additional control condition ($M = .46$ and $SD = .39$; $p = .019$) and the no-FCS condition ($p = .032$). Moreover, control and no-FCS participants performed similarly ($p = .959$). Hence, despite limited reliability of this additional condition owing to the small sample size, results suggest that temporal distinctiveness cannot account for the benefit of FCS on PM performance observed in the present study.

Second, in the no-FCS condition, as participants did not practice the ongoing task separately (i.e., Phase 1 formed part of the ongoing task), the first PM target occurred 40 LDT trials (approximately 45 seconds) later (relative to the PM instructions) than in the FCS condition. Hence, it could be argued that reduced target detection in the no-FCS relative to the FCS condition was due to the longer retention interval between PM instructions and the first target occurrence. The observation that the effect of FCS was modulated by WM capacity counteracts this interpretation of the data. Furthermore, McBride, Beckner, and Abney (2011, Experiment 2) have shown that for nonfocal PM tasks, the majority of forgetting occurs in the first couple of minutes, which were filled with the distractor activities in the present study.

In sum, this chapter provides preliminary evidence that the benefit of FCS on PM performance is limited to high WM young adults. This suggests that controlled attention might be particularly important (e.g., to strategically plan intention execution and optimize deployment of resources to monitor for the nonfocal target) for PM performance to benefit from exposure to the retrieval context. Interesting avenues for future research may involve further examination of the effect of WM capacity in FCS by extending the low/high WM classification also to a sample of older adults. In addition, such research might benefit from using procedures that increase the level of control over the factors being manipulated. For instance, one possibility would be to limit the ongoing task to Phase 2 only in both the FCS and the no-FCS conditions and then either give participants the opportunity to practice the ongoing task before PM encoding or not. That is, whereas Phase 1 could comprise practice on the ongoing task in the FCS condition, in the no-FCS condition it could consist of a task with similar duration but no relation with the ongoing task (e.g., the Spot-the-Difference task used in the present study). Hence, the two conditions would be matched for encoding distinctiveness, and also in terms of retention interval between the PM instructions and the first target presentation. That is, whether participants practiced the ongoing task before intention encoding or not would be the only distinction between the FCS and no-FCS conditions.

Chapter 5: Context Specification Effects in PM

As reviewed in Chapter 1, two main theories have been proposed to explain how individuals maintain and retrieve intentions. The multiprocess view (McDaniel & Einstein, 2000; McDaniel, Guynn, et al., 2004) proposes a flexible system in which PM retrieval can rely either on resource-demanding monitoring processes or on spontaneous processes. By contrast, the PAM theory (Smith, 2003; Smith & Bayen, 2004; Smith et al., 2007) proposes that PM performance must always rely on resource-demanding preparatory attentional processes being engaged before the target event to monitor the environment for the occurrence of the targets. Importantly, both theories assume that attention-demanding monitoring processes need to be engaged for successful performance with nonfocal PM tasks. That is, because monitoring will draw on limited-capacity resources, the multiprocess and the PAM theories converge in their predictions that significant ongoing task cost should be observed when the PM target is nonfocal.

Monitoring processes in PM

Although examining the extent to which monitoring is necessary for PM performance has been the focus of much research (e.g., Einstein et al., 2005; J. B. Knight et al., 2011; Scullin, McDaniel, & Einstein, 2010; Smith et al., 2007), studies examining whether task interference exerts a general effect or whether it involves trial-by-trial changes in the allocation of attention are scarce. As will become apparent throughout this chapter, and from the results of Experiments 5 and 6 in particular, this line of research can play a considerable role in detailing the nature of the monitoring processes. Next, the findings from the few studies to date that have contributed to enhancing our understating about the processes underlying ongoing task cost are considered. A pioneering study by Marsh, Cook, et al. (2006b), briefly mentioned in Chapter 1, is discussed first. In this study, the authors examined if task interference can change flexibly as a result of material specific processing, such that cost would be reduced for stimuli not relevant to the intention. In line with their view postulating that there can be local changes to task interference (Hicks et al., 2005; Marsh, Cook, et al., 2006b; Marsh et al., 2005), Marsh, Cook, et al. (2006b) showed a reduction in task interference for the irrelevant material (e.g., picture trials when the intention was to perform an action to furniture words) under some conditions. Specifically, task interference was reduced for irrelevant material when presentation of word and picture trials was blocked or when participants could predict the nature of the upcoming trial (i.e., when a cue was presented at the start of each trial, Experiments 1B-3), but not when relevant and irrelevant stimuli were presented at random (Experiment 1A).

Although Marsh, Cook, et al. (2006b, Experiment 1A) found no evidence of greater interference for intention-relevant than intention-irrelevant material when trials were varied at random with no cuing, this result may have been uniquely tied to their particular approach. Specifically, their ongoing task required participants to continuously and randomly switch between two task judgments (i.e., naming pictures and reading words). The need to coordinate two tasks and randomly load distinct production rules should impair performance by likely taxing central executive resources. According to the task switching literature (e.g., Duncan, 1995), the need to switch between tasks unpredictably from trial-to-trial causes task uncertainty, which increases the resource demands of ongoing cognitive processing (e.g., Marsh, Cook, et al., 2006b; Marsh, Hancock, et al., 2002). Note that the magnitude of the overall interference effect for the PM phase in Marsh et al.'s study was greater for the random than for the blocked presentation (Experiments 1A and 1B, respectively). This difference is consistent with the idea above that the need to randomly and continuously switch between ongoing task judgments posed additional cognitive demands and limited the amount of attentional resources that could be devoted to coordinating the processing required by both ongoing and PM activity.

Moreover, in contrast with Marsh, Cook, et al.'s (2006b) lack of evidence for trial-by-trial modulation of task interference when relevant and irrelevant stimuli were presented at random, recent results suggest that item-level changes in monitoring might occur at least under some circumstances. Thus, a few studies have reported significant task interference to word trials in an ongoing LDT in the absence of cost to nonword trials when a set of words were used as PM targets (Cohen, Jaudas, et al., 2008; Smith, 2010; Smith et al., 2007; but for different results see Loft & Yeo, 2007; Smith, 2003). For instance, Cohen, Jaudas, et al. (2008) showed that task interference for word items increased linearly with the increase in the number of word targets, whereas task interference for nonwords fluctuated between conditions and displayed more random variations. These results provide a hint that in LDTs, task interference can vary as a function of the extent to which ongoing task stimuli share some target features (i.e., lexicality) and thus are relevant for the PM task.

More recently, Cohen et al. (2012) investigated task interference for word and nonword trials in a LDT when PM targets were a set of either words or nonwords. Relative to a no-PM control condition, significant cost was found only for the stimuli that matched some of the targets' properties (e.g., for word but not for nonword trials when targets were a set of words). That is, having an intention selectively interfered with items relevant to the PM task such that cost was observed for items that matched the intention, but not for those that did not (stimulus specific interference effect). Finally, J. B. Knight et al. (2010) reported that when participants performed a LDT and the PM task consisted of responding to word items in one of seven possible colors, slowing from the baseline to the PM block was observed for filler words, but not for nonwords. Because a no-PM control group was not included, the authors were unable to establish whether or not task interference for nonword trials was completely eliminated. Nonetheless, J. B. Knight et al.'s (2010) results clearly showed that the cost to nonword trials from having a complex PM task (i.e., target defined by both lexicality and color) was at least reduced.

Experiment 5

In Experiment 5, a new paradigm was implemented in which all stimuli required the same type of ongoing task judgment regardless of their relevance for the nonfocal PM task. On each trial, participants were presented with an uppercase and a lowercase letter in one of two colors and were asked to determine the side of the uppercase letter. The PM task consisted of performing a target action when upper and lowercase letters were in a particular color and were the same letter. Thus, trial relevance for the intention was manipulated by associating the PM task with one of the colors of ongoing stimuli at instructions. The first aim was to investigate whether task interference in a nonfocal PM task can change on a trial-by-trial basis when intention-relevant and irrelevant stimuli vary at random with no cuing. It was predicted that when availability of attentional resources is not reduced by the need to frequently and randomly switch between ongoing task judgments, participants should be able to modulate their attention depending on the stimulus properties associated with the intention.

Second, this experiment aimed to examine target detection and task interference effects as a function of whether the presentation of stimuli in the color associated with the intention was random versus blocked (i.e., every eight trials). In particular, the interest was to examine for the first time the dynamics of cost for intention-irrelevant trials when presentation was blocked, that is, when the occurrence of stimuli associated with PM targets could be predicted. It was hypothesized that in the blocked condition, participants would allocate fewer attentional resources to intention processing on trials distant from intention-relevant stimuli (i.e., trials where the need to prepare for the opportunity to execute the intention was reduced). Accordingly, a more refined assessment of task interference for these stimuli was conducted by examining cost across the eight-trial sequence. Also, unlike some of the previous research (e.g., J. B. Knight et al., 2010; Marsh, Cook, et al., 2006b), a control condition with no PM demands was included to allow examination of task interference while accounting for practice effects on the ongoing task.

Finally, past research has shown that intention-related items, such as words semantically related to targets, can improve PM performance when presented during an ongoing task where all trials are relevant to the PM task (e.g., Taylor et al., 2004; Chapter 2 of this thesis). More recently, J. B. Knight et al. (2011) examined processing of exact-match lures (i.e., stimuli that exactly matched the targets) by linking the intention with a distal phase of the experiment and presenting target words outside this phase. The authors showed that RTs for exact-match lures were slower than to control words. Because task interference was eliminated for the phase where lures were presented (i.e., phase not associated with the PM task), results were interpreted as evidence that lures were spontaneously noticed (see also Einstein et al., 2005; Scullin et al., 2009, for related findings). A final goal of Experiment 5 was therefore to investigate how embedding exact-match lures in the irrelevant context affected ongoing task processing and PM performance both in the random and blocked conditions. Note that in contrast with J. B. Knight et al. (2011), the present paradigm allowed examination of the influence of out-of-context lures on PM performance by presenting lures in the color opposite to the targets and in close proximity to them (i.e., five trials before each target occurrence). In line with the previous research, it was anticipated that lures would be noticed, but because lures were irrelevant to the intention it was an open question whether these items would affect PM performance.

Method

Design and participants. The main design was a 2 x 2 x 2 mixed factorial, with condition (random, blocked) and PM condition (lures, no-lures) as the between-subjects factors, and phase (baseline, PM) as the within-subjects factor. Undergraduate students from Warwick University volunteered in exchange for course credit or were paid £3 for their participation. Eighty-five participants (41 female) aged 17-28 years (*M* = 20.4, *SD* = 2.2) were randomly assigned to four conditions: random lures (n = 22), random no-lures (n = 21), blocked lures (n = 21), and blocked no-lures (n = 21); however, data from one participant in each of the random lures, blocked lures, and blocked no-lures conditions had to be discarded as detailed in the Results section. Participants were tested individually in sessions lasting approximately 25 min.

In addition, 20 participants (12 female, *M* = 21.2 years, *SD* = 2.0) were tested in a no-PM-demands control condition. These were randomly assigned to the random lures, random no-lures, blocked lures, and blocked no-lures versions of the task (n = 5, 6, 5, and 4, respectively). Given that participants in the control condition never received the PM instructions, there was no a priori reason to expect differences between these subgroups in either accuracy or RTs on the ongoing task so their data were combined.

Materials and procedure. Participants were first given instructions about the capital letter task (see Gilbert, Gollwitzer, Cohen, Oettingen, & Burgess, 2009, for the task on which the current one was based). They were told that on each trial they would be presented with a fixation cross in the center of the screen together with a letter of the alphabet on each side of the fixation cross, one in uppercase and the other in lowercase. Stimuli were presented in a font size of 30 pt with a height corresponding to approximately 1.3º viewing angle at a distance of 50 cm and approximately 2.1º to the left and to the right of the fixation cross. Participants were told that the letters would be yellow or white against a black background, and that the color of the letters would change randomly or every eight screens (random vs. blocked conditions, respectively). They were instructed to decide as quickly and accurately as possible whether the uppercase letter was on the left or right side of the screen by pressing the left (‘Z’) key with their left index finger if the uppercase letter was on the left, and the right (‘M’) key with their right index finger if it was on the right. Following encoding, participants were asked to explain the instructions to the experimenter and any omissions or mistakes were corrected. Next, participants were given 16 practice trials and the opportunity to ask questions before they commenced the first phase of the capital letter task. On each trial, the fixation cross and letters remained on the screen until a response was made, or for a maximum of 3000 ms, and then the screen remained black until the spacebar was pressed by the participant to advance to the next trial.

There were two experimental phases, with each phase comprising 128 trials with yellow stimuli and 128 trials with white stimuli (256 trials per phase in total). Participants performed the first (baseline) phase, which consisted of the capital letter ongoing task only. Next they were informed that they would perform a second (PM) phase of the task. All participants with the exception of those in the control condition were then given the PM instructions. These stated that, in the second phase, in addition to performing the capital letter task, if the letters were in yellow (or white; see below) and the same letter was presented in uppercase and lowercase they should first make their decision about the side of the uppercase letter and then press the ‘T’ key during the black screen that followed or as soon thereafter as they could. All participants were reminded that they should respond as quickly and accurately as possible to the side of the uppercase letter on each trial. For participants with a PM task, color of the PM target was counterbalanced such that half of the participants were instructed to respond to yellow targets and half to white targets. There were five PM targets, presented on Trials 50, 98, 146, 194, and 242 of the PM phase.

In addition, participants in the lures conditions were presented with five exact-match lures (i.e., trials where the same letter was presented in uppercase and lowercase, but in the opposite color to the target), one preceding each PM target. Lures were always presented five trials before the targets on Trials 45, 93, 141, 189 and 237 of the PM phase. In the no-lures conditions, the letters in the exact-match lures trials were re-paired such that five new pairs composed of different letters were formed (lure controls). In the blocked conditions, lures/lure controls always occurred as the fifth item in the sequence of eight trials that did not match the color of the target and PM targets as the second item in the sequence of eight trials that matched the color of the target.

Before performing the second phase of the capital letter task, all participants carried out a filler task consisting of a task-switching procedure requiring speeded categorization on the basis of shape (rectangle/triangle) and/or color (blue/red). Two single task blocks (32 trials of categorization on color and 32 trials on shape, with the order of color and shape blocks counterbalanced) were followed by a task switching block (64 trials in total). The procedure used was similar to that of Reimers and Maylor (2005). This filler task served as a delay, lasting approximately seven minutes, between the instructions and the beginning of the second phase.

At the end of the second phase, participants in the PM condition answered a post-experiment questionnaire to test their recall of the intended action. Finally, all participants were asked to complete a demographic questionnaire.

Results

When queried about the PM task at the end of the experiment, three participants in the PM condition had no memory for the color of the PM target and so their data were not included due to their failure in encoding and retaining the instructions.

PM performance. PM accuracy was defined as the proportion of target items for which the participant pressed the 'T' key in the screen that followed the target or within the next trial. All but one PM response occurred during these periods. The overall means are shown in Figure 8. A 2 x 2 ANOVA with condition (random, blocked) and PM condition (lures, no-lures) as between-subjects factors revealed a significant main effect of lures, $F(1, 78) = 4.22$, $MSE = 0.07$, $p = .043$, $\eta_p^2 = .05$, such that cue detection was worse with lures ($M = .66$, $SD = .30$) than with no lures ($M = .79$, $SD = .25$). Neither the main effect of condition, $F(1, 78) = 2.20$, $p = .142$, nor the interaction, $F < 1$, reached significance.

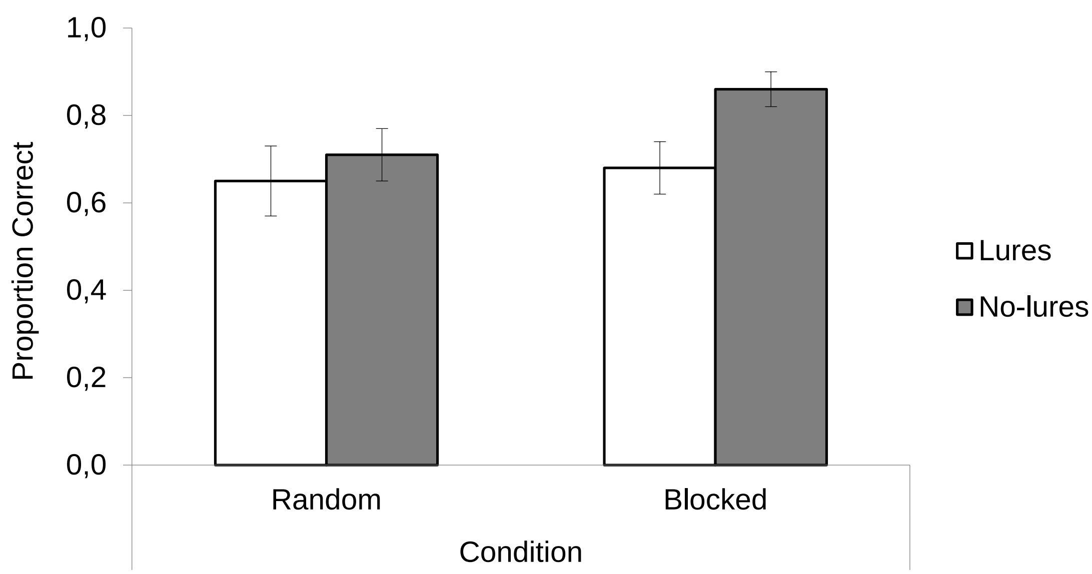

Figure 8: Mean proportion correct for the prospective memory task across conditions. Error bars represent ± 1 standard error.

Ongoing task performance. It was first examined whether having a PM task affected the accuracy of performing the ongoing (capital letter) task. Proportion correct was analyzed in a 3 x 2 mixed ANOVA with condition (control, random, blocked) as the between-subjects factor and phase (baseline, PM) as the within-subjects factor. There was no main effect or interaction involving condition (*F*s < 1). Proportion correct was very high in both phases of the task and similarly so for the control (M = .96, SD = .05) and PM (M = .97, SD = .02) conditions. These results are consistent with previous research (e.g., Einstein et al., 2005) showing no cost of performing a PM task in terms of accuracy on the ongoing task.

Based on previous PM research (e.g., J. B. Knight et al., 2011), RTs were trimmed to include only correct responses that were less than 2.5 *SD*s away from each participant's mean. Trimming was done separately for the baseline and PM phases and for color match and mismatch trials (PM targets and lures/lure controls, as well as the trial immediately following each of the PM targets and lures/lure controls, were excluded from both accuracy and filler RT analyses), which resulted in the elimination of 2.6% of RTs. These data were included in a 3 x 2 ANOVA with condition (control, random, blocked) as the between-subjects factor and phase (baseline, PM) as the within-subjects factor to establish the presence of overall task interference.[16] There was a significant condition by phase interaction, $F(2, 99) = 23.54$, MSE = 1,596.21, $p < .001$, $\eta_p^2 = .32$, indicating considerable task interference. Whereas RTs in the control condition were significantly longer in the baseline phase (M = 470 ms, SD = 41) than in the PM phase (M = 452, SD = 40), $t(19) = 6.24$, $p < .001$, RTs in the PM conditions were significantly shorter in the baseline phase than in the PM phase (random: *M*s = 480 and 553, *SD*s

[16] The color (match, mismatch) factor was omitted here as the distinction between match and mismatch trials is linked directly to the PM task (i.e., color associated with the PM targets determines the trials that fall into each color category) and therefore not applicable to the control condition.

= 66 and 88, *t*(41) = -6.45, *p* < .001; blocked: *M*s = 481 and 563, *SD*s = 63 and 77, *t*(39) = -11.00, *p* < .001). Note, however, that the main reason for inclusion of a control condition was not to determine that having a nonfocal PM task causes overall task interference; that has been consistently demonstrated in previous research (e.g., Einstein et al., 2005; Scullin, McDaniel, Shelton et al., 2010). Rather, the control condition provides a crucial comparison for more detailed analyses of the blocked condition's eight-trial sequences (see appropriate section below).

Table 9: *Means and Standard Deviations for Response Times in Milliseconds on Color Match and Color Mismatch Filler Items in Baseline and Prospective Memory (PM) Phases for Each Condition*

	Color match				Color mismatch			
	Baseline		PM		Baseline		PM	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Random								
Lures	497	59	581	98	493	61	561	86
No-lures	464	70	550	95	465	69	522	77
Blocked								
Lures	480	64	587	95	480	56	506	60
No-lures	482	69	644	115	480	69	515	54

Because a primary aim of the present research was to determine how randomizing versus blocking the presentation of stimuli associated with a nonfocal intention affects the speed of performing the ongoing task, task interference across different trial types for the PM conditions was first investigated. The overall means can be found in Table 9, with task interference (i.e., baseline-PM phase differences)[17] displayed in Figure 9. RTs were entered into a 2 x 2 x 2 x 2 mixed ANOVA with condition (random, blocked) and PM condition (lures, no-lures) as the between-subjects factors, and phase (baseline, PM) and color (match, mismatch) as the within-subjects factors. Table 10 summarizes the results, with numbers in square brackets below referring to the effects as listed in the table. There was significant task interference, such that RTs were longer when participants were performing a PM task than when they were not [4]. RTs were also longer for color match than color mismatch trials [8], and more so in the blocked than in the random condition [9]. Phase interacted with color [12], suggesting that task interference from adding a PM task was higher for color match than for color mismatch trials. Most importantly, the three-way interaction between phase, color and condition was significant [13], such that the greater task interference for match than mismatch trials was much more evident in the blocked than in the random condition. In addition to these highly significant effects (ps < .001), there were also two weaker interactions (ps < .05) involving lures [10,14] such that the greater task interference for match than mismatch trials was less evident in the presence than in the absence of lures.

[17] Note that this measure of cost underestimates actual task interference because it does not account for practice effects on the ongoing task from the baseline to the PM phase. Thus, slowing in the PM conditions contrasted with an 18-ms practice effect in the no-PM-demands control condition.

Table 10: *ANOVA Results for Response Times on Filler Items, With Two Between-Subject Factors (Condition and Lures) and Two Within-Subject Factors (Phase and Color)*

		F(1, 78)	*MSE*	*p*	η_p^2
Effect					
1.	Condition	0.13	2,269.55	.724	.00
2.	Lures	0.27	4,946.42	.602	.00
3.	Condition * Lures	2.83	51,092.76	.096	.04
4.	Phase	128.07	3,884.77	.000	.62
5.	Phase * Condition	0.44	3,884.77	.510	.01
6.	Phase * Lures	0.98	3,884.77	.324	.01
7.	Phase * Condition * Lures	1.75	3,884.77	.189	.02
8.	Color	109.34	803.74	.000	.58
9.	Color * Condition	41.21	803.74	.000	.35
10.	Color * Lures	4.56	803.74	.036	.06
11.	Color * Condition * Lures	3.24	803.74	.076	.04
12.	Phase * Color	99.11	835.66	.000	.56
13.	Phase * Color * Condition	40.85	835.66	.000	.34
14.	Phase * Color * Lures	4.94	835.66	.029	.06
15.	Phase * Color * Condition * Lures	1.48	835.66	.228	.02

Note. Between-subject factors: condition (random, blocked); and PM condition (lures, no-lures). Within-subject factors: phase (baseline, PM); and color (match, mismatch).

Figure 9 (left-hand panel) suggests that greater task interference for match than mismatch trials was observed even when presentation of intention-relevant and irrelevant trials was random. This was confirmed by submitting RTs in the random condition to a 2 x 2 x 2 (Lures x Phase x Color) mixed ANOVA. In line with the present predictions, results showed a significant phase by color interaction, F(1, 40) = 13.86, *MSE* = 392.60, p = .001, η_p^2 = .26, such that slowing that resulted from adding a PM task was greater for match trials (*M* = 85 ms, *SD* = 86) than for mismatch trials (*M* = 62 ms, *SD* = 65). This reduction in cost for intention-irrelevant trials suggests that, when the ongoing task does not require participants to repeatedly and randomly switch between two types of judgment, trial-by-trial changes in task interference can be observed with random presentation. The equivalent 2 x 2 x 2 ANOVA for RTs in the blocked condition again showed a highly significant phase by color interaction, $F(1, 38) = 83.71$, MSE = 1,302.04, $p < .001$, $\eta_p^2 = .69$, with slowing greater for match (*M* = 135 ms, *SD* = 75) than mismatch trials (*M* = 30 ms, *SD* = 42). In addition, results revealed a lures by phase interaction, $F(1, 38) = 4.92$, MSE = 2,068.76, $p = .033$, $\eta_p^2 = .12$, as well as a marginally significant three-way interaction, $F(1, 38) = 3.70$, MSE = 1,302.04, $p = .062$, $\eta_p^2 = .09$, indicating that in the blocked condition task interference was greater in the no-lures than in the lures condition for color match trials, $F(1, 39) = 5.87$, MSE = 4,943.65, $p = .020$, $\eta_p^2 = .13$, but not color mismatch trials, $F < 1$ (see right-hand panel of Figure 9).[18]

[18] This finding is noteworthy because task interference has been previously identified as supporting PM retrieval with nonfocal targets (e.g., Scullin, McDaniel, & Einstein, 2010). Thus, whether PM accuracy was related to task interference for intention-relevant trials was investigated. A 2 x 2 analysis of covariance was conducted that included condition (random, blocked) and PM condition (lures, no-lures) as between-subjects factors, and task interference in color match trials as a covariate. There was a marginally significant effect of the covariate, $F(1, 77)$ = 3.45, $MSE = 0.07$, $p = .067$, $\eta_p^2 = .04$, and the effect of lures was now only marginally significant, $F(1, 77) = 2.98$, $MSE = 0.07$, $p = .088$, $\eta_p^2 = .04$. Thus, the negative effect of out-of-context lures on target detection was reduced after controlling for differences in ongoing task slowing in color match trials.

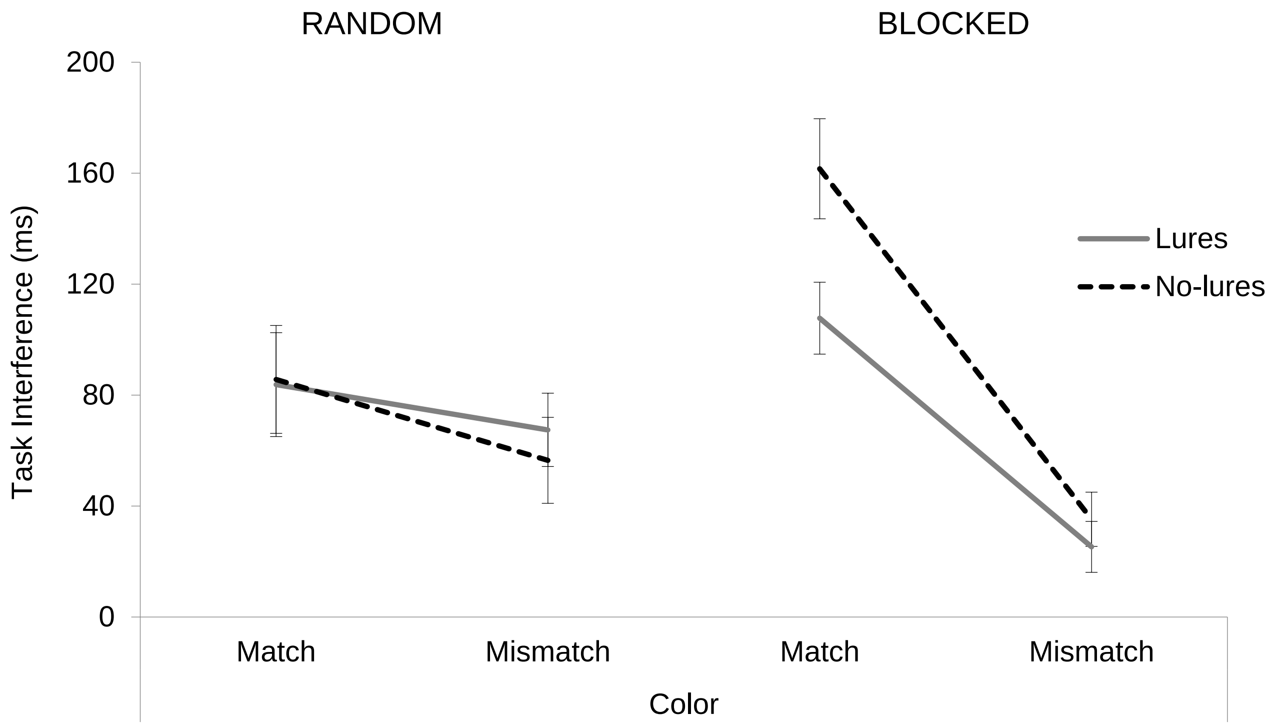

Figure 9: Task interference (prospective memory phase minus baseline phase response time) in milliseconds (ms) for color match and color mismatch filler items with and without lures, for random (left) and blocked (right) conditions. Error bars represent ± 1 standard error.

The above analyses indicate that trial-by-trial modulations in task interference occurred regardless of whether stimulus presentation was random or blocked. But does presentation of intention-irrelevant stimuli in a predictable, blocked fashion reduce cost for these trials relative to random presentation? A mixed 2 x 2 x 2 (Condition x Lures x Phase) ANOVA was conducted for RTs in color mismatch trials. As shown in Figure 9, the slowing that resulted from adding a PM task was greater in the random than in the blocked condition, $F(1,78) = 6.62$, $MSE = 1{,}554.55$, $p = .012$, $\eta_p^2 = .08$, for the condition by phase interaction ($F < 1$ for the three-way interaction). Consistent with the present predictions, participants showed the least slowing for color mismatch trials in the blocked condition. However, the more pertinent and theoretically relevant issue is whether or not task interference remained constant throughout the sequence of mismatch trials. This is addressed below, but first the results of the 2 x 2 x 2 (Condition x Lures x Phase) ANOVA for color match trials are reported. The condition by phase interaction was significant, $F(1, 78) = 8.07$, $MSE = 3{,}165.88$, $p = .006$, $\eta_p^2 = .09$, as task interference was greater in the blocked than in the random condition. This suggests that more attentional resources were engaged for the processing of intention-relevant stimuli when presentation was blocked than random. The three-way interaction was not significant, $F(1, 78) = 2.19$, $p = .143$.

Blocked condition Trials 1-8. In light of the above findings showing that slowing was markedly reduced for mismatch trials in the blocked condition, cost across the eight-trial sequence was examined next. Thus, if participants can anticipate the occurrence of stimuli associated with target presentation, they should show differences in costs across the sequence as a result of variations in the level of intention activation in memory. RTs for color mismatch trials (see right-hand panel of Figure 10) were submitted to a mixed 2 x 2 x 8 (Lures x Phase x Trial) ANOVA. Critically, there was a significant phase by trial interaction, $F(7, 266) = 40.58$, $MSE = 779.61$, $p < .001$, $\eta_p^2 = .52$, suggesting that the amount of resources recruited towards intention processing changed as a function of the trial location in the sequence of intention-irrelevant trials.[19]

[19] For completeness, a similar 2 x 2 x 8 mixed ANOVA was conducted for RTs in color match trials (see left-hand panel of Figure 10). There was a significant main effect of trial, $F(7, 266) = 3.21$, $MSE = 1{,}288.94$, $p = .003$, $\eta_p^2 = .08$, as RTs were slower to the first than to the following trials in the sequence. The phase by trial interaction was only marginal, $F(7, 266) = 1.83$, $MSE = 1{,}281.30$, $p = .082$, $\eta_p^2 = .05$, and reflected a trend for slowing at the beginning of the sequence of trials to be more evident in the PM than baseline phase.

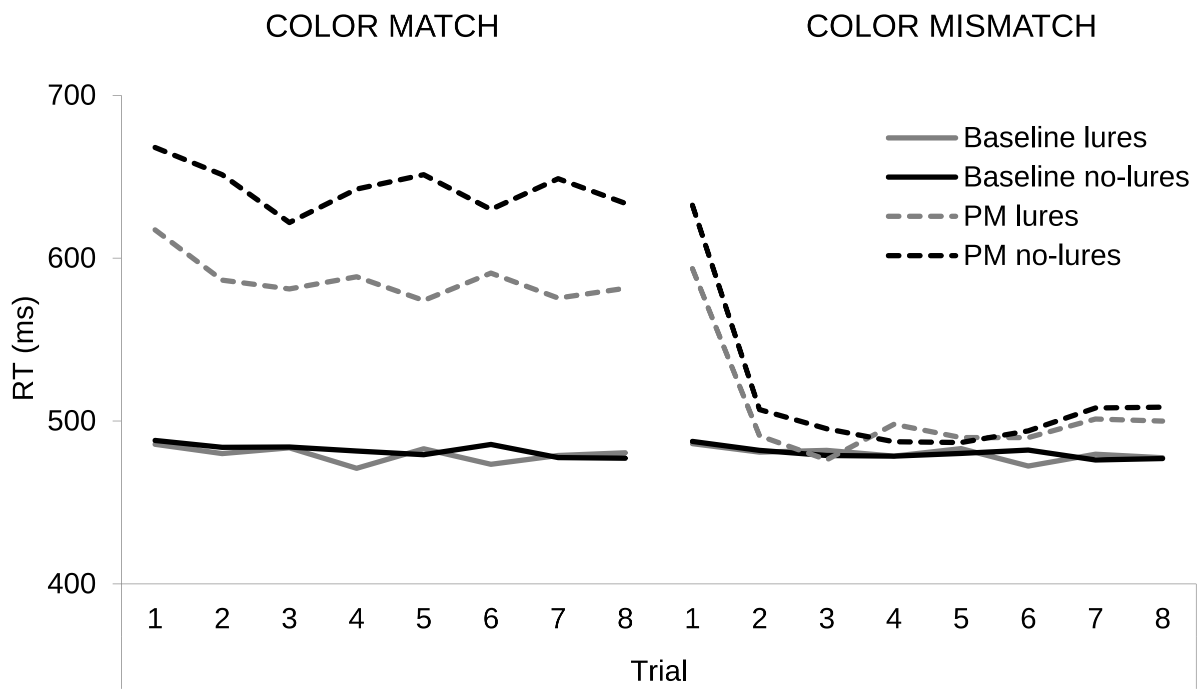

Figure 10: Mean correct response time (RT) in milliseconds (ms) for filler trials in the blocked condition over the eight-trial color match (left) and mismatch (right) sequences, for baseline and PM phases with lures and no lures.

Slowing for each of the eight trials in the sequence of mismatch trials relative to the no-PM control condition was examined by conducting independent samples *t* tests on the difference scores for RTs from the baseline to the PM phase. For these analyses the significance threshold was set to .006, as required by the Bonferroni correction method. First, for Trials 1, 7 and 8 the contrasts with the control condition were highly significant (*p*s < .001, slowing of 126, 27 and 27 ms, respectively, relative to a speeding up of 18 ms in the control condition). These results suggest that there was a one-trial carry-over effect from the relevant to the irrelevant context followed by a substantial reduction in task interference for the second trial in the sequence. In addition, slowing for the two trials immediately preceding the relevant context suggests that there was an anticipation effect possibly reflecting an increase in the activation of the intention in memory in preparation for the opportunity to execute the intended action. Second, for Trials 2-6 contrasts did not exceed the Bonferroni-corrected significance criterion (*p*s < .02). Notwithstanding, RTs were always numerically higher in the PM condition (i.e., slowing ranging from 5 to 18 ms relative to a speeding up of 18 ms in the control condition; see right-hand panel of Figure 10), suggesting the presence of cost for all trials. As such, the most conservative conclusion to be drawn from these analyses is that task interference associated with a PM task was substantially reduced for intention-irrelevant trials in the center of the sequence, but that some residual attention to the PM task remained for the entire duration of the irrelevant context.

Lure Processing. The aim here was to first examine processing of exact-match lures (i.e., color mismatch trials where the uppercase and lowercase letters were the same), and to then examine whether these items caused temporary cost. First, lure interference was defined as the average latency to make a correct capital letter decision on the five lure trials (lure control trials in the no-lures condition) minus the average latency to make the same decision in color mismatch filler trials in the PM phase (see Table 11). Lure interference was examined in a 2 x 2 ANOVA that included condition (random, blocked) and PM condition (lures, no-lures) as the between-subjects factors. This revealed a main effect of lures, $F(1, 78) = 29.11$, MSE = 15,525.57, $p < .001$, $\eta_p^2 = .27$, such that slowing was observed for lures but not for lure controls. Although lure interference was numerically greater for lures in the random than in the blocked condition, but similar for lure controls, the interaction between condition and lures was not significant, $F(1, 78) = 2.26$, $p = .137$.

Table 11: *Means and Standard Deviations for Response Times in Milliseconds to Lures/Lure Controls and Color Mismatch Filler Items, and Differences Between Them (Lure Interference), Across Conditions*

	Lures/Lure controls		Color mismatch		Lure interference	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*
Random						
Lures	740	209	561	86	179	171
No-lures	511	84	522	77	-11	46
Blocked						
Lures	610	183	506	60	104	165
No-lures	512	69	515	54	-3	57

The second question of interest was whether noticing the lure items caused any subsequent temporary disruption to the ongoing task. Figure 11 shows RTs for trials before and after lures/lure controls.[20] The three trials preceding each lure/lure control (pre-lures) were averaged and compared them to the trials immediately succeeding each lure/lure control, while excluding only incorrect trials. A 2 x 2 x 4 mixed ANOVA was conducted with condition (random, blocked) and PM condition (lures, no-lures) as the between-subjects factors, and trial (pre-lure, lure+1, lure+2, lure+3) as the within-subjects factor. Consistent with the previous analysis suggesting noticing of lures, there was a significant lures by trial interaction, $F(3, 234) = 15.41$, $MSE = 3{,}740.66$, $p < .001$, $\eta_p^2 = .17$. Paired *t* tests with Bonferroni correction (statistical significance set at $p < .017$) revealed that in the lures condition there was slowing from pre-lures to the first post-lure trial, $t(40) = -5.68$, $p < .001$. By contrast, *t* tests did not reach significance

[20] In the blocked condition, lures/lure controls were always presented as the fifth item in the sequence of eight color mismatch trials. Therefore, in this condition the depicted trials all represent color mismatch trials with the exception of lure+4, which was the first item of the sequence of eight color match trials that followed.

for the second (p = .047) and third (p = .018) post-lure trials. Thus, as illustrated in Figure 11, lures caused marked ongoing task cost on the trial immediately after the lure but slowing was not sustained over the following post-lure trials.

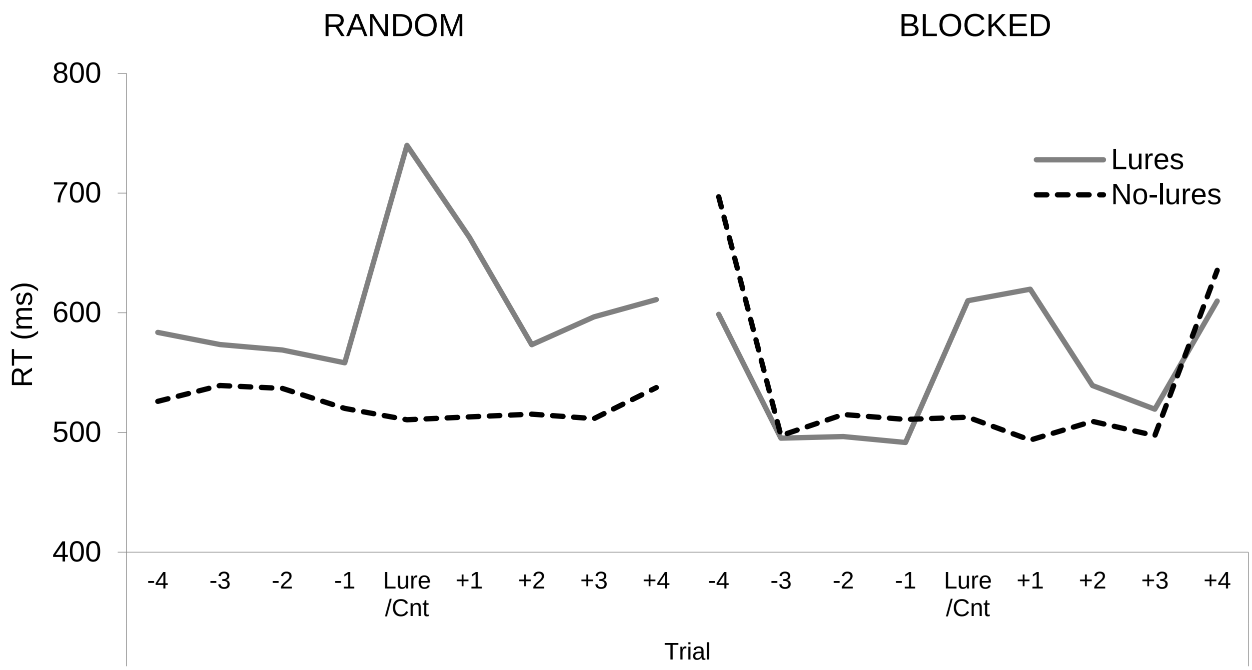

Figure 11: Mean correct response time (RT) in milliseconds (ms) for the random (left) and blocked (right) conditions to lures/lure controls, and the four trials immediately preceding and succeeding them.

Discussion

In Experiment 5, PM context was manipulated by linking the nonfocal intention with stimuli in a particular color, so that all ongoing task trials required the same type of judgment. Task interference was then examined when the context associated with the PM task was presented either randomly or predictably in a blocked fashion. Results showed that the cost of having a PM task was higher when stimuli matched the color of the target items than when they did not. Crucially, trial-by-trial changes in task interference as a function of relevance of the stimuli for the intention were found even when trial presentation was random and there was no cue regarding the nature of the upcoming trial. Furthermore, slowing for intention-irrelevant stimuli was drastically reduced by grouping match and mismatch trials into repeated and known blocks. It was also demonstrated that the additional processes engaged for intention-relevant trials (e.g., increasing the activation of the PM task, and/or item checking) were promptly disengaged when the irrelevant context was reached as well as gradually reinstated in close proximity to the relevant trials.

As introduced in Chapter 1, Guynn (2003) proposed that strategic monitoring comprises two types of processes: maintaining a retrieval mode and checking for target items. The first involves maintaining the intention at an increased state of activation and reflects the cognitive system's readiness to perform the future action. By contrast, item checking is a more intermittent process that requires the allocation of attention to the context where the PM target can occur in order to verify whether or not stimuli meet the criteria for a PM response. The present data are broadly in line with this two-process model of strategic monitoring. First, low task interference on irrelevant color mismatch trials is consistent with the maintenance of a retrieval mode – that is, maintaining the PM intention actively in mind throughout the ongoing task. Moreover, there was minimal but persistent slowing even for stimuli at the center of the intention-irrelevant sequence of trials (blocked condition), suggesting that sustaining the activation of the intention at a level that allows the intention to be successfully executed when the appropriate retrieval context arises requires attentional resources. Second, results showed that task interference was greater for stimuli relevant versus irrelevant for the intention and reliably so even when the two types of items were presented randomly with no cuing. This supports the proposal of an intermittent target checking process whereby additional attentional resources are engaged for stimuli where the PM target can occur in order to verify whether or not these meet the criteria for a PM response. Thus, the results suggest that some form of poststimulus processing contributes to the task interference effect with the present paradigm. As discussed at the start of this chapter, Marsh, Cook, et al.'s (2006b, Experiment 1A) failure to find a material-specific interference effect when the nature of the upcoming trial could not be predicted probably reflects the inability to prevent a generalized task interference effect when resources need to be deployed to continuously and unpredictably switch between judgment types in the ongoing task.

In addition, there was greater task interference for match trials in the blocked than in the random condition. It is likely that the different pattern reflects variation in the strategic approaches to perform the PM task as a function of anticipated task demands. The overall need for attentional control might be higher in the random condition due to the uncertainty about the nature of the upcoming trial. This might pose additional challenges in terms of having to repeatedly adjust the amount of intention-related processing to avoid deploying unnecessary resources on task-irrelevant trials, and lead participants to monitor less actively in the random condition. On the other hand, cost on mismatch trials was lower in the blocked than in the random condition. When presentation was blocked, the ability to anticipate the appearance of the relevant context probably increased participants' capacity to optimize attentional resources. That is, results showed that interference on mismatch trials was kept to a minimum by promptly disengaging the additional processes associated with target detection when the irrelevant context was reached. Interestingly, it was also found that cost for intention-irrelevant items in the blocked condition was not evenly distributed across the sequence of eight trials. This suggests that the reduction in cost for these items was not the sole result of participants rejecting stimuli quicker when they did not have properties in common with the PM target.

The pattern of task interference from the sequence of eight intention-irrelevant trials is theoretically informative and deserves closer scrutiny. First, cost dropped to residual levels from the first to the second trial in the sequence. This suggests that the intention underwent deactivation and that the decrease in attention devoted to the PM task was triggered by the occurrence of an external event (i.e., change in trial color to that opposite to the target). Second, although cost was substantially attenuated for trials in the center of the sequence of intention-irrelevant trials, holding an intention interfered with ongoing task processing even during these periods, suggesting persistent activation of the intention. This finding is especially interesting because participants were explicitly instructed about the blocked presentation and that targets would not occur during these color mismatch trials. Third, there was an increase in task interference for the final two trials in the sequence, relative to the center trials, suggesting increased recruitment of attentional resources associated with the PM task in close proximity to the relevant context occurrence.

Finally, the present experiment also examined how embedding exact-match lures in the irrelevant context affects performance. Consistent with previous studies (J. B. Knight et al., 2011; R. West & Craik, 1999; R. West, Herndon, & Crewdson, 2001), RTs to lures were slower than to lure controls. Also, post-lure cost was significant for the trial immediately after each lure. Thus lures attracted attention and probably triggered the recruitment of additional resources to check the lure against the PM representation and prevent an inappropriate response. In addition, target detection was slightly decreased when exact-match lures were presented. This finding was unexpected, but perhaps lures caused some confusion about the features (i.e., color) associated with the intention, resulting in some of the targets going unnoticed. At least one study suggests that lures might cause disruption to processing. Specifically, Bisiacchi, Schiff, Ciccola, and

Kliegel (2009) showed increased slowing and false alarms for lures in comparison to ongoing trials, which was attributed to the need to employ additional resources for identifying and rejecting these items as targets.

Importantly, the counterintuitive effect of lures on PM performance was only marginal when ongoing task slowing was taken into account. Note that, in contrast with previous research (e.g., Scullin, McDaniel, & Einstein, 2010; R. West et al., 2001), participants were never forewarned that lures would be presented or about their relationship with target occurrence. Moreover, post-lure slowing was mostly confined to the trial immediately following each lure. These findings indicate that exact-match lures did not elicit active monitoring for the targets, possibly because lures were irrelevant to PM task performance and engaging in monitoring is cognitively demanding (cf. Vortac et al., 1993). Notably, Dewitt et al. (2012) recently reported that presenting implicit cues (i.e., items that were previously paired with target events) improved PM performance only when the cue-target pairs were in relatively close proximity, that is, when separated by two, but not five or eight, intervening trials. Importantly, the amount of slowing caused by encountering the cues was significantly reduced as distance from the cue increased. The authors suggested that encountering cues facilitated retrieval of the PM task into awareness. Additionally, they proposed that the passage of time and the requirement to continuously process ongoing task information limited the individual's capacity to actively maintain the intention in WM and, consequently, the positive effect of cues on performance. In sum, Experiment 5 introduced a novel way of embedding intention-related events in the irrelevant context shortly before the occurrence of PM targets. Whether the distance in time between the occurrence of lures and the opportunity to fulfill the intention can moderate the effect of out-of-context lures on PM performance might represent an interesting avenue for future research.

Experiment 6

Although previous research (e.g., Einstein et al., 2005; Scullin, McDaniel, Shelton, et al., 2010) has already established that performing a nonfocal intention results in a cost to ongoing task processing, Experiment 5 showed that the cost of having a nonfocal PM task was higher when ongoing stimuli matched versus mismatched the target's color. Moreover, cost for intention-irrelevant stimuli was minimized, though never eliminated, by blocking match/mismatch trials. The main aim of Experiment 6 was again to examine in more detail the processes underlying nonfocal PM retrieval, but this time by focusing on a manipulation of target context specification. Specifically, participants were asked to perform an ongoing LDT together with a PM task (responding to the syllable *tor*). However, participants' expectations regarding the target context were manipulated by explicitly instructing them that targets would occur in word trials only or in both word and nonword trials.

Crucially, Experiment 6 tested whether the finding of trial-by-trial changes in task interference as a function of stimulus relevance to the nonfocal intention holds when participants' expectations about the target context are manipulated. A commonality between the previous studies examining item-level changes in task interference (Cohen, Jaudas, et al., 2008; Cohen et al., 2012; Einstein & McDaniel, 2010; J. B. Knight et al., 2010; Marsh, Cook, et al., 2006b; Smith et al., 2007; as well as Experiment 5 in this chapter) is that the task conditions implied that PM targets could only appear in a portion of trials (e.g., word trials in a LDT when targets were a set of words). By contrast, in Experiment 6 a nonfocal target (syllable *tor*) that could in principle occur in any ongoing lexical decision trial was used. By manipulating target context specification, task interference could be examined when the intention was linked versus not linked to a specific context (i.e., when participants were explicitly instructed that the PM targets would occur only in a subset of ongoing trials vs. any trial). Can individuals who are given a specific target context minimize disruption to intention-irrelevant trials on a trial-by-trial basis? Note that, regardless of the instructions, the target syllable always occurred in word trials and, as such, the objective PM demands were exactly the same for all participants.

Previous research has shown that participants can utilize monitoring processes in an efficient way by limiting deployment of monitoring to the task in which the PM targets are expected. For instance, Marsh, Hicks, and Cook (2006) showed that context-linking an intention to a distal phase of the experiment eliminated task interference during the context preceding the PM phase (see also J. B. Knight et al., 2011; Scullin & Bugg, 2013). Yet, in the real world the general retrieval context might be known, but the intention might lack specification. For example, you might form the intention to meet a particular researcher at a poster presentation. This might prove a difficult task unless you have further details about the researcher's appearance (e.g., height, age, glasses, or other key features that you have identified from his/her website photo) that can support you in monitoring the conference attendees for the target researcher. Accordingly, a provocative possibility is that conditions that explicitly inform participants about the specific items where targets can occur will allow them to adopt more efficient monitoring strategies, including recruiting additional attentional resources associated with target-related processing (e.g., recognition checks) only when stimuli that are relevant to the intention are encountered. Such changes would result in a monitoring pattern characterized by distinct task interference levels for ongoing task items relevant and irrelevant for the intention.

In sum, the main aim of Experiment 6 was to examine whether target context specification can trigger item-level changes in task interference as a function of the stimulus relevance to the nonfocal PM task. Relevant and irrelevant contexts were varied at random on a trial-by-trial basis within a single ongoing task by asking participants to perform a LDT and to give a PM response to a particular syllable. Although the target syllable always occurred in word trials, participants' expectations about the target context were manipulated at instructions by either telling them that the syllable would always occur in words or that it could occur in both words and nonwords (specific and nonspecific conditions, respectively). It was hypothesized that task interference for nonword trials would be reduced when the PM target context was specified. In addition, it was predicted that this reduction for the stimuli not associated with the intention would have no impact on PM performance as targets never occurred in nonword trials. Finally, a few researchers (Einstein et al., 2005; Loft et al., 2008; Scullin, McDaniel, Shelton, et al., 2010) have shown that task interference can decline across the ongoing task when PM targets are not presented. An open question in the present study was whether resource allocation to nonword trials in the nonspecific condition would remain constant across the ongoing task or, instead, decline as the PM targets were repeatedly and without exception presented in word trials despite participants' expectations.

Method

Design and participants. The design was a 3 x 2 mixed factorial, with condition (control, specific, nonspecific) as the between-subjects factor, and block (baseline, PM) as the within-subjects factor. Participants aged 18-24 years (M = 20.4, SD = 1.5) were undergraduate students from Warwick University and were an opportunity sample. One hundred and five participants (58 female) were randomly assigned to the control (n = 28), specific (n = 38), and nonspecific (n = 39) conditions. Four participants (1 control; 2 specific; 1 nonspecific) were excluded as detailed in the Results section. Testing took place individually in sessions lasting approximately 25 min. During the session, participants completed the DSST (Wechsler, 1981). Analysis revealed no main effect of condition, indicating that participants randomly assigned to the different conditions were equivalent on this measure of processing speed (M = 67.9, 70.8, and 68.0, and SD = 9.5, 9.5, and 10.2, for the control, specific, and nonspecific conditions, respectively, $F < 1$).

Materials and procedure. Participants were first given instructions about the LDT where they were told to decide as quickly and accurately as possible whether a string of letters was a word or not. They were told to press the ‘J’ key with their right index finger if the string was a word and the ‘F’ key with their left index finger if it was not a word. It was added that after each decision a *waiting* message would appear on the screen and that they should press the spacebar with one of their thumbs to see the next item. Participants were asked to summarize the instructions before starting the baseline block.

At the end of the baseline block, participants were given instructions for the PM block. All participants were told that they would be completing another block of the LDT and were reminded that they should respond as quickly and accurately as possible. Those in the PM conditions were additionally given instructions for the PM task. Namely, participants were told that whenever they saw the syllable *tor* they should press the ‘F6’ key after they made their lexical decision or as soon thereafter as they could. Critically, it was added either that this syllable would occur only in words (specific condition) or that it could occur in both words and nonwords (nonspecific condition). Participants were asked to summarize the instructions and the experimenter checked that they knew the target syllable, response key and the target context (i.e., word trials or word and nonword trials) before proceeding. A delay of approximately five minutes between PM instructions and the start of the PM block was created by asking participants to complete the DSST (Wechsler, 1981) and to fill in a demographic questionnaire.

The procedure was similar for those in the control condition, except that they did not receive the PM instructions.

The baseline and PM blocks each consisted of 252 lexical decision trials (126 words, 126 nonwords) with the six trials at the start of each block being buffer trials. The target syllable *tor* always occurred in a word and was presented eight times, once in each of the words *dormitory*, *factory*, *history*, *torches*, *torment*, *tornado*, *tortoise*, and *victory*. The order of appearance of these eight PM targets was randomized between participants; they were presented on Trials 31, 62, 93, 124, 155, 186, 217, and 248 of the PM block, resulting in PM targets being always 30 trials apart. Filler words for the LDT were generated from the Balota et al. (2007) English Lexicon Database. Words were 4-9 letters in length, 2-4 syllables, and had a mean log-transformed HAL frequency of 8.0. The *tor* words were matched with filler words on mean length, syllables, and frequency. Nonwords were also selected from Balota et al. (2007) and were 4-9 letters in length.

All items appeared in lowercase letters, and were presented at the center of the screen in a font size of 30 pt with a height corresponding to approximately 1.3º viewing angle at a distance of 50 cm. Each trial started with a 250-ms fixation cross, followed by the presentation of the letter string, and finally the *waiting* message, the latter two presented until the participant responded or 4000 ms had elapsed. At the end of the LDT, participants in the PM conditions answered a post-experiment questionnaire to check their memory for the PM task. They were asked to repeat the instructions for the second block of the LDT and all were able to correctly recall the corresponding PM instructions.

Results

Four participants who were more than 2.5 *SD*s from their group's mean RT in the LDT were removed, though excluding these data did not qualitatively change the results reported here.

Ongoing task performance. Accuracy on the LDT was examined by including percentage correct in a 3 x 2 x 2 ANOVA with condition (control, specific, nonspecific) as the between-subjects factor, and block (baseline, PM) and trial type (word, nonword) as within-subjects factors. There was a main effect of trial type, $F(1, 98) = 12.40$, $MSE = 22.28$, $p < .001$, $\eta_p^2 = .11$, such that accuracy was higher for words (95.7%) than for nonwords (94.1%). The only other significant effect was an interaction between condition and block, $F(2, 98) = 3.17$, $MSE = 10.53$, $p = .047$, $\eta_p^2 = .06$. As illustrated in Table 12, there was a decrease in accuracy from the baseline to the PM block in the nonspecific condition, $t(37) = 3.14$, $p = .003$, but not in the other two conditions (both *t*s < 1).[21]

[21] Although the three-way interaction did not reach significance, it can be noted that the overall pattern for ongoing task accuracy in Table 12 (i.e., reductions in accuracy from the baseline to the PM block for words in the specific condition and words and nonwords in the nonspecific condition) was consistent with that for RTs in Figure 12, with no evidence of any speed-accuracy tradeoffs.

Table 12: *Mean Percentage of Correct Responses to Word and Nonword Lexical Decision Filler Trials as a Function of Block and Condition*

	Block							
	Baseline				PM			
	Words		Nonwords		Words		Nonwords	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control	95.1	3.4	92.6	5.1	94.7	4.7	93.6	4.5
Specific	96.7	3.4	95.1	4.4	95.5	4.6	95.2	4.1
Nonspecific	97.0	2.3	94.9	5.0	95.4	3.8	93.1	7.4

For RTs on the LDT, filler trials were trimmed to include only correct responses that were less than 2.5 *SD*s away from each participant's mean (e.g., Knight et al., 2011). Trimming was done separately for the baseline and PM blocks and for word and nonword trials. The three filler trials immediately following each target were excluded to avoid potential bias from slowing associated with target-related processes. Trimming resulted in the elimination of 2.6% of correct RTs. Data were analyzed with a 3 x 2 x 2 ANOVA with condition (control, specific, nonspecific) as a between-subjects factor, and block (baseline, PM) and trial type (word, nonword) as within-subjects factors. The three-way interaction was highly significant, $F(2, 98) = 6.69$, $MSE = 3{,}548.90$, $p = .002$, $\eta_p^2 = .12$. Inspection of Figure 12 suggests that this interaction was obtained because there was a practice effect from the baseline to the PM block in the control condition but a cost in the PM conditions, and cost was greater in the nonspecific than in the specific condition for nonwords but similar for words.

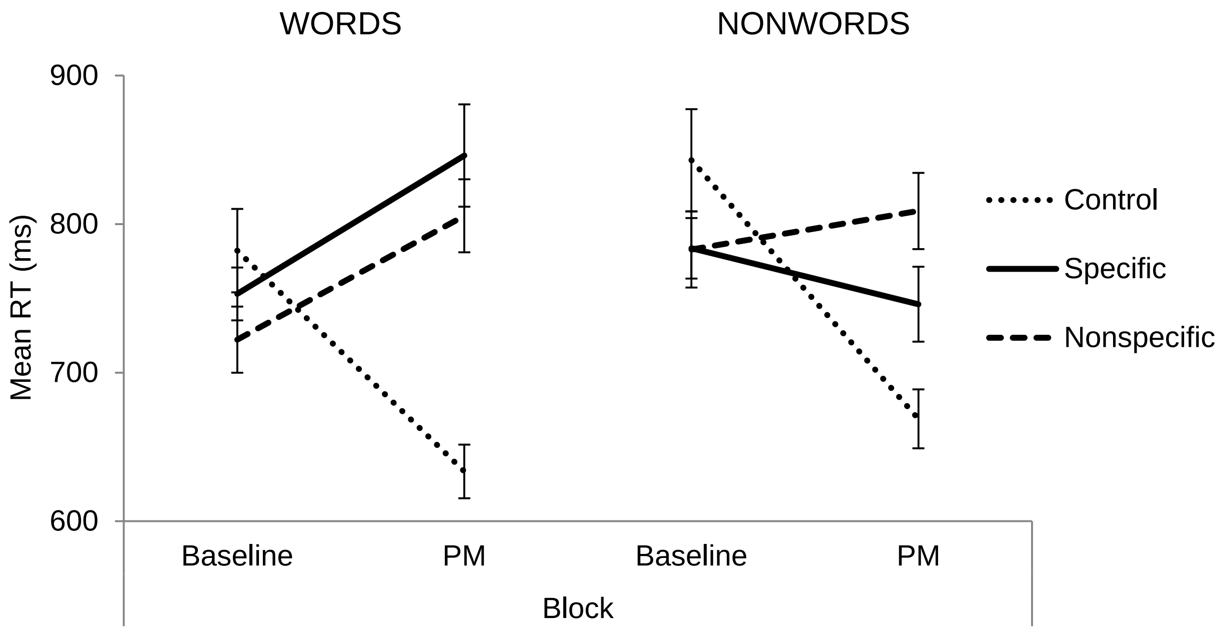

Figure 12: Mean correct response time (RT) in milliseconds (ms) in the lexical decision task as a function of block and condition for words (left) and nonwords (right). Error bars represent ± 1 standard error.

Next, to gain direct evidence for the different pattern of task interference between the specific and nonspecific conditions depending on the type of trial, a 3 x 2 ANOVA with condition (control, specific, nonspecific) as the between-subjects factor, and block (baseline, PM) as the within-subjects factor was conducted for word RTs. Results revealed a highly significant interaction, $F(2, 98) = 31.50$, $MSE = 8{,}818.85$, $p < .001$, $\eta_p^2 = .39$. A follow-up 2 x 2 (Condition x Block) ANOVA comparing the control and specific conditions showed that task interference was highly significant, $F(1, 61) = 44.15$, $MSE = 10{,}220.37$, $p < .001$, $\eta_p^2 = .42$, for the interaction. That is, the difference between ongoing task RTs from the baseline to the PM block changed as a function of whether participants held an intention or not. A similar ANOVA comparing the control and nonspecific conditions yielded a highly significant interaction, $F(1, 63) = 74.49$, $MSE = 5{,}705.45$, $p < .001$, $\eta_p^2 = .54$, again indicating the presence of task interference. By contrast, the comparison between the specific and nonspecific conditions revealed only a main effect of block, $F(1, 72) = 27.85$, $MSE = 10{,}355.68$, $p < .001$, $\eta_p^2 = .28$, such that RTs were longer for the PM than the baseline block ($F < 1$ for the interaction). Thus, having a nonfocal PM task led to noticeable slowing in word trials, and similarly so for the two PM conditions.

The 3 x 2 ANOVA for nonword RTs also revealed a highly significant interaction, $F(2, 98) = 25.58$, $MSE = 6{,}261.79$, $p < .001$, $\eta_p^2 = .34$. Follow-up 2 x 2 (Condition x Block) ANOVAs were conducted to examine cost for nonwords in each of the PM conditions relative to the control condition. Task interference was highly significant in the specific condition, $F(1, 61) = 23.64$, $MSE = 6{,}079.47$, $p < .001$, $\eta_p^2 = .28$, for the interaction. This was also the case for the nonspecific condition, $F(1, 63) = 49.62$, $MSE = 6{,}367.16$, $p < .001$, $\eta_p^2 = .44$, for the interaction. Crucially, and in contrast with word trials, comparison between the specific and nonspecific conditions revealed a significant interaction, $F(1, 72) = 5.91$, $MSE = 6{,}324.05$, $p = .018$, $\eta_p^2 = .08$. Thus, as expected, specifying the target context affected task interference in nonword trials, such that cost on these trials was reduced when the intention was associated with a specific context (i.e., word trials).

To directly test that task interference in the specific condition changed on a trial-by-trial basis as a function of the relevance of the type of trial for the intention, RTs in the specific condition were included in a 2 x 2 x 2 ANOVA with condition (control, specific) as a between-subjects factor, and block (baseline, PM) and trial type (word, nonword) as the within-subjects factors. Results revealed a significant three-way interaction, $F(1, 61) = 10.34$, MSE = 4,141.68, $p = .002$, $\eta_p^2 = .15$. Figure 12 suggests that this result was obtained because task interference (i.e., slowing from the baseline to the PM block in the specific relative to the control condition) was greater for words than nonwords. Follow-up 2 x 2 (Condition x Trial Type) ANOVAs revealed that, as expected, for the baseline block there was only a main effect of trial type, $F(1, 61) = 9.01$, MSE = 7,014.27, $p = .004$, $\eta_p^2 = .13$, such that RTs were longer for nonwords than for words as is commonly found with LDTs ($F < 1$ for the interaction). By contrast, for the PM block there was a highly significant interaction, $F(1, 61) = 31.10$, MSE = 4,555.28, $p < .001$, $\eta_p^2 = .34$. Whereas RTs were longer for nonwords than words in the control condition ($p = .009$), the opposite was true for the specific condition ($p < .001$) where the relevant word trials displayed longer RTs instead (see Figure 12). Thus, these results clearly demonstrate that explicitly instructing participants about the specific ongoing task trials that were relevant for the PM task produced trial-by-trial changes in task interference as a function of the relevance of the type of trial for the intention.[22]

Because the eight PM targets were consistently presented in word trials only, another interest of the present study was to examine whether the pattern of task interference found for word and nonword trials remained constant throughout the course of the ongoing task. Did participants in the nonspecific condition develop awareness that targets were presented in only word trials, despite their expectation, and devote fewer resources to target detection in nonword

[22] Figure 12 suggests that although cost for nonword trials was greater in the nonspecific than in the specific condition, participants in the nonspecific condition appeared to also display slightly greater task interference for words than nonwords. Task interference in the nonspecific condition was investigated by conducting a 2 x 2 x 2 ANOVA with condition (control, nonspecific) as a between-subjects factor, and block (baseline, PM) and trial type (word, nonword) as the within-subjects factors. Results revealed main effects of block, $F(1, 63) = 18.29$, $MSE = 9{,}825.01$, $p < .001$, $\eta_p^2 = .23$, and of trial type, $F(1, 63) = 13.31$, $MSE = 7{,}610.42$, $p = .001$, $\eta_p^2 = .17$, that were qualified by two significant interactions. Namely, there was a block by trial type interaction, $F(1, 63) = 12.08$, $MSE = 2{,}247.61$, $p = .001$, $\eta_p^2 = .16$, indicating that RTs decreased from the baseline to the PM block and more so for nonwords than for words, as well as a condition by block interaction, $F(1, 63) = 75.00$, $MSE = 9{,}825.01$, $p < .001$, $\eta_p^2 = .54$, such that RTs greatly decreased from the baseline to the PM block in the control condition, but increased in the nonspecific condition. Importantly, the three-way interaction was not significant, $F(1, 63) = 1.80$, $MSE = 2{,}247.61$, $p = .185$, thus providing no strong support for differential costs to words and nonwords in the nonspecific condition.

trials as a result? RTs in the two halves of the PM block were compared[23] (see Table 13). A 3 x 2 x 2 ANOVA with condition (control, specific, nonspecific) as a between-subjects factor, and trial type (word, nonword) and PM half (first, second) as the within-subjects factors revealed a main effect of PM half, $F(1, 98) = 56.64$, $MSE = 3{,}985.74$, $p < .001$, $\eta_p^2 = .37$, as participants sped up from the first to the second half. There was also a significant condition by PM half interaction, $F(2, 98) = 5.54$, $MSE = 3{,}985.74$, $p = .005$, $\eta_p^2 = .10$, such that the decrease in RTs was smaller for the control condition (17 ms) than for both the specific and nonspecific conditions, which showed similar decreases in RTs of 63 and 65 ms, respectively. Thus, task interference was reduced from the first to the second half of the ongoing task and similarly so for the two PM conditions. Interestingly, there was no significant three-way interaction ($p = .292$), indicating that the pattern of costs with respect to words/nonwords did not change from the first to the second half of the ongoing task.

Table 13: *Mean Correct Response Time in Milliseconds for Word and Nonword Lexical Decision Filler Trials in the Prospective Memory Block as a Function of Block Half and Condition*

	PM Block Half							
	First				Second			
	Words		Nonwords		Words		Nonwords	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control	643	97	680	113	629	93	661	97
Specific	886	203	775	167	813	221	722	153
Nonspecific	839	174	845	171	780	145	775	155

[23] The same result was obtained when task interference before the first target occurrence was compared to that before the eighth (final) target occurrence.

PM performance. A PM response was scored as correct if the participant pressed the 'F6' key during the target trial or within the next trial. Less than 1% of the PM responses occurred outside these periods. Overall PM performance was examined first. An independent samples *t* test showed that there was no difference in the percentage of targets detected between the specific (M = 78.1, SD = 26.5) and nonspecific (M = 77.0, SD = 25.1) conditions, $t(72) < 1$. The observed levels of performance and the nonsignificant result are consistent with the results found for the LDT. Namely, the analyses reported above demonstrated that task interference was both significant and of similar magnitude for word trials (i.e., trials where the PM targets always occurred) in the two PM conditions.

Finally, because previous studies have shown that a decrease in ongoing task costs, as observed in the present study from the first to the second halves of the PM block, can be associated with reductions in PM performance (e.g., Einstein et al., 2005), detection for Targets 1-4 was compared to that for Targets 5-8 (i.e., targets presented in each half of the PM block). The data were submitted to a 2 x 2 ANOVA with condition (specific, nonspecific) as the between-subjects factor and target (first-half, second-half) as the within-subjects factor. There was only a main effect of target, such that PM performance declined from the first to the last four targets, $F(1, 72) = 4.48$, $MSE = 493.02$, $p = .038$, $\eta_p^2 = .06$ ($F < 1$ for the interaction). Thus, target detection was lower in the second half of the PM block where cost was reduced, and this was similarly the case for the two PM conditions (M_{first} = 81.3% and M_{second} = 75.0% for the specific condition; M_{first} = 81.6% and M_{second} = 72.4% for the nonspecific condition).

Discussion

Results from Experiment 6 showed that associating a nonfocal PM task with a subset of ongoing task stimuli reduced task interference for stimuli not linked to the intention. Importantly, the target context specification effect on task interference was observed even though trial presentation was random and not cued in any way. Moreover, although explicitly instructing participants that the nonfocal PM targets would occur only in a subset of stimuli led to a trial-by-trial reduction in task interference, it did not completely eliminate task interference for irrelevant nonword items. Notably, participants were able to adjust their strategies in approaching the task in accordance with information about the specific ongoing trials where targets can occur without compromising PM performance. This suggests that participants can engage monitoring processes more efficiently when given the chance to do so, such as when target context is clearly specified as was done here.

The presence of task interference for nonword trials when participants were explicitly instructed that these items were irrelevant for the intention (i.e., specific condition) is consistent with Guynn's (2003) proposal that a retrieval mode is engaged across ongoing trials in preparation for the opportunity to execute the intention. Like in Experiment 5, significant cost for irrelevant trials aligns well with evidence suggesting that maintenance of a retrieval mode is associated with increased activation in the frontal cortex and can rely on effortful processing as well as be affected by task switching (e.g., Düzel, 2000; Jostmann & Koole, 2006; Morcom & Rugg, 2002; Nyberg et al., 1995). In addition, slowing was greater for word trials than for irrelevant nonword trials when information about the local target context was available. This strongly suggests that additional processes, such as Guynn's target checking, were recruited in the specific ongoing task trials that were relevant to the intention in order to support intention-related processing.[24] Note that Marsh, Hicks, and Watson (2002) proposed that cue interference

[24] The PAM theory proposes that PM performance is determined by the interaction of preparatory and retrospective memory processes (Smith, 2003; Smith et al., 2007). In its current formulation, recognition checks could account for the greater slowing for word relative to nonword trials found in the specific condition. Thus, preparatory attentional

(i.e., slowing associated with target detection) results from a combination of cognitive processes including cue recognition, verification that the cue and the surrounding context are appropriate for a response, retrieval of the target action, and coordination of ongoing and PM responses. Following Marsh, Hicks, et al. (2002), it is assumed that the additional slowing for relevant trials in the present study was mostly due to the process of verification that occurs once a word trial has been identified as such. Response retrieval and coordination processes should come into play only when the verification yields a positive outcome (i.e., target occurrences).

Of further interest in Experiment 6 was the pattern of task interference across the ongoing task, in that slowing for the PM conditions in comparison to the control was smaller in the second than in the first half of the PM block. This suggests that task interference decreased during the ongoing task and is line with previous findings showing that monitoring is a resource-demanding process that is difficult to sustain over extended periods of time (e.g., Einstein et al., 2005; Loft et al., 2008).[25] Furthermore, regardless of the targets being consistently presented in word trials, there was no qualitative change in the relationship between task interference for words and nonwords across the ongoing task in the nonspecific condition. Because PM instructions explicitly stated that the targets could occur in both trials, perhaps participants developed an expectation that a target in a nonword trial would eventually be presented and/or that an earlier occurrence had simply been missed (cf. Loft et al., 2008). Thus, results suggest that, at least with the number of target occurrences tested here, when participants are not warned that targets will always be presented in a subset of task stimuli, the representation of the target

processes may serve the function of signaling relevant ongoing trials, such that once these trials are encountered, retrospective memory processes that allow for the discrimination between targets and nontargets can be engaged.

[25] Alternatively, one could posit that task interference stayed stable but that difficulty of the ongoing task eased with practice. Given that PM performance was also reduced for the second half of the PM block, and that previous research (e.g., Einstein et al., 2005) has shown that engaging in costly monitoring processes is important for the detection of nonfocal targets, reduction of task interference seems more in line with the present results.

context is not updated to reflect experience with the PM targets – hence target checks will occur regardless of the ongoing trial type.

General discussion

PM studies to date have focused largely on examining the type of process (i.e., monitoring or spontaneous retrieval) required to support PM retrieval. Undeniably, such focus has been useful in increasing our understanding of this type of memory. The pair of experiments presented here focused on another important, but perhaps understudied, issue in PM research, that is, the nature of the monitoring processes. Both Experiments 5 and 6 showed trial-by-trial changes in task interference with a nonfocal PM task when ongoing trials involved the same material and response type (i.e., there was no need to expend resources continuously switching between task sets; cf. Marsh, Cook, et al., 2006b). In particular, Experiment 5 showed that participants were able to modulate their attention depending on the stimulus properties (i.e., color) associated with the intention. It additionally showed that the dynamics of cost for intention-irrelevant trials varied as a function of whether the presentation of these trials was random versus blocked (i.e., every eight trials). Furthermore, Experiment 6 showed that specifying the PM target context reduced cost to items irrelevant to the intention (nonwords) while leaving PM performance intact. These results suggest that stimulus processing can be modulated according to participants' expectations about the lexical properties of the target, with trial-by-trial changes in task interference as a function of stimulus relevance to a nonfocal intention observed as a consequence.

In both Experiments 5 and 6, specifying the intention-relevant items at instructions reduced, but did not completely eliminate, the cost of holding a PM task for intention-irrelevant trials (i.e., color mismatch and nonword trials, respectively). By contrast, Cohen et al. (2012)

found no significant cost for ongoing task trials that were not relevant to the intention. Accordingly, the authors proposed that participants were able to selectively attend to those stimuli that matched some of the PM targets' properties and filter out those that were not potential targets (stimulus specific interference effect). However, across all three of Cohen et al.'s (2012) experiments the difference was in the direction of such a cost for intention-irrelevant trials. It is possible that the failure to find significant task interference was due to insufficient statistical power. In addition, interpretation of findings is complicated by the fact that ongoing task accuracy was not reported and therefore a speed–accuracy tradeoff cannot be ruled out (see Smith, 2010; Smith et al., 2007). By contrast, as Experiment 6 used a nonfocal PM task that is known to be demanding (e.g., Meeks et al., 2007), one could also posit that the different outcomes between this and Cohen et al.'s study were due to the different PM tasks. However, there have been previous reports of significant ongoing task cost for nonwords under PM demands similar to those of Cohen et al. (2012) (e.g., Loft & Yeo, 2007; Smith, 2003).

Regardless, all three studies clearly show that task interference can vary as a function of trial type when the nature of the upcoming stimulus cannot be predicted. They also suggest that trial-by-trial changes in task interference are not the sole result of the explicit (Experiments 5 and 6) or implicit (Cohen et al.'s, 2012, study) nature of the PM task instructions. Still, it is possible that the capacity to spontaneously modulate the deployment of attention according to stimulus relevance to an intention varies between individuals and that, all experimental conditions being equal, using explicit instructions reduces the variability of strategies used to approach the task (e.g., by providing a strong cue for how to flexibly allocate attention to minimize ongoing task interference).

Considering the mechanisms that might underlie the present trial-by-trial modulations of task interference, findings from Experiments 5 and 6 converge to suggest that top-down attentional control processes, as well as stimulus-driven processes to a lesser degree, caused the trial-by-trial changes in task interference in the present paradigms (e.g., Guynn, 2003). In feature-based selective attention tasks, it has been reasoned that a goal-directed attentional set is formed when one has knowledge in advance about the target-defining features. It is assumed that this set is involved in the top-down cognitive selection of stimuli and responses to reflect the individual's expectations or goals and is associated with the recruitment of dorsal frontoparietal regions (Corbetta & Shulman, 2002; Langton & Bruce, 1999; Mulckhuyse & Theeuwes, 2010). In similar fashion, it is proposed here that people will rely on available information about the target context (e.g., target-defining features, such as color or lexicality in the present experiments) to establish an attentional set at the outset of the task that combines ongoing and PM task representations. Attention allocated to ongoing task stimuli will therefore depend on the individual's expectations or goals. These ideas are elaborated in more detail below.

Experiment 5 showed that task interference increased for intention-irrelevant trials in anticipation of the relevant context in the blocked condition, even though all irrelevant stimuli in the sequence were perceptually similar and the occurrence of the relevant context was not cued in any way. These findings strongly suggest the action of a supervisory attentional system (Shallice & Burgess, 1991), or a similar executive control mechanism, that supports the increase in the amount of attentional resources deployed to the PM task in preparation for the context where targets can occur and at the expense of ongoing task processing. Notwithstanding, capture of attention in a relatively automatic or reflexive stimulus-driven way has been associated with the presence of exogenous cues or salient stimuli (e.g., Langton & Bruce, 1999; Mulckhuyse &

Theeuwes, 2010). As intention-relevant stimuli were associated with a specific color in Experiment 5, it is possible that attention towards relevant items was initially captured in a stimulus-driven way through a relatively automatic or reflexive process. On detecting a relevant marker, a more top-down attentional control would then direct attention to the PM task to meet the individual's goals (cf. Mulckhuyse & Theeuwes, 2010). Consistent with this idea, J. B. Knight et al. (2010) recently reported electrophysiological data showing attentional modulations associated with color processing of incoming stimuli in a manner consistent with the target attributes and as early as 140 and 220 ms post-stimulus. Interestingly, in Experiment 6 (and unlike Experiment 5 or other previous studies; e.g., Guynn, 2003; Marsh, Cook, et al., 2006b), the nature of the upcoming trial was not cued in any way, and relevant and irrelevant stimuli were perceptually similar as they could be distinguished only on the basis of lexicality. Hence, environmental cues such as color could not have determined, and/or contributed to, the allocation of attention to relevant ongoing stimuli (Guynn, 2003). Instead, results from Experiment 6 suggest that trial-by-trial changes in task interference can also occur mainly as the result of top-down attentional control processes (Guynn, 2003; J. B. Knight et al., 2010).

Thus, it is proposed in this chapter that top-down control will be exercised to modulate the deployment of attentional resources according to PM demands, such that additional attentional resources will be recruited to evaluate whether the stimulus is or is not a cue to perform the PM action when relevant, but not irrelevant, items are presented. However, when a distinction between relevant and irrelevant stimuli is not possible (e.g., when target context is not specified; nonspecific condition of Experiment 6), the pattern of costs should be similar across trials. Moreover, results from Experiment 5 additionally suggest that the allocation of attention can sometimes be at least partially stimulus-driven (e.g., J. B. Knight et al., 2010). As discussed above, target-defining features such as color can capture attention at an early stage of processing followed by a more top-down attentional control in accordance with the individual's goals.

Note that the present experiments did not intend to distinguish between the PAM and multiprocess theories. Rather, they aimed to provide a more detailed examination of the processes contributing to task interference with nonfocal intentions. Using two very different paradigms, it was demonstrated that monitoring processes can change flexibly such that trial-by-trial modulations in task interference will be observed as a function of stimulus relevance for the intention. The present results were interpreted in terms of Guynn's (2003) two-process model of strategic monitoring. However, it is important to note that, similar to Guynn (2003), Marsh and colleagues (Hicks et al., 2005; Marsh, Cook, et al., 2006b; Marsh et al., 2005) have also argued that attentional processes are dynamic. They assumed that participants establish a global attentional allocation policy at the outset of the ongoing task and that there can be local changes in task interference due to material-specific processing and to attention and effort naturally waxing and waning over the course of the ongoing task as a result of irrelevant thoughts or interruptions. Accordingly, in the current experiments it could be argued that ongoing stimuli that were initially classified as irrelevant for the PM task were processed more efficiently (e.g., quicker rejection of nonwords as targets in Experiment 6). However, the results in this chapter are at odds with Marsh, Cook, et al.'s (2006b) proposal that for item-level changes in task interference to be observed, participants must be able to predict the nature of the upcoming trial. The present results suggest that such forewarning might be particularly crucial with paradigms that involve task switching between more than one type of ongoing task judgment (e.g., Marsh, Cook, et al., 2006b). For instance, cuing could allow selection of the appropriate response set, ensuring that top-down attentional control is exercised to modulate resource allocation according to PM demands, and not, instead, to suppress irrelevant responses when the stimulus is presented.

Chapter 6: The Role of Implicit Demands in PM

Chapter 5 demonstrated that explicit information about target-defining features influences the extent to which attentional resources are devoted to intention-related processing throughout the ongoing task, and highlighted the flexible nature of attention allocation with nonfocal PM tasks. This chapter explored whether implicit information about the PM task demands can also affect participants' strategies in approaching the task. Consider the act of forming an intention: what information do people use to decide how much effort they should expend to ensure that the intention will be successfully remembered? And how capable are people in dealing with unforeseen changes to planned intentions? To illustrate, consider the intention to fill a prescription. One might anticipate that the sight of a pharmacy sign on the way home would easily cue remembering of the intention. However, one might fail to fill the prescription if the (expected) neon sign of the pharmacy is not working and the shop no longer captures attention.

Recent findings on the role of metacognition in PM have suggested that people's estimates about their likelihood of successfully fulfilling intentions are generally well calibrated (e.g., R. G. Knight, Harnett, & Titov, 2005; Meeks et al., 2007; Schnitzspahn, Zeintl, Jaeger, & Kliegel, 2011). To determine the likelihood of success, participants rely on metacognitive beliefs about the cognitive demands of the entire task set (i.e., ongoing and PM activities) and their ability to perform the upcoming tasks (Einstein & McDaniel, 2008; Marsh et al., 2005; Meeks et al., 2007). These beliefs will influence the attention allocation policy established by participants at the outset of the task, which specifies the relative weighting of attention to the ongoing and PM tasks (Hicks et al., 2005; Marsh et al., 2005, 2003; see also Einstein et al., 2005; Smith, 2003). The key question in the present study was whether available information about potential target events has any bearing on how attentional resources are devoted to the PM task.

Studies have shown an increase in task interference (i.e., slowing to the ongoing task) when PM task difficulty is increased by changing objective task demands such as number of targets or specificity of intentions (e.g., Cohen, Jaudas, et al., 2008; Hicks et al., 2005). Also, in Experiment 6 (Chapter 5 of this thesis) it was shown that when target context was not specified, task interference for intention-irrelevant trials increased relative to when specific information about the target context was provided. Similarly, when PM tasks are nonfocal (i.e., ongoing task processing does not direct attention toward processing the relevant features of the target), individuals devote extra resources to remembering the intention (e.g., Einstein et al., 2005; Scullin, McDaniel, Shelton, et al., 2010). Another approach has involved manipulating anticipated task demands through explicit instructions while leaving objective task demands intact. For instance, instructing participants that the PM task is more important than the ongoing task affects attention allocation as evidenced by an increase in both task interference and PM performance (e.g., Einstein et al., 2005; Kliegel et al., 2004). More recently, Boywitt and Rummel (2012, Experiment 1) manipulated anticipated task demands by instructing participants that targets would be presented for only 10% of all participants (or 90% in another condition). Using a diffusion model analysis, the authors showed that participants who expected the probability of target presentation to be low were less cautious in their responding. Thus, participants’ strategic approach to performing the ongoing task depended on anticipated PM task demands.

Experiment 7

Experiment 7 addressed the question of whether implicit PM task demands can affect participants' effort and success in a nonfocal PM task. Rather than manipulating expected PM demands using explicit instructions – as in all prior work – a categorical (nonfocal) PM task was used and the particular target exemplars (typical vs. atypical) presented prior to the experimental trials were varied. It was predicted that when asked to give a PM response to animal words during an ongoing LDT, participants instructed using typical exemplars of the target category (i.e., exemplars that are fluently processed and easily accessible in memory; Koriat, Bjork, Sheffer, & Bar, 2004) would expect to successfully accomplish the PM task with low effort and thus display smaller ongoing task costs than those instructed using atypical exemplars. Critically, objective task demands were kept constant such that all PM targets presented during the ongoing task were atypical animals. Hence, it was additionally predicted that participants presented with typical exemplars at encoding would perform worse on the PM task because successful PM performance in nonfocal tasks requires the engagement of attention-demanding processes (e.g., Einstein et al., 2005).

Finally, it was examined whether incongruence between expected and actual PM task demands can lead to local changes in participants' attention allocation policy. Can individuals adjust their strategies if their expectations regarding the PM targets are incorrect? It was predicted that participants given typical exemplars (low expected PM demands) would adapt to the new demands and show increased task interference after realizing that targets could be atypical instances.

Method

Design and participants. The design was a 3 x 2 mixed factorial, with expected PM demands (high, low, none) as the between-subjects factor, and block (baseline, PM) as the within-subjects factor. Participants were 90 undergraduate students (39 female) aged 18-23 years (M = 20.8, SD = 1.0). Thirty participants were randomly assigned to each of the three conditions. Testing took place individually in sessions lasting approximately 25 min.

Materials and procedure. Participants were first told about the LDT. Instructions stated that they had to decide as quickly and accurately as possible whether a string of letters was a word (‘J’ key press with right index finger) or not (‘F’ key press with left index finger). Following the opportunity to ask questions, participants performed 20 practice trials and then a baseline block (see Table 14) consisting of 10 buffer trials and 100 lexical decision trials (50 words and 50 nonwords).

Next, participants were told that they would perform a second block of the LDT, and additionally given the PM instructions. Those in the high and low expected PM demands conditions were given the same PM task of responding to animal words, but were presented with different animal exemplars at both instructions and practice. These were atypical exemplars (*walrus* and *raccoon*) or typical exemplars (*dog* and *mouse*) in the high versus low expected PM demands conditions, respectively. Specifically, participants were instructed that if they ever saw an animal word (e.g., “WALRUS” or “DOG”, included in brackets according to condition) they should press the ‘Y’ key after they made their lexical decision or as soon thereafter as they could. Participants explained the instructions to the experimenter before completing 20 practice trials, which included the presentation of an animal word (*raccoon* or *mouse*, according to condition) on Trial 15. To create a delay between PM task instructions and the start of the PM block, participants completed the DSST (Wechsler, 1981) and a demographic questionnaire. Those in the no PM demands condition went through the same procedure except that they did not receive the PM task instructions. The PM block comprised 10 buffer trials and 260 lexical decision trials, of which 256 were filler trials (128 words and 128 nonwords) and four were PM trials. PM targets (all atypical animals) were presented on Trials 101, 152, 203 and 254 (*puffin*, *gazelle*, *boar*, and *hyena*,[26] respectively).

[26] Before being debriefed, participants in the PM groups were asked to fill in typicality ratings on a scale from 1 (very typical animal) to 5 (very atypical animal). As expected, *dog* and *mouse* (M = 1.5, SD = 0.4) were rated as more typical than *walrus* and *raccoon* (M = 3.9, SD = 0.6) and *puffin*, *gazelle*, *boar*, and *hyena* (M = 3.2, SD = 0.4), and the two PM groups did not differ in their ratings.

Table 14: *Illustration of the Main Design and Procedure for Participants with High, Low and None Expected Prospective Memory (PM) Demands, with Typicality of Animals Indicated in Italics*

	Expected PM Demands		
	High	Low	None
Baseline Block	Lexical Decision Task (LDT)		
PM Instructions	Press “Y” to animal words (e.g., WALRUS) *Atypical*	Press “Y” to animal words (e.g., DOG) *Typical*	---
Practice (1 target)	LDT + PM task ...….raccoon...…. *Atypical*	LDT + PM task ...….mouse...…. *Typical*	LDT
Delay	DSST + Questionnaire		
PM Block (4 targets)	LDT + PM task ...….puffin...….gazelle...….boar...….hyena...…. *Atypical*		LDT

Each trial consisted of a fixation cross presented for 250 ms, followed by the letter string in lowercase (30-pt font) until classified as a word/nonword, and finally a *waiting* message until the spacebar was pressed. Filler words in the LDT, matched with the PM targets on mean length, syllables, and frequency, were 4–7 letters, 1–3 syllables, and HAL frequency 5.5–7.5 according to Balota et al. (2007); nonwords with 4–7 letters were selected from the same source. At the end of the PM block, participants completed a questionnaire to test their recall of the intended action. Recall was perfect for all participants.

Results

Two participants in the high expected demands condition who were more than 2.5 *SD*s from their group's mean RT in the ongoing task were excluded. As is commonly observed in LDTs, performance was highly accurate with 93% of words identified correctly and no significant differences across conditions. Based on previous PM research (e.g., Knight et al., 2011), word RTs were trimmed to include only correct responses to words that were less than 2.5 *SD*s away from each participant's mean. Trimming was done separately for the baseline and PM blocks (PM targets and the trial immediately following each of the targets were excluded) and resulted in the elimination of 2.6% of correct RTs.

The main question of interest was whether implicit information about the PM targets at instructions/practice can influence expectations about PM task demands as reflected by task interference. Mean RTs on filler word trials (see Figure 13) were included in a 3 x 2 mixed ANOVA with expected PM demands (high, low, none) as the between-subjects factor and block (baseline, PM) as the within-subjects factor. Neither main effect was significant (*p*s > .2) but the interaction was highly significant, $F(2, 85) = 17.48$, $MSE = 3{,}731.21$, $p < .001$, $\eta_p^2 = .29$. Two further mixed 2 x 2 (Expected PM Demands x Block) ANOVAs for high versus low PM demands conditions, and low versus none PM demands conditions, were therefore conducted. Both yielded highly significant interactions ($p = .006$ and .003, respectively). The PM block was also divided into four subsets (i.e., correct word trials preceding each PM target; see Figure 14) and ongoing task cost was examined for the first subset, namely, trials occurring before the first target presentation. The pattern of results was similar to that from the overall task interference analysis, with a significant interaction for the 3 x 2 ANOVA ($p < .001$), a significant interaction for the high vs. low demands ANOVA ($p < .002$), but this time only a marginally significant interaction for the low vs. none demands ANOVA ($p = .074$). Therefore, in line with predictions, ongoing task cost was influenced by the manipulation of implicit PM task demands such that task interference in the low expected demands condition was significantly lower than in the high demands condition and this was evident overall and before the first PM target occurrence.

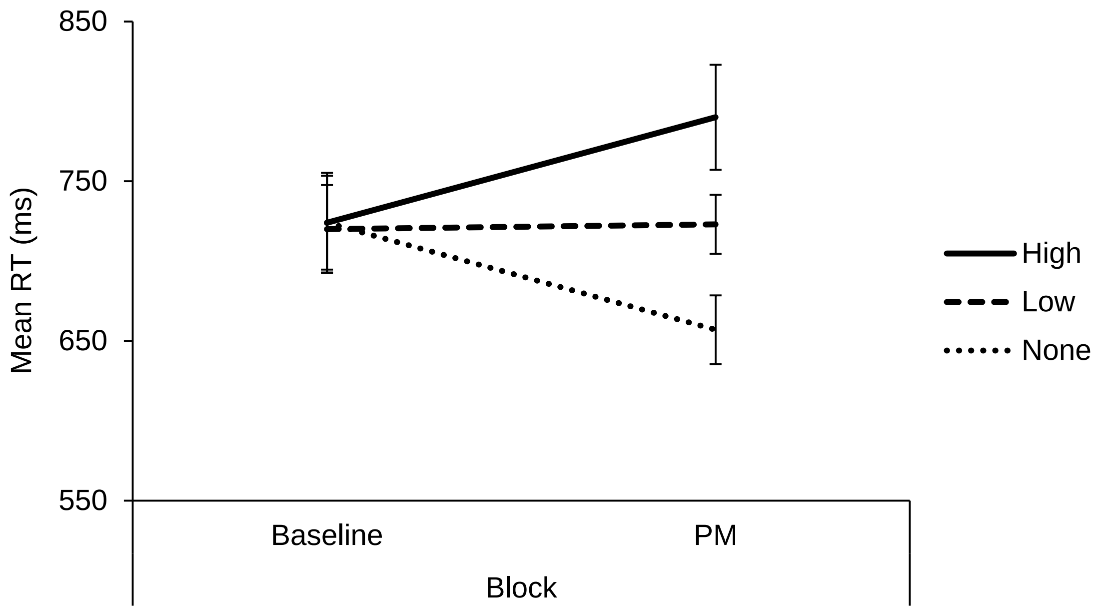

Figure 13: Mean correct response time (RT) in milliseconds (ms) for lexical decisions to filler words for high, low and none expected prospective memory (PM) demands conditions across blocks. Error bars represent ± 1 standard error.

While actual PM task demands did not differ between conditions, targets were consistent with expectations in the high but not in the low demands condition. Thus an important question is whether participants in the low demands condition adjusted their allocation of attention when PM task demands turned out higher than expected. To examine if task interference changed from the first to the fourth PM block subset, filler word RTs were included in a 2 x 4 mixed ANOVA with expected PM demands (high, low) as the between-subjects factor and PM block subset (1-4) as the within-subjects factor (see Figure 14). There was neither a main effect of PM subset, $F < 1$, nor an interaction, $F(3, 168) = 1.51$, $p = .215$. Thus, RTs remained stable throughout the PM block in both PM conditions.

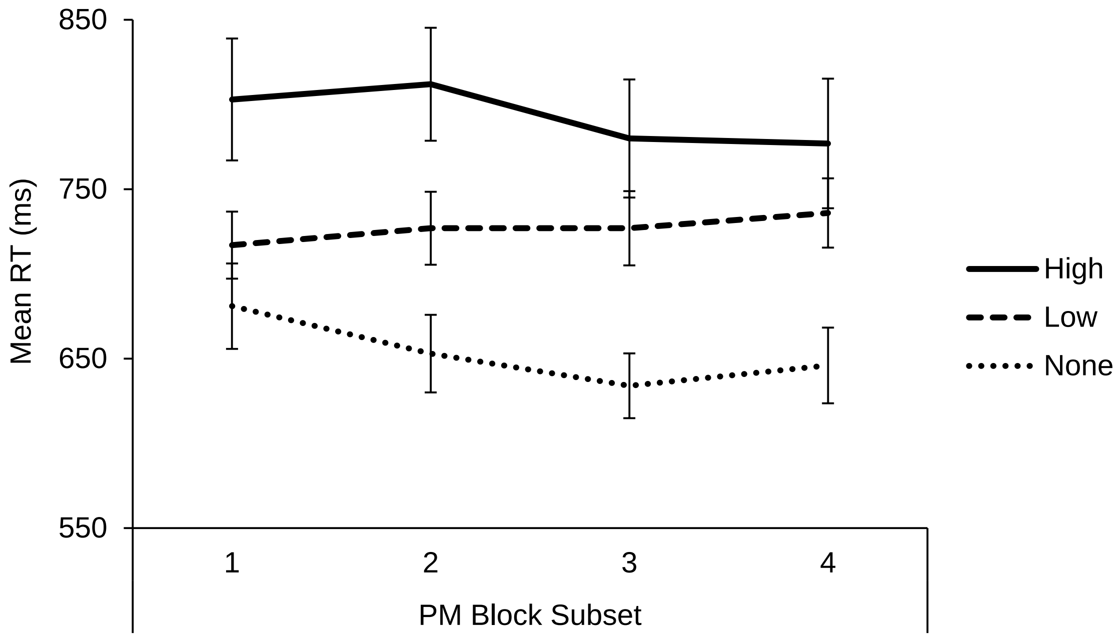

Figure 14: Mean correct response time (RT) in milliseconds (ms) for lexical decisions to filler words across conditions and subsets in the prospective memory (PM) block. Error bars represent ± 1 standard error.

The overall pattern of RTs suggests that participants in the low expected demands condition allocated fewer resources to the PM task and also failed to adapt to the higher than expected attentional demands posed by the task. However, of particular interest here is examination of task interference according to success to the first target presentation in the low expected demands condition. Did participants who successfully detected the first target (n = 12) show subsequently increased task interference in comparison to those who failed (n = 18)? RTs in the low expected demands condition were included in a 2 x 2 mixed ANOVA with first target (success, failure) as the between-subjects factor and PM block subset (1 vs. 2) as the within-subjects factor. Results revealed a significant interaction, $F(1, 28) = 8.60$, $MSE = 64{,}211.91$, $p = .007$, $\eta_p^2 = .24$, such that there was slowing from trials preceding to those succeeding the first target when target detection was a success (*M*s = 711 and 765 ms, *SD*s = 93 and 121, respectively; $t(11) = -2.84$, $p = .016$), but not when it was a failure (*M*s = 722 and 701 ms, *SD*s = 120 and 112, respectively; $t(17) = 1.25$, $p = .230$).[27]

Having shown that manipulation of expected PM demands affected attention allocation policies, it is examined next whether it also affected PM task performance (Figure 15). PM responses were scored as correct if participants pressed the ‘Y’ key during the target trial or within the next trial. A 2 x 4 mixed ANOVA with expected PM demands (high, low) and PM target (1-4) as between- and within-subjects factors revealed an effect of expected PM demands, $F(1, 56) = 8.34$, $MSE = 0.44$, $p = .006$, $\eta_p^2 = .13$, such that PM performance was significantly better with high than with low expected demands (.64 vs. .39) with no other significant effects (both *p*s > .3).

[27] Some readers might be concerned that this pattern could also be explained by monitoring being reinstated following detection of the first target (cf. Scullin, McDaniel, Shelton, et al., 2010). This analysis was therefore repeated while also including expected PM demands (high, low) as a between-subjects factor. Although there was a reduced number of participants (six) missing the first target in the high demands condition, the three-way interaction was marginally significant, $F(1, 54) = 2.83$, $MSE = 3{,}108.34$, $p = .098$, $\eta_p^2 = .05$. In the high expected demands condition (contrary to the low) there was no greater slowing from trials preceding to those succeeding the first target when target detection was successful (791 to 799 ms) relative to when it was unsuccessful (847 to 859 ms). These data are consistent with the interpretation of the results as reflecting an adjustment of the attention allocation policy following realization that targets could be atypical exemplars.

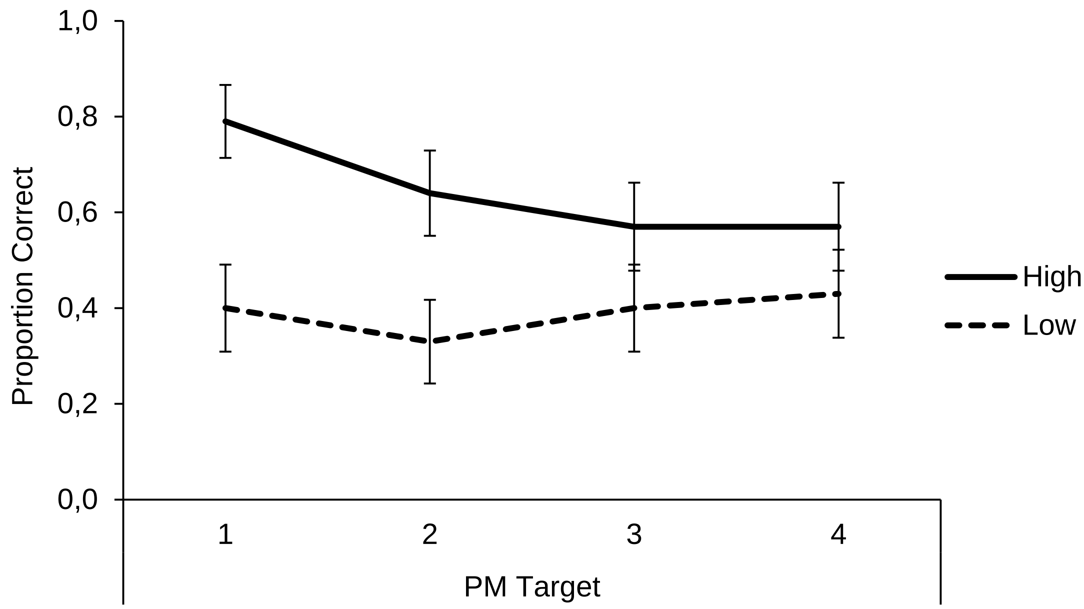

Figure 15: Mean proportion correct for the prospective memory (PM) task across conditions for each of the four PM targets. Error bars represent ± 1 standard error.

Discussion

The present data show that implicit PM task demands can affect participants' effort and success in a PM task. Specifically, those given typical exemplars at encoding (low expected demands condition) showed less task interference and worse PM performance than those given atypical ones, suggesting that participants take into account implicit information regarding task difficulty when allocating attention to the intention. Crucially, the results also demonstrate that, although biased expectations can harm PM performance when actual demands turn out higher than expected, participants can adapt following target experience.

Experiment 7 provides novel evidence that detecting PM targets that are inconsistent with implicit demands can elicit local changes in attention allocation. Specifically, participants in the low expected demands condition who detected the first PM target (hence realizing that targets could be atypical exemplars) showed an increase in ongoing task RTs following this first target and also went on to perform similarly to those in the high expected demands condition (.67 vs. .64 success to Target 2). This extends previous research showing that individuals can adjust the amount of attention devoted to the intention when monitoring goes unreinforced due to the lack of PM target occurrences (e.g., Boywitt & Rummel, 2012; Loft et al., 2008; Scullin, McDaniel, Shelton, et al., 2010), and also that trial-by-trial changes in the allocation of attention can occur. For example, task interference can change flexibly as a result of changes in the effort toward an ongoing task (Marsh et al., 2005) or an item's relevance for the PM task (e.g., Experiments 5 and 6 in Chapter 5; Marsh, Cook, et al., 2006b). The present results provide support to the proposal that attention allocation is flexible, such that experience with the ongoing and the PM task can also change the policy over time (Hicks et al., 2005; Marsh et al., 2005).

In addition, participants were presented with an atypical/typical category exemplar at both instructions and practice. Previous research suggests that learners' metacognitive beliefs about how item characteristics affect memorability are sensitive to task experience (e.g., Tullis & Benjamin, 2012). By analogy, it is assumed that intention retrieval during practice may have strengthened participants' beliefs about the difficulty/ease of successfully fulfilling the intention. Future research could examine whether target exemplars presented at instructions (i.e., at the time of intention formation) guide attention allocation or whether metacognitive beliefs about the difficulty of completing the PM task are also determined by direct task experience during practice. Although the present study does not isolate the locus of the effect more precisely, it does demonstrate that information about particular target exemplars influences the amount of attention devoted to a categorical intention and thereby impacts task interference.

It is argued here that worse PM performance in the low relative to the high expected demands condition was due to differences in attention allocation policies. Alternatively, it could be claimed that worse PM performance in the low demands condition (typical exemplars at encoding) was due to the mismatch between encoding and retrieval contexts (Tulving & Thomson, 1973). Participants might have generated animal exemplars at encoding (Ellis & Milne, 1996) and, because all PM targets were atypical animals, doing so would facilitate recognition of targets for individuals in the high demands condition only. Even if it is assumed that participants spontaneously generated category exemplars at encoding, and that in the high demands condition these were the same items later presented, the context matching account is inconsistent with the observation that implicit demands affected task interference prior to any target occurrence. If participants disregarded the information about the target exemplars when allocating attention to the PM task, there should have been no difference in the representation of the intention in memory and, accordingly, no cost differences between low and high expected demands conditions. Therefore, the most parsimonious explanation of the results is that reduced PM performance for the low demands condition was primarily due to participants allocating insufficient resources to meet actual task demands.

Finally, note that the term “implicit demands” means that participants were not, at any point, explicitly instructed with respect to the demands of the PM task. Instead, demands were conveyed implicitly by providing participants with particular exemplars of PM targets before ongoing task performance. It is not claimed here that the effect of target exemplars on attention allocation occurred without individuals’ conscious apprehension, although it is acknowledged that this is a possibility. As proposed by Hicks et al. (2005, p. 442) “[t]he setting of an initial attentional allocation policy need not be conscious, but may represent a metacognitive strategy about how to approach the entire task set, and therefore, not necessarily be accessible to conscious awareness”.

In sum, the results from Experiment 7 showed that implicit demands affected participants' attention allocation policies such that task interference was greater for the high than low demands condition. Also, PM performance was reduced in the low relative to the high demands condition. Participants in the low demands condition who succeeded to the first target showed a subsequent increase in task interference, suggesting adjustment to the higher than expected demands. This is the first study to demonstrate that implicit information regarding the PM task can affect ongoing task processing as well as harm PM performance when actual demands are higher than expected. Furthermore, in line with the proposal that attention allocation is a dynamic and flexible process, results showed that PM task experience can trigger changes in ongoing task interference.

Chapter 7: The Effect of Target Repetition on PM

The question of whether PM retrieval can rely on spontaneous retrieval processes remains one of the most contentious, yet most fundamental, within the PM literature (e.g., Einstein & McDaniel, 2010; Smith, 2010). For the most part, this question has been addressed by examining PM retrieval under conditions of no ongoing task cost. By contrast, in this chapter the goal was not to examine PM when monitoring processes were absent. It is proposed here that the presence of spontaneous retrieval processes can be inferred from finding an increase in PM performance at no extra cost to ongoing task performance. As in previous chapters, the approach was again to focus on ongoing task processing to examine the process(es) that support PM retrieval.

In event-based PM tasks, people rely on external cues to signal that it is appropriate to perform an intended action. Notably, in real-world situations an intention can often be triggered by multiple cues. Consider the PM task of picking up your toddler from nursery on your way home. Although the child's car seat, a toy in the car, or a direction sign to the nursery might all act as cues to retrieve the intention, the execution of this important task might be consistently associated with only one of the possible cues (e.g., the sight of the child's seat on your back seat). Such repeated retrieval of the intention in response to a particular cue is likely not only to decrease the possibility of failing to execute the intention, but also to reduce the need to engage resources to monitor for the PM task. In addition, what happens when the intention to pick up the child from nursery must be accomplished in response to a different, infrequent cue (e.g., imagine the child's seat had to be removed for cleaning or you happened to change car with your partner for the day)? Although past investigations have devoted considerable attention to exploring how the nature of the intention or experience with the ongoing activity influence performance (e.g., Cohen, Jaudas, et al., 2008; Einstein et al., 2005; Kliegel et al., 2004; Loft et al., 2008; see also

Chapter 6 in this thesis), the question of how experience with the target cues affects prospective remembering has gained little attention.

A new approach for examining PM retrieval via spontaneous retrieval processes

The PAM theory (Smith, 2003; Smith et al., 2007) and the multiprocess view (Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel, Guynn, et al., 2004) constitute the two major theoretical views of the processes underlying prospective remembering. To recap briefly, the PAM theory claims that PM retrieval must always rely on nonautomatic preparatory attentional processes. By contrast, the multiprocess view proposes that, in addition to effortful strategic processes such as monitoring, successful target detection may sometimes rely on spontaneous retrieval processes. This theory proposes that spontaneous retrieval can occur through two different mechanisms: a reflexive associative process or a discrepancy-plus-search process (see Chapter 1 for a review).

As discussed in Chapter 1, to distinguish between the claims of the PAM and multiprocess theories, an important line of research has focused on determining whether preparatory attentional processes are always necessary for successful PM performance by examining target detection under conditions of no task interference (e.g., Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, et al., 2010; Smith, 2010). For instance, Scullin, McDaniel, and Einstein (2010) showed high PM performance levels with a focal, but not a nonfocal, target when monitoring was eliminated in close proximity to the targets, suggesting that focal PM can rely on spontaneous retrieval processes. Undeniably, examining PM performance under conditions that discourage devoting attention to the PM task has been a fruitful approach. Importantly, Einstein and McDaniel (2010; see also Einstein et al., 1997) have argued that when individuals can rely on both monitoring and spontaneous retrieval processes, PM performance should be enhanced. Hence, it is suggested that an equally important yet unexplored approach is to develop paradigms that stimulate an increase on PM performance in the absence of a concomitant increase in task interference. In particular, results showing an increase in target detection but no evidence of extra ongoing task cost would provide evidence that prospective remembering relied on spontaneous retrieval processes.

Experiment 8

In the present experiment, participants were given the PM task of pressing a designated key to a set of six target words (learned to criterion at instructions) in the context of a LDT. Previous research already established that engaging in resource-consuming monitoring processes is necessary for high levels of PM performance under conditions that impose significant cognitive load, such as when multiple targets are used as in the present experiment. However, unlike previous studies (e.g., Cohen, Jaudas, et al., 2008; Einstein et al., 2005; Loft et al., 2008; Marsh, Hicks, et al., 2002; Smith, 2003), the present experiment manipulated whether each target occurrence consisted of a different target or whether one of the targets in the set was repeatedly presented (see Table 15). It was anticipated that target repetition within a set would stimulate retrieval of the intention through a discrepancy-plus-search process and boost PM performance relative to when no targets were repeated (i.e., when retrieval must rely primarily on strategic processes). Note that focal cues were used, which according to the multiprocess perspective can promote spontaneous retrieval (Einstein & McDaniel, 2010; Einstein et al., 2005). Hence, the focus was not to examine performance when cost-inducing monitoring processes were absent, but rather to manipulate target repetition within a set with the aim of creating conditions in which successful PM performance could be achieved through relatively automatic processes.

In Experiment 8, participants were instructed to respond to multiple PM targets, but whereas for some participants all studied targets were presented (i.e., a different target occurred at every target presentation), for others the same target was repeatedly presented up to the final presentation where a different target occurred. Hence, frequency of target presentation was kept constant and target experience was manipulated by varying the particular PM targets (within the set of studied items) that were presented during the ongoing activity (cf. Czernochowski, Horn, & Bayen, 2012; Einstein, McDaniel, Smith, & Shaw, 1998; Ellis, Kvavilashvili, & Milne, 1999; Loft et al., 2008). The present experiment aimed to address several questions. These are considered next.

Harrison and Einstein (2010) recently showed high levels of PM performance in the absence of monitoring when a single, highly salient target event was used. In this vein, target repetition might improve PM by enhancing retrieval of the intention through spontaneous retrieval processes. It is speculated that repetition might cause the target item to be processed more fluently relative to the surrounding context, leading to attention capture and to a search for the source of discrepancy. This should boost target detection relative to conditions where retrieval needs to rely on monitoring processes alone. Therefore, beyond determining whether repeatedly presenting the same target enhances PM, the first major aim of the present study was to explore the cognitive processes that underlie the anticipated benefit of target repetition within a set. It is proposed that the presence of spontaneous retrieval can be inferred from target repetition leading to an increase in PM performance (relative to a condition where a different target in the set was always presented instead) without any additional costs to ongoing task performance. If the outcomes are as predicted, this would strongly suggest that successful target detection can rely on both strategic and spontaneous retrieval processes, as proposed by the multiprocess view.

The second goal was to examine whether the anticipated benefit of target repetition would be specific to the target being repeated or whether it would generalize to other targets in the set. To examine this, the final target occurrence consisted of a not yet presented target in all experimental conditions. It was reasoned that each successfully identified PM target might lead to enhanced detection of a new, nonpracticed target by increasing the activation level of the intention or acting as a reminder of the PM task (e.g., Czernochowski et al., 2012). Recently, Walser, Fischer, and Goschke (2012) showed that completed intentions affected subsequent performance in a task in which a new intention was embedded. Namely, stimuli associated with a completed PM task displayed increased RTs and more false alarms, suggesting that intentions persisted in an increased state of activation after completion. Moreover, slowing was found for stimuli associated with a completed categorical PM task even when the specific exemplar had not been previously presented, suggesting that interference could not be explained by simple episodic retrieval of the stimulus-response association. Thus, there is some evidence to suggest that retrieval to a specific target might later influence performance to a different target also associated with the intended action.

A third aim was to examine whether the extent to which the target repetition benefit is specific or general depends on the relationship among the studied targets. To address this, a third group of participants formed the intention to respond to a set of semantically related targets. One of the targets in the set was then repeated up until the last target occurrence where a not yet presented target occurred. Participants might not, for example, consciously rehearse the entire set of targets following each successful retrieval of the intention to the repeated target. However, when target items share a preexisting association, target repetition might benefit PM performance by increasing the activation level of all target items in memory (e.g., through a spreading activation process; Anderson, 1976).

Finally, it is important to highlight that, unlike previous research (e.g., Czernochowski et al., 2012; Loft et al., 2008), in the present study the frequency of target presentation was equal across all three PM conditions and so was the number of target items encoded during instructions. Furthermore, the set of targets learned to criterion at instructions was also exactly the same for the two conditions where target items were unrelated. That is, only target experience at retrieval (i.e., whether all or only two targets in the set occurred) was manipulated. This was in order to maximize the ability to isolate differences on PM performance that can be attributed to retrieval relying on spontaneous retrieval processes as discussed above. Note that, as in other studies (e.g., Einstein et al., 2005; Marsh, Cook, & Hicks, 2006a), a no-PM control condition was not included in the present experiment. This is because past research has already established that significant ongoing task slowing is observed when participants are instructed to respond to multiple targets items (e.g., Cohen, Jaudas, et al., 2008), even when related (Marsh et al., 2003).

Method

Design and participants. The design was a 3 x 2 mixed factorial, with condition (unrelated-unrepeated, unrelated-repeated, related-repeated) as the between-subjects factor and block (baseline, PM) as the within-subjects factor. The three conditions will hereafter be abbreviated as unrel-unrep, unrel-rep, and rel-rep, respectively. Participants were 87 undergraduate students (42 female) aged 18-27 years (M = 20.1, SD = 1.5). Twenty-nine participants were randomly assigned to each of the three conditions. Two participants (one in the unrel-unrep and one in the rel-rep condition) were excluded as detailed in the Results section. Testing took place individually in sessions lasting approximately 25 min. Participants completed the DSST (Wechsler, 1981) used as an indicator of processing speed (*M* = 75.5, *SD* = 11.7); the three groups did not differ, $F < 1$.

Materials and procedure**.** Participants were first given instructions about the LDT. They were asked to press ‘J’ with their right index finger if the string of letters was a word and ‘F’ with their left one if it was not, and to make their judgments as quickly and accurately as possible. Participants were then given the opportunity to ask questions and 20 practice trials. Each of these trials was followed by speed and accuracy feedback. After practice, participants began the baseline block consisting of 10 buffer trials at the start followed by 100 lexical decision trials (50 words and 50 nonwords), this time without feedback.

At the end of the baseline block, encoding of the PM targets took place. Participants were told that their next task was to memorize some words and that they would have a few seconds to study the words before telling them to the experimenter. Six words were then displayed for 30 seconds, followed by the request to recall the items. This cycle was repeated until words were learned to criterion, namely, participants correctly recalled all of the six words twice in a row. Words were arranged in a vertical list on the center of the screen and presented in lowercase in a font size of 14 pt with a height corresponding to approximately 0.6º viewing angle at a distance of 50 cm; order of items in the list was randomized for every participant and each presentation. Those in the unrel-unrep and unrel-rep conditions studied a list of six unrelated target words (*bald*, *cracks*, *fitted*, *jointly*, *ropes*, and *spice*; Nelson, McEvoy, & Schreiber, 1998). By contrast, those in the rel-rep condition studied a list of six related words (*garlic*, *herbs*, *onion*, *pepper*, *salt*, and *spice*), which all belonged to the category of substances for flavoring food (Van Overschelde et al., 2004).

Following learning of the list of words (PM targets), participants were given instructions for the PM block. They were told that next they would perform a second block of the LDT where again they had to decide if a string of letters was a word or not. Additionally, if they ever saw any of the six words from the list they had just studied, they should press ‘Y’ after they made their lexical decision or as soon thereafter as they could. Participants were reminded to make their word/nonword judgments as quickly and accurately as possible. Before moving on, they were asked to explain the instructions to the experimenter including recall of the six targets words. After a delay of approximately four minutes, filled by completion of the DSST (Wechsler, 1981) and a demographic questionnaire, participants began the PM block.

The PM block comprised 10 initial buffer trials as well as 356 lexical decision filler trials (178 words and 178 nonwords) and six PM target trials. Targets were presented after every 50 trials on Trials 51, 102, 153, 204, 255, and 306. Target repetition within the set was manipulated. Whereas those in the unrel-unrep condition were presented with all six studied target words, those in the unrel-rep and rel-rep conditions were repeatedly presented with the same target up to the sixth (final) target presentation where a different target word was presented. The sixth (final) target word was always “spice” and this was the same for all conditions. In the unrel-unrep condition, each of the other five target words appeared once, with order of presentation randomized between participants. In the unrel-rep and rel-rep conditions, the same target word was repeated for the first five target presentations and the particular target word that was repeated was counterbalanced across participants for each condition (see Table 15).

Table 15: *Prospective Memory (PM) Targets Studied During Instructions and Examples of PM Targets Presented During the Ongoing Task in Each Experimental Condition*

		Condition		
PM Targets		**Unrelated-unrepeated**	**Unrelated-repeated**	**Related-repeated**
Study[a]		bald cracks fitted jointly ropes spice	bald cracks fitted jointly ropes spice	garlic herbs onion pepper salt spice
PM Block[b]	**1**	jointly	fitted	pepper
	2	bald	fitted	pepper
	3	fitted	fitted	pepper
	4	cracks	fitted	pepper
	5	ropes	fitted	pepper
	6	spice	spice	spice

a Items at study were always presented in a random order.

b Items at test were always presented in a random order except that "spice" was always the final target in all conditions. For the repeated conditions, the repeated target was counterbalanced across participants.

Each trial consisted of a fixation cross presented for 500 ms, followed by the letter string presented in the center of the screen until the participant responded or 4000 ms had elapsed, and finally a *waiting* message until the spacebar was pressed. Words in the LDT were 4-8 letters in length, and 1-3 syllables, with a mean log-transformed HAL frequency of 7.4 according to Balota et al. (2007); nonwords with 4–8 letters were selected from the same source. Stimuli were presented in lowercase in a font size of 30 pt with a height corresponding to approximately 1.3º viewing angle at a distance of 50 cm. At the end of the PM block, participants answered a post-experiment questionnaire to test their recall of the target words and intended action. If participants were unable to recall all the PM targets, a recognition task consisting of 18 words (6 target words, 6 filler words, and 6 words not presented in the LDT) was administered. Recognition of the set of target words was perfect for all participants.

Results

In each of the unrel-unrep and rel-rep conditions, one participant who was more than 2.5 *SD*s from their group's mean RT in the LDT was removed, and excluding these data did not qualitatively change the results.

PM performance. PM responses were scored as correct if participants pressed the 'Y' key during the target trial or within the next trial. This captured all PM responses. First, it was examined whether target repetition benefited target detection. PM performance was included in a 3 x 4 mixed ANOVA with condition (unrel-unrep, unrel-rep, rel-rep) as the between-subjects factor and target trial (2, 3, 4 and 5) as the within-subjects factor.[28] There was a main effect of condition, $F(2, 82) = 34.97$, $MSE = 0.15$, $p < .001$, $\eta_p^2 = .46$. Post hoc tests revealed that target detection was better in the unrel-rep ($M = .91$) and rel-rep ($M = .94$) conditions than in the unrel-unrep ($M = .55$) condition (both *p*s < .001). Therefore, repeatedly presenting the same target word boosted PM performance and similarly so for the unrel-rep and rel-rep conditions. Because there were no significant effects involving target trial (both *p*s > .350), proportion correct was averaged across targets 2 to 5 for each PM condition and used as a single score in subsequent analyses.

[28] Proportion correct for target trials 2, 3, 4 and 5 was .50, .64, .57 and .46, respectively, in the unrel-unrep condition; .86, .83, 1.00 and .93 in the unrel-rep condition; and .93, .96, .96 and .89 in the rel-rep condition.

Next, proportion correct was included in a 3 x 3 mixed ANOVA with condition (unrel-unrep, unrel-rep, rel-rep) as the between-subjects factor and target trial (1, 2-5 and 6) as the within-subjects factor (see Figure 16 for means). Results revealed a significant main effect of target trial, $F(2, 164) = 5.86$, $MSE = 0.15$, $p = .003$, $\eta_p^2 = .07$, such that accuracy was higher for Targets 2-5 ($M = .80$) than for Targets 1 ($p = .006$) and 6 ($p = .001$) (*M*s = .65 and .60, respectively). There was also a significant main effect of condition, $F(2, 82) = 5.71$, $MSE = 0.20$, $p = .005$, $\eta_p^2 = .12$, such that accuracy in the rel-rep condition was higher than in the unrel-unrep ($p = .002$) and unrel-rep ($p = .018$) conditions (*M*s = .81, .59 and .65, respectively), and a significant interaction, $F(4, 164) = 3.79$, $MSE = 0.15$, $p = .006$, $\eta_p^2 = .09$. Follow-up tests were conducted to examine differences between the three conditions for each target presentation. For the first target, a Kruskal-Wallis test revealed that the effect of target repetition was marginally significant, $\chi^2(2) = 5.52$, $p = .063$, suggesting that there was a trend for accuracy to be higher in the rel-rep than in the unrel-unrep and unrel-rep conditions. For Targets 2-5, there was a highly significant effect of target repetition as reported above. Finally, for the sixth (final) target, there were no significant differences, $\chi^2(2) = 2.57$, $p = .277$. Thus, the PM performance benefit of the unrel-rep (and rel-rep) condition over the unrel-unrep condition due to target repetition was eliminated when a different, not yet presented target occurred. Moreover, the lack of a performance advantage for the new target in the repetition conditions was found regardless of the relatedness between studied PM targets.

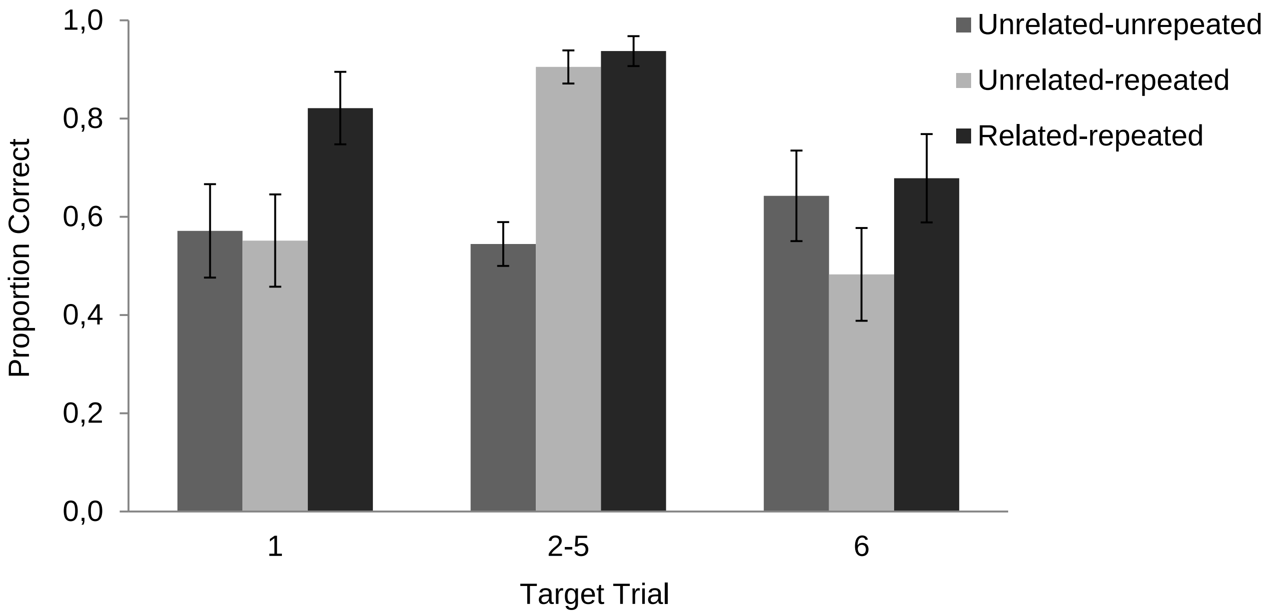

Figure 16: Mean proportion correct for the prospective memory task across conditions for Target 1, mean of Targets 2-5, and Target 6. Error bars represent ± 1 standard error.

***Ongoing task performance*.** Accuracy of performing the ongoing task was examined first. Percentage correct for word trials in the LDT was included in a 3 x 2 mixed ANOVA with condition (unrel-unrep, unrel-rep, rel-rep) as the between-subjects factor and block (baseline, PM) as the within-subjects factor (see Table 16, upper panel). There was a significant main effect of block, $F(1, 82) = 7.90$, $MSE = 7.23$, $p = .006$, $\eta_p^2 = .09$, such that accuracy was lower in the baseline block (93.5%) than in the PM block (94.7%). There were no other significant effects (both *p*s > .324).

Table 16: *Means and Standard Deviations for Performance on Word Filler Trials in the Lexical Decision Task as a Function of Block and Condition*

	Block			
	Baseline		PM	
Measure and Condition	*M*	*SD*	*M*	*SD*
Percentage Correct				
Unrelated-unrepeated	94.4	4.3	95.3	3.4
Unrelated-repeated	93.3	3.6	94.2	4.1
Related-repeated	92.9	4.3	94.5	2.9
Mean Response Times in milliseconds				
Unrelated-unrepeated	642	94	663	87
Unrelated-repeated	644	77	663	66
Related-repeated	640	83	621	60

RTs for words in the LDT were examined next. RTs were analyzed for accurate word filler trials that were trimmed to include only RTs that were less than 2.5 *SD*s away from each participant's mean (e.g., J. B. Knight et al., 2011). Trimming was done separately for the baseline and PM blocks, with the three filler trials immediately following each target excluded to avoid potential bias from slowing associated with target-related processes. Trimming resulted in the elimination of 3.0% of correct RTs. Data were analyzed with a 3 x 2 ANOVA with condition (unrel-unrep, unrel-rep, rel-rep) as a between-subjects factor and block (baseline, PM) as a within-subjects factor (see Table 16, lower panel). There was a condition by block interaction, $F(2, 82) = 3.30$, $MSE = 2{,}109.62$, $p = .042$, $\eta_p^2 = .07$. The source of the interaction was examined by conducting follow-up ANOVAs separately for each block. For the baseline block, there was no significant difference between conditions, $F < 1$. By contrast, for the PM block there was a significant effect of condition, $F(2, 82) = 3.17$, $MSE = 5{,}115.49$, $p = .047$, $\eta_p^2 = .07$, such that RTs were slower in the two unrelated conditions than in the related condition. This suggests that instructing participants to respond to a set of unrelated targets caused significantly greater task interference than did a set of related targets.

Crucially, the results above also show that enhanced target detection in the unrel-rep relative to the unrel-unrep condition was obtained in the absence of any group difference in overall cost. Given that recent research has suggested that overall task interference may not be an adequate measure of the relation between monitoring and PM performance (e.g., Scullin, McDaniel, & Einstein, 2010), proximal cost (i.e., mean correct word RTs on the five trials immediately preceding the target event) was examined next. An independent samples *t* test showed that there was no difference in RTs between the unrel-unrep and unrel-rep conditions (*M*s = 670 and 655 ms, *SD*s = 103 and 61, respectively; $t < 1$). In other words, in line with the overall task interference analysis, there was no evidence of increased recruitment of monitoring processes proximal to the target events in the unrel-rep relative to the unrel-unrep condition, despite substantial differences in target detection.

Discussion

This experiment demonstrates that repeatedly presenting the same target within a set of studied items is an effective approach to boost PM performance. In particular, the results showed substantial improvement in PM performance relative to a condition where frequency of target presentation and set of encoded targets were the same, but in which a different target in the set was presented each time. Crucially, enhanced target detection in the unrel-rep relative to the unrel-unrep condition was not accompanied by higher monitoring costs as reflected by both accuracy and RT data. This finding is interpreted as evidence that the present target repetition manipulation was effective in stimulating retrieval through spontaneous processes. That is, target repetition may produce discrepancy, signaling the significance of the target and stimulating a search in memory that leads to target detection. Results also clearly showed that the benefit of target repetition for PM performance was observed for the repeated target only and did not subsequently generalize to other targets in the set. Moreover, data from the rel-rep condition showed that this was true regardless of whether or not the targets in the set were semantically related.

Replicating previous research (e.g., Cohen, Jaudas, et al., 2008), instructing participants to respond to a set of six unrelated targets caused ongoing task slowing, suggesting that attentional resources were devoted to monitoring for the PM targets (Einstein et al., 2005; Smith et al., 2007). More important, results showed an increase in PM performance in the unrel-rep relative to the unrel-unrep condition and yet no additional costs to ongoing task performance. That is, despite substantial differences in target detection, ongoing task performance was identical between conditions both in terms of accuracy and RTs. It is argued that repeated target presentation increased the probability of spontaneously retrieving the intention and enhanced target detection through a discrepancy-plus-search process (Einstein & McDaniel, 2010).[29] That is, repetition should enhance the processing fluency of the target, thus causing the target to stimulate a search in memory for the source of the discrepancy. Alternatively, the PM performance benefit could be interpreted in terms of the reflexive associative view. Namely, repeated target presentation could result in the target and intended action becoming closely associated in memory and lead to better PM performance due to the target's presentation

[29] Smith et al. (2007) have also argued that salient stimuli can capture attention and stimulate the engagement of preparatory attentional processes leading to recognition of the stimulus as a target and increased PM performance (but see Einstein & McDaniel, 2010, for a discussion on how this mechanism might be akin to the discrepancy-plus-search process assumed to support spontaneous retrieval).

spontaneously bringing the intended action to mind via a reflexive associative process. If so, then a more gradual increase in PM performance across target repetitions in the unrel-rep condition would be expected because the formation of a strong association should require time to build up. Hence, the fact that a benefit was observed already for the first target repetition suggests that the discrepancy view provides a better account of the results.

Notably, the present findings are in line with the multiprocess view's proposal that individuals can recruit a variety of cognitive processes to support PM and further suggest that spontaneous retrieval processes can be flexibly engaged in order to optimize PM task performance (Einstein & McDaniel, 2010). Recently, Scullin et al. (2013) also spoke more directly to the notion that prospective remembering results from a dynamic interplay of spontaneous retrieval and monitoring processes. The authors showed that monitoring was not sustained throughout the entire performance interval when a contextual variability paradigm (i.e., multiple ongoing tasks) was used. Moreover, they demonstrated that even though cost was absent in the trials preceding the initial target cue every time a new ongoing task was presented, some individuals successfully detected these cues. Results also showed that monitoring followed successful PM performance for the initial target, suggesting that environmental cues can trigger spontaneous retrieval of the intention and stimulate selective and flexible engagement of monitoring processes. The results from Experiment 8 align perfectly with this notion that monitoring and spontaneous retrieval are dynamically interconnected processes. They also demonstrate that individuals may rely on spontaneous retrieval processes to boost PM performance, relative to when retrieval relies primarily on monitoring processes alone, when a particular target is repeatedly presented.

It was reasoned that high retrieval success to the repeated target could lead to an increase in the activation of the entire set of targets in memory and result in a generalized benefit of target repetition. That is, in the repeated cues conditions, retrieving the intention from memory upon target presentation and verifying that the item was one of the target cues stored at intention formation could serve as a reminder for the PM task (Czernochowski et al., 2012; Loft et al., 2008) and promote heightened activation of the intention representation in memory. The fact that the benefit of target repetition for PM performance did not generalize to a nonpracticed target suggests that the full set of targets was not repeatedly brought to mind during the multiple retrieval successes, or, as a minimum, was not rehearsed following intention retrieval.

Furthermore, the lack of a general benefit also when the set of targets was semantically related suggests that retrieving the intention did not strengthen the intention representation of nonpracticed targets or, at least, did not increase its activation to a level sufficient for target-driven thoughts to reach awareness upon encountering the item. Even if it is assumed that retrieving the intention in response to the repeated target increased the activation in memory for the entire set of targets, results suggest that such activation was either temporary or insufficient to affect detection when a nonpracticed target was finally presented. This rationale is consistent with studies that use a delayed execution paradigm and show that introducing a relatively short delay between target presentation and the opportunity to execute the intention action causes a significant drop in PM performance (Einstein et al., 2000). In addition, spreading activation from an activated item to associated concepts has been shown to be short-lived (e.g., Masson, 1995). Therefore, irrespective of whether retrieving the intention from memory caused activation of all the targets in the set, the present data suggest that the link between the specific PM target and the associated action might need to be directly strengthened through retrieval of the intention to the actual target for a benefit to be observed.

RTs in the unrelated conditions were significantly slower than in the related condition, suggesting the presence of task interference due to additional resources being devoted to accomplishing the PM task when targets in the set were unrelated. This is in line with work suggesting that ongoing task cost reflects, at least partially, a metacognitive strategy established at encoding about how to approach a task set. Specifically, Marsh et al. (2005; see also Harrison & Einstein, 2010; Hicks et al., 2005; Marsh, Hicks, et al., 2006) proposed that when intentions are encoded in memory, individuals set an attentional allocation policy that establishes the division of limited-capacity attentional resources between the PM and ongoing tasks. Consistent with this view and in line with previous research (e.g., Marsh et al., 2003), ongoing task cost was greater when task demands were increased, that is, when the set of targets was unrelated relative to when targets were semantically related. This suggests that participants allocated attention to the PM task according to information available at encoding.

In sum, target repetition within a set produced a substantial increase in PM performance; however, there was no evidence of any additional ongoing task cost, suggesting that capacity-demanding attentional resources did not underlie the PM benefit. It was argued here that repetition increased the processing fluency of targets (relative to other ongoing task items) and stimulated spontaneous retrieval of the intention through a discrepancy-plus-search process. In addition, the benefit of target repetition for PM did not extend to other targets in the set and this was true regardless of the relatedness between studied targets. Collectively, the results demonstrate that target repetition can play a role in optimizing PM and they highlight the potential challenges of sustaining high levels of PM performance upon introduction of a different, nonpracticed target. Furthermore, in line with the multiprocess view, the results suggest that monitoring and spontaneous retrieval can occur together to support prospective remembering.

Chapter 8: Conclusion

This chapter summarizes and considers the results and conclusions from the previous chapters. In addition, theoretical and practical implications of these findings and potential avenues for future research are considered. The overall aim of the thesis was to clarify and understand how a specific set of intention-related manipulations affected prospective remembering and influenced the extent to which monitoring processes were engaged and/or the type of process required to support PM retrieval. The overall approach was to examine task interference throughout the ongoing task in order to more precisely inform the nature of the processes supporting PM retrieval.

Overview of findings

Chapter 2 showed that high WM young adults performed better on a nonfocal PM task than did low WM ones, a finding that is in line with previous research (e.g., Brewer et al., 2010; Smith & Bayen, 2005). The novel finding was the demonstration that presenting intention-related information eliminated the deficit in nonfocal performance for low relative to high WM young adults. Importantly, analysis of ongoing task cost revealed that the benefit for low WM individuals was not due to intention-related material triggering the engagement of additional resources to monitor for the target events. It was proposed that intention-related events might benefit performance in a demanding nonfocal PM task by compensating for deficits in the efficiency of executive control processes in low relative to high WM individuals. Presentation of intention-related information may have stimulated periodic thoughts about the PM task (as opposed to distracting internal thoughts) and reduced PM failures associated with momentary lapses of attention. Crucially, the results from Experiment 1 suggest that individuals with low

WM capacity can optimize performance when intentions involve a high degree of strategic processing by relying on environmental cues to increase the efficiency of attentional control.

Chapter 3 provided an opportunity to examine how age-related reductions in distraction control (Hasher et al., 2007, 1999; Hasher & Zacks, 1988; Lustig et al., 2006) can affect PM by presenting distractor information that was intention-related during the ongoing task. It was demonstrated that older adults' PM performance was higher when distractor lure words were presented than when these items were absent (Experiment 2); no such benefit was observed for young adults (Experiments 2 and 3). It was speculated that intention-related distractor information facilitated older adults' PM performance by enhancing the processing quality or salience of the targets (relative to other ongoing task items) and stimulating retrieval through a mechanism akin to the discrepancy plus search process. Such a claim is in line with the observation that a PM benefit was found even for older adults who had no explicit memory for the distractor lure words. Nonetheless, it is also possible that, at least for some participants, encountering intention-related information stimulated monitoring for the targets. Given older adults' increased susceptibility to momentary lapses of attention, monitoring in close proximity to the target events would likely reduce PM failures. Moreover, research suggests that metamemory problems in older adults (i.e., unawareness of the need to rehearse the intention in order to successfully fulfill the PM task) may contribute to age-related deficits in PM performance (McDaniel, Einstein, Stout, & Morgan, 2003). Hence, encountering intention-related distractor information might compensate for older adults' reduced capacity to continuously monitor for PM targets, as well as disinclination to spontaneously do so.

Chapter 4 demonstrated that FCS (via practicing the ongoing activity prior to encoding the PM task) enhanced nonfocal PM performance for high WM young adults, but not for low

WM young adults and older adults. This suggests that the benefit of FCS may rely on some optimal level of central-executive resources (e.g., for engaging in elaborate encoding of the intention, planning intention execution, etc.). An important procedural feature of Experiment 4 was the fact that participants in the FCS condition were given experience with the ongoing task, but not explicitly asked to formulate a plan. It was proposed that individuals with reduced processing resources were less likely to spontaneously use their knowledge about the retrieval context to optimize subsequent PM performance. That is, although FCS supposedly provided individuals with the opportunity to form a more detailed plan for accomplishing the intention, resources were required for such self-directed elaborative encoding.

Chapter 5 revealed that trial-by-trial changes in task interference with nonfocal PM tasks can be observed when relevant and irrelevant stimuli vary at random with no cuing (Experiments 5 and 6). Moreover, it demonstrated that Cohen et al.'s (2012) finding of a stimulus specific interference effect (i.e., absence of ongoing task cost for intention-irrelevant stimuli) when a set of particular PM targets was used does not extend to nonfocal PM tasks. Together with a more localized interference effect for stimuli that shared some of the target features, a general and pervasive task interference effect was found in both Experiments 5 and 6. Critically, what Cohen et al. (2012) and Chapter 5's studies clearly showed was that monitoring is a flexible mechanism such that trial-by-trial modulations in task interference can be observed with both focal and nonfocal PM tasks when the nature of the upcoming stimulus cannot be predicted. On the basis of these findings, together with the task switching literature (e.g., Monsell, 2003; see also Marsh, Hancock, et al., 2002; McNerney & West, 2007), it was proposed that for trial-by-trial modulations in task interference to be observed it is important that attentional resources are not taxed by the need to continuously and randomly switch between two task judgments (e.g., Marsh, Cook, et al., 2006b, Experiment 1A).

Furthermore, Experiment 5 demonstrated that the nature of the stimulus presentation modulated the magnitude of the trial-by-trial changes in task interference, such that cost differences between intention-relevant and irrelevant trials were maximized when presentation was blocked relative to when it was random. Most important, an interesting pattern of results in the blocked condition was found in terms of the cost dynamics throughout the sequence of intention-irrelevant trials. Specifically, there was a one-trial carry-over effect at the start of the irrelevant context followed by a substantial reduction in task interference up until when the relevant context was about to be reached again. It was proposed that top-down control processes influenced the deployment of attentional resources in accordance with PM demands.

Additionally, in Experiment 6 participants' expectations about the target context were manipulated at instructions. Importantly, unlike previous studies (Cohen et al., 2012; Marsh, Cook, et al., 2006b), the nature of the PM task (i.e., respond to a target syllable) meant that any ongoing task trial could be a potential target. It was demonstrated that explicitly instructing participants that the nonfocal PM targets would only occur in a subset of stimuli (i.e., word trials) led to a trial-by-trial reduction in task interference for intention-irrelevant items while leaving PM performance unaltered. This suggests that participants not only used their awareness of to-be-expected task demands to flexibly allocate attention, but that they could do so efficiently. Past research had already shown that ill-specified intentions carry greater cost to ongoing activities than well-specified ones. However, specificity had been varied by having specific vs. categorical targets (e.g., Hicks et al., 2005) or by associating the intention with a specific phase of the ongoing task (e.g., Logie & Maylor, 2009; Marsh, Hicks, et al., 2006).

Crucially, Experiment 6 identified a new dimension of specificity in PM scenarios and demonstrated that specifying the target context has the potential to reduce ongoing task cost.

Chapter 6 examined the role of implicit demands in PM. It was demonstrated that implicit demands affected participants' attention allocation and PM success, such that those given typical exemplars prior to the experimental trials (low expected demands condition) showed less task interference and worse PM performance than those given atypical ones. Equally important, results showed that when actual demands were higher than expected, detecting PM targets triggered local changes in attention allocation (i.e., an increase in the amount of resources devoted to the PM task). Critically, Experiment 7 demonstrated that in studying attention allocation policies and their impact on task interference in PM tasks, it is important to consider the role of implicit information about PM task demands (e.g., as conveyed by specific target exemplars at encoding). Such information can influence individuals' beliefs about the ease of fulfilling a PM task, as evidenced by its effect on ongoing task processing, and can harm PM performance when actual demands turn out higher than expected.

Chapter 7 showed that repeatedly presenting the same target within a set of studied items improved PM performance. Most important, results revealed a dissociation between target detection and the amount of task interference, such that repeated presentation of one of the targets in the set boosted PM performance without causing any additional ongoing task slowing. It was proposed that target repetition increased the processing fluency of target items (relative to the nonrepeated filler items) and elicited spontaneous retrieval of the intention through a discrepancy-plus-search process. Furthermore, results showed that the benefit of target repetition on PM performance did not extend to other targets in the set, regardless of the targets in the set being semantically related or not. Crucially, Experiment 8 showed that target repetition can play a role in optimizing PM and demonstrated that monitoring and spontaneous retrieval can interact dynamically to support prospective remembering.

Speculation and future directions

Interesting routes for future work can be derived from the findings outlined above, and these findings also have the potential to stimulate further theoretical developments in PM. The implications of these findings are discussed in more detail below. The discussion is structured into topics according to the various intention-related factors examined in this thesis.

Intention-related information and delay-execute PM tasks

Real-world PM demands commonly require individuals to delay execution of the intended action as the result of interruptions. For instance, in health care settings, interruptions might include a nurse stopping medication preparation as the result of turning to an alarming monitor, or postponing drawing a blood sample due to a pager requiring picking up a patient from another floor (Chisholm, Collison, Nelson, & Cordell, 2000; Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2010). Crucially, in settings such as health care, aviation or human-computer interaction, interruption of PM tasks might pose serious safety issues and contribute to failures or even accidents (Chisholm et al., 2000; Iqbal & Horvitz, 2007; McDaniel & Einstein, 2007).

In the laboratory, researchers have used a *delay-execute* procedure (Einstein et al., 2000) to study PM tasks where retrieved intentions must be retained over brief delays. In this procedure, participants must retrieve the intention when a salient target occurs (to ensure high levels of initial intention retrieval), but postpone execution until some time period has elapsed and meanwhile continue to perform the ongoing task. An example would be to delay intention execution until after answering a series of comprehension questions. It has been shown that demanding divided attention conditions or interruptions during the delay impair intention execution. Furthermore, instructions to rehearse the intention during the delay or implementation intention strategies (i.e., forming a detailed plan in which the target event is specifically associated with the intended action; e.g., Chasteen, Park, & Schwarz, 2001) did not eliminate or reduce the negative effect of divided attention or interruptions on delayed PM performance (McDaniel et al., 2003). These results suggest that maintaining the intention even over a brief delay involves moderate attentional demands. Most likely, divided attention/interruptions impair individuals' ability to implement strategic rehearsal of the intention during the delay due to limited attentional resources.

Interestingly, McDaniel, Einstein, Graham, and Rall (2004) showed that presentation of a salient external reminder (i.e., presenting a blue dot on the screen until the end of the delay and explicitly instructing participants that the dot was a reminder to fulfill the intention) eliminated the negative effect of an interruption on delayed PM performance. This finding fits well with real-world observations. For example, Grundgeiger et al. (2010) found that when faced with the need to postpone execution of a PM action, nurses used behavioral strategies (e.g., holding, or continuing to hold, an artifact such as a syringe) on 18.8% of the cases to reduce or eliminate potential PM failures associated with the interruption. Critically, the use of these salient external reminders may not always be available and not all PM tasks afford a similar manual strategy. Consider, for example, a scenario where a nurse might be drawn to an alarming monitor before being able to report on a patient's food allergies to the nurse coming in, or where an emergency room doctor might postpone giving medication to a patient due to the arrival of a critically-ill patient who requires immediate care, etc. In Experiment 1 in this thesis, it was shown that focally processed intention-related information can benefit PM performance. A related question that clearly bears practical relevance is whether the negative effect of delaying execution of an intention can also be overcome by encountering intention-related material (e.g., the sight of a food tray, a pill bottle on a table, utensils to take a blood sample on the medication desk, etc.) in proximity to the appropriate time for intention execution.

Furthermore, investigating the effect of intention-related information on delay-execute PM tasks as a function of WM capacity (cf. Experiment 1) under demanding divided attention conditions could also be theoretically informative. Specifically, one possibility is that the effect of intention-related information is sensitive to the availability of resources on delay-execute PM tasks. For instance, resources might be required to retrieve the intention from memory when encountering the items and maintaining the activation of this intention until the end of the delay, and/or to reformulate the plan for intention execution. Moreover, Experiment 1 in this thesis found evidence that both low and high WM individuals noticed the intention-related words. Nonetheless, if divided attention interferes with full processing of the items (e.g., Einstein & McDaniel, 2010), then a benefit of intention-related information on delay-execute PM tasks might be restricted to individuals with higher availability of attentional resources. That is, encountering intention-related information might improve intention execution only for high WM individuals when attentional resources are reduced by divided attention.

Alternatively, an increase in intention execution might be observed regardless of WM capacity if resources are not required to sustain the activation of the intention in the face of distraction throughout the delay. That is, provided that multiple intention-related events occur during the delay and that these are fully processed, these items might trigger periodic thoughts about the PM task and increase the activation of the intention (e.g., Freeman & Ellis, 2003;

Kvavilashvili & Fisher, 2007). If continuous reactivation of the intention throughout the delay compensates for the need to devote resources required to keep the retrieved intention sufficiently activated, then intention-related events should increase delayed execution of the PM action for all participants (cf. Einstein et al., 2000). Interestingly, Kvavilashvili and Fisher (2007) suggested that in naturalistic PM tasks, intentions are spontaneously retrieved by individuals from time to time as a result of encountering incidental external cues that are related to the intention. These continuous incidental triggers should enhance the likelihood of fulfilling the intention by increasing the activation of the intention and further sensitizing the individual toward the occurrence of the target and/or relevant environmental events. Note, however, that Kvavilashvili and Fisher (2007, Study 1) found that participants were less likely to report experiencing rehearsals (e.g., thoughts about the intention triggered by incidental external or internal cues) when engaged in attentionally demanding controlled activities as opposed to automatic activities, such as cleaning their teeth (38% vs. 62 % of rehearsals, respectively). This suggests that a reduction in available attentional resources might reduce the frequency of occurrence of involuntary conscious intention thoughts throughout the performance interval. Regardless, examining the effect of intention-related information on delay-execute PM tasks could have important implications for everyday cognitive performance, especially when the environment is rich in information that is related to the intention.

Intention-related distractor information and PM tasks

Experiment 2 in Chapter 3 presented the first examination of how age-related increases in the susceptibility to distractor information affect prospective remembering. In line with research on retrospective memory (Gopie et al., 2011; Lustig et al., 2006), presenting intention-related distracting information improved PM performance for older, but not young adults. Although

Experiment 2 was not theoretically decisive in terms of elucidating the mechanisms that underlie the positive effect of distraction on older adults' PM performance, it represents an important first step on the topic of (relevant) distraction on PM. Future research is needed to determine the specific processes underlying the age-related benefit of (relevant) distraction on PM. Notwithstanding, extending the results of Experiment 3 by additionally testing a sample of older adults would provide an efficient way to do so. Furthermore, recent evidence (Gopie et al., 2011) suggests that when the ability to engage in controlled processing is reduced, for instance by dividing attention with a secondary task, young adults show the same benefit from implicit memory for irrelevant information as do older adults. Another interesting direction for future work would therefore be to investigate if young adults under divided attention would also display an improvement in PM performance when presented with intention-related distractor information.

Continued examining of the conditions where age-related vulnerability to distraction can be beneficial to some future goal has important real-world relevance. It was proposed here that one of the mechanisms through which intention-related distractor information might enhance PM is by increasing the accessibility of the intention. Critically, because aging mainly challenges the integrity of monitoring processes, it is possible that when distracting information holds relevance to the person's intentions, older adults' increased susceptibility to irrelevant information may serve a compensatory role and aid prospective remembering. Understanding whether the representation of the intention in memory can change as a function of exposure to intention-related distractor information, the circumstances under which distraction can be a facilitator for older adults' PM performance, or whether such benefit can be obtained while recruiting minimal resources, are therefore issues of considerable practical concern. This is especially important given the impact that PM failures can have on normal everyday functioning and the constant presence of distraction in real-world environments.

Improving PM performance through FCS

An interesting avenue for future research would be to explore the role of explicitly instructing participants about the importance of using experience with the prospective context for planning intention retrieval. For instance, Altgassen, Zollig, Kopp, Mackinlay, and Kliegel (2007) showed that emphasizing the PM task importance during instructions eliminated differences in PM performance between control participants and patients with Parkinson's disease. The authors suggested that directing participants' attention to the intention during encoding likely stimulated higher order encoding or planning, which would not be spontaneously implemented otherwise. Moreover, they also found that the effect of emphasizing the PM task during intention formation was strongly associated with executive control as assessed by WM capacity. In addition, research has shown that in complex PM tasks (Kliegel et al., 2007), specific planning aids aimed at increasing the specificity and elaboration of PM plans (e.g., guidance in terms of plan structure, implementation, etc.) improved PM performance in both young and older adults. Notwithstanding, Kliegel et al. (2007) found that older adults' complex PM performance was never raised to the levels observed in young adults. Given that aging is associated with reduced frontal functioning, and that frontal processes are particularly relevant for planning (e.g., Shallice & Burgess, 1991), it is possible that planning aids were not sufficient to overcome the processing demands. That is, executive resources were probably required to maintain multiple task representations and coordinate execution of the complex PM task with the demanding ongoing activities as planned (Kliegel et al., 2007). Note that some studies have observed an almost perfect correlation (r = .99) between a WM capacity construct and an executive function factor (both calculated on the basis of performance on several measures; McCabe & Soderstrom, 2011), and that performance in WM tasks is supported by prefrontal activation (e.g., Braver & Cohen, 2001). Hence, it is likely that young adults with low WM capacity would also show only a limited benefit of planning aids in complex PM tasks.

By contrast, it is hypothesized here that, with less complex PM tasks, FCS coupled with explicit planning instructions might aid even individuals with reduced frontal functioning (i.e., older adults and low WM young adults). These instructions should highlight the importance of using experience with the prospective context to form more elaborate and specific plans (e.g., forming an integrated representation of the PM target in the retrieval context, encoding of a strong target-action association, anticipating the target events to establish a more specific plan on how to coordinate ongoing and PM task responses once the target is encountered, etc.). Finding a PM performance benefit of FCS with explicit instructions for low WM young adults and older adults would reinforce the proposal that FCS benefits prospective remembering by promoting more elaborate encoding of the PM task (see Chapter 4). Moreover, it would show that when PM task demands are moderate (cf. Kliegel et al., 2007), explicitly instructing participants about the benefit of using experience with the prospective context to plan intention retrieval can compensate for PM deficits associated with the inability to spontaneously form effective plans.

Neural underpinnings that support monitoring processes in PM

Neuroimaging studies have consistently shown that sustained anterior prefrontal cortex activation, along with activation in other components of the frontoparietal attention system, is associated with strategic monitoring processes in PM tasks (Burgess et al., 2008, 2011, 2001; Burgess, Scott, & Frith, 2003; McDaniel & Einstein, 2011; Reynolds, West, & Braver, 2009; Simons, Schölvinck, Gilbert, Frith, & Burgess, 2006). Likewise, in studies using event-related potentials (ERPs) (Bisiacchi et al., 2009; Chen, Huang, Yang, Ren, & Yue, 2007; Cona et al., 2012; J. B. Knight et al., 2010; R. West, 2007, 2011; R. West et al., 2006; R. West, McNerney, & Travers, 2007; R. West, Scolaro, & Bailey, 2011), sustained activity expressed over prefrontal and frontal regions during ongoing trials has been interpreted as reflecting the allocation of attention necessary to monitor for nonfocal PM targets. However, neuroimaging and ERP studies have not been able to specify the nature of the cognitive processes reflected by the sustained activity. For instance, sustained activity expressed over frontal and posterior regions has been associated with a retrieval mode (R. West et al., 2011), but also with target checking (R. West et al., 2007). It has also been suggested that early modulations of ERPs over occipital-parietal regions might be related to the processing of target related features, with later sustained activity over these regions associated with target checking (Cona et al., 2012; J. B. Knight et al., 2010).

Examining the specific nature of the cognitive processes underlying strategic monitoring is of theoretical relevance and merits more thorough examination. Experiments 5 and 6 in this thesis represented an important step in moving our understating about the monitoring processes further. Thus, conducting an fMRI study using Experiment's 5 paradigm might afford an innovative advantage for examining the neural mechanisms that support strategic monitoring. Specifically, a paradigm with the interleaving of short blocks of intention-irrelevant and relevant trials (associated with retrieval mode vs. retrieval mode and target checking processes, respectively; see Chapter 5 for a discussion) may provide an effective approach for establishing the degree to which each of the neural mechanisms linked with strategic monitoring are involved in retrieval mode and target checking processes. Furthermore, a crucial feature of Experiment 5's paradigm was that, unlike other studies examining item-level changes in task interference (e.g., Marsh, Cook, et al., 2006b), relevant and irrelevant stimuli were not associated with a change in the type of material. Using this paradigm would therefore eliminate variance associated with material specific activation in the brain (e.g., activation related to the processing of picture vs. word stimuli, regardless of the intentionality of these items).

Furthermore, examining the neural underpinnings of monitoring processes can also have considerable practical importance as it might open the door to a more thorough examination of the neural mechanisms that contribute to robust age-related PM deficits associated with a decline in strategic monitoring. That is, future research could potentially also investigate age-related differences in the pattern of activation linked with each of the two monitoring processes. Currently, it is unknown whether older adults' reduced ability to engage strategic monitoring processes is linked with a similar impairment in both retrieval mode and target checking processes, whether one process is more hampered than the other, or even whether some of the neural mechanisms that support monitoring are spared in older adults. Using neuroimaging to study PM in older adults has the potential to provide data that will help to characterize the neural underpinnings of monitoring in older adults as well as (potential) activation changes that may mediate age-related deficits in PM performance (cf. McDaniel & Einstein, 2011). Hence, the proposed avenue of research holds promise to pioneer an important new line of inquiry regarding the examination of the neural mechanisms linked with monitoring processes in PM.

Lastly on the topic of using paradigms designed for the study of trial-by-trial changes in monitoring processes, another fruitful avenue for future research may involve investigating item-level changes in task interference as they relate to individual differences in WM. Experiment 6 demonstrated that associating a nonfocal intention with a subset of stimuli reduced cost for stimuli not linked to the intention. One possibility is that target context specification might compensate for PM deficits in low WM participants (e.g., Brewer et al., 2010) by restricting the set of potential targets and promoting checking of intention-relevant items only. Alternatively, it is possible that the higher susceptibility of low WM individuals to task-unrelated thoughts and impoverished ability to flexibly control attentional resources (e.g., Kane et al., 2007) might interfere with their ability to modulate the deployment of attention. Returning to the example in Chapter 6, will high WM individuals be more capable of optimizing their overall efficiency in monitoring for a target researcher at a poster presentation by focusing only on attendees that bear some resemblance to some of the researcher's key features? Regardless, extensions of Experiment 6's results could have important implications for everyday cognitive performance.

The flexibility of attention allocation

It has been postulated that participants set an attention allocation policy at the outset of a task that establishes the relative weighting of attention to the ongoing and PM tasks (Hicks et al., 2005; Marsh et al., 2005; McDaniel & Einstein, 2007; Smith, 2003). Importantly, Marsh and colleagues (Hicks et al., 2005; Marsh, Cook, et al., 2006b; Marsh et al., 2005) have also suggested that attentional processes are dynamic such that the amount of attention allocated to the PM task can change according to the relevance of the material being processed for the intention, and due to attention and effort naturally waxing and waning during the ongoing task as a result of irrelevant thoughts or interruptions (cf. R. West & Craik, 1999). Several findings have provided compelling evidence for this view by showing that attention can change flexibly throughout the ongoing task (e.g., Cohen, Jaudas, et al., 2008; Cohen et al., 2012; Experiments 5 and 6 in this thesis; Marsh, Cook, et al., 2006b; Marsh et al., 2005; see Chapter 5 for details).

Crucially, task conditions can be different from what was anticipated at encoding and it would, therefore, be advantageous if attention allocation could also be flexibly adjusted on the basis of task experience. Some initial support for this proposal comes from studies showing that the amount of attention devoted to the PM task declines when monitoring goes unreinforced due to the lack of PM target occurrences (e.g., Loft et al., 2008; Scullin, McDaniel, Shelton, et al., 2010). Likewise, research suggests that individuals can engage in monitoring after spontaneously retrieving the intention in response to a target occurrence (i.e., after identifying a context where PM targets will be encountered; Scullin et al., 2013), or that individuals can increase attention to the PM task when, contrary to expectation, targets are presented (Boywitt & Rummel, 2012). This research provides evidence that attention allocation policies set by participants can be adjusted on the basis of the local experience with the task. Furthermore, findings from Experiment 7 in this thesis drew attention to the fact that implicit information regarding the PM task demands also affects participants' effort in a PM task. Most importantly, it demonstrated that individuals can adjust the amount of attention allocated to the intention following PM task experience when the cognitive effort required to successfully fulfill the intention is higher than expected.

The research just discussed highlights the importance of experience with the ongoing and the PM tasks in triggering local changes to attention allocation policies, and suggests that individuals will use task experience to flexibly adjust attention to the PM task so that it best meets current demands. Notwithstanding, determining the mechanisms that underlie local changes to attention allocation requires further empirical work. Moreover, as pointed out by Loft et al. (2008), neither the multiprocess nor the PAM theory currently captures how individuals might adjust the amount of attention allocated to the PM task on the basis of task experience. Thus, the challenge ahead for researchers will also be to integrate findings into wider theoretical frameworks that posit possible mechanisms responsible for local adaptations in the allocation of attention as the result of ongoing and/or PM task experience. In Chapter 5, it was proposed that top-down attention control might modulate the deployment of attentional resources on the basis of PM demands (e.g., target-defining features specified at instructions) and underlie trial-by-trial changes in task interference (Experiments 5 and 6). Likewise, it is possible that top-down attentional control would be involved in making adjustments to the initial attention allocation policy on the basis of task experience to meet the individual's goals (cf. Mulckhuyse & Theeuwes, 2010). Such a control mechanism might, for instance, be responsible for recruiting additional attentional resources when the ongoing and/or PM task becomes more cognitively demanding than initially anticipated in order to promote a good level of performance. Moreover, evaluating the impact of top-down influences may be easier when combining behavioral and neuroimaging approaches to investigate the neuropsychological systems associated with local changes to attention allocation policies. A stronger reliance on converging findings from both types of studies could ultimately advance our understanding about the recruitment of attentional processes in PM tasks.

Lastly on this point, it should be highlighted that whether older adults can also adjust the amount of attention allocated to the PM task on the basis of task experience merits examination in future studies. This seems even more important given the present demonstration (Experiment 7) that implicit information regarding the PM task can not only affect ongoing task processing, but also harm PM performance when actual demands are higher than expected. Given age-related declines in attentional resources (e.g., Craik, 1986; Salthouse, 1991), it is possible that older adults are limited in their ability to effectively exert control over attention deployment and adjust attentional resources allocated to the PM task. For instance, some optimum level of centrally mediated resources might be required to reset the attention allocation policy while continuously faced with ongoing and PM task demands. Moreover, research shows that older adults have a greater tendency to perseverate than young adults (Foldi, Helm-Estabrooks, Redfield, & Nickel, 2003; Scullin et al., 2012). Older adults may therefore need extra experience with the ongoing and/or PM task before they can update their knowledge about the task demands and adjust their attention allocation to optimize performance.

PM retrieval and the nature of the underlying processes

Without restating the arguments set out within the literature, it is clear that the debate regarding the cognitive processes that support PM retrieval will not be settled easily. Although evidence from behavioral research methods, such as estimating task interference levels throughout the ongoing task, mostly suggests that PM can rely on multiple processes, interpretation of the research findings has not been without criticism (Einstein & McDaniel, 2010; Smith, 2010). Given this controversy, it is also clear at this point that examining PM retrieval is not an aspect that can be overlooked or dismissed lightly by future PM research. Recently, there has been an increasing interest in cognitive neuroscience approaches to PM due to their potential for improving our understanding of the neural mechanisms that support PM retrieval in different theoretically important contexts (e.g., nonfocal vs. focal PM tasks) (McDaniel & Einstein, 2011; McDaniel, LaMontagne, Beck, Scullin, & Braver, 2013). Most importantly, a recent fMRI study by McDaniel et al. (2013; see also Gordon, Shelton, Bugg, McDaniel, & Head, 2011) provided compelling neurally based evidence in support of the multiprocess view by demonstrating that the particular neurological systems supporting PM were variable and influenced by the focal/nonfocal nature of the PM task. Specifically, McDaniel et al. (2013) found sustained activation in the anterior prefrontal cortex (associated with top-down attentional control in PM tasks; Burgess et al., 2011) with a nonfocal PM task. By contrast, a focal PM task was associated with purely transient activity (selective to PM trials) in a widely-distributed set of parietal and ventral brain regions (including increased transient activation in the precuneus and right middle temporal gyrus relative to the nonfocal PM task). Importantly, these regions are thought to be involved in bottom-up processes and in the detection of salient targets (e.g., attentional capture, target detection, episodic retrieval) (Cabeza, Ciaramelli, Olson, & Moscovitch, 2008; Seeley et al., 2007).

As mentioned in Chapter 7, Scullin et al. (2013) recently advanced the dynamic multiprocess framework, which proposes that cue-driven spontaneous retrieval and effortful strategic monitoring processes may be interconnected processes that can be utilized dynamically to support PM performance. The authors argued that naturalistic PM tasks frequently involve long retention intervals and contextual variability, and that it would therefore be unlikely that individuals would continuously engage in resource-consuming monitoring to support prospective remembering (see also Einstein & McDaniel, 2010). To gain evidence for their claims, Scullin et al. (2013) examined performance using a focal PM task that incorporated contextual variability (i.e., participants were instructed that the target words could occur in any of the subsequent ongoing tasks). In line with their theoretical framework, the authors showed that there was no evidence of monitoring prior to the initial PM target occurrence in each new context, but that cost consistently followed this target for individuals who successfully detected the item. This suggests that spontaneous retrieval processes supported initial performance (cf. Kvavilashvili & Fisher, 2007), but that once individuals realized that PM targets could be expected within that context they engaged monitoring. These findings provide support for the proposal that spontaneous retrieval processes can support focal prospective remembering when monitoring processes are disengaged (e.g., Cohen, Jaudas, et al., 2008; Einstein et al., 2005; Harrison & Einstein, 2010; Kvavilashvili et al., 2009; Scullin, McDaniel, & Einstein, 2010).

Scullin et al.'s (2013) proposal of an interplay between spontaneous retrieval and monitoring processes converges well with the new approach for testing the presence of spontaneous retrieval advanced in Chapter 7 and tested in Experiment 8. This approach proposes that it is possible to examine retrieval through spontaneous retrieval processes under conditions where cost-inducing monitoring processes are present. Specifically, it was argued that finding an increase in PM performance at no extra cost to ongoing task performance would be evidence that retrieval is relying on spontaneous retrieval processes for some of the target trials. In line with the proposed approach, using a PM task that comprised multiple targets (a condition known to stimulate the engagement of monitoring processes; e.g., Cohen, Jaudas, et al., 2008), it was demonstrated that target repetition within a set increased prospective remembering via bolstering spontaneous retrieval. That is, target repetition enhanced PM retrieval without additionally compromising ongoing task performance.

The finding that target repetition can substantially boost prospective remembering (while expending minimal resources) might hold a tremendous practical value. An immediate implication is that one should use a well-practiced environmental cue as the trigger for the intention (and set up this cue so that it is likely to be focally processed). This might be especially critical in circumstances in which PM misses are harmful, such as when taking medication. The advantage is enhanced PM at no extra cost (although no such advantage generalizes to related, non-practiced targets). It will certainly be important for future research to establish whether target repetition within a set can also enhance intention retrieval for individuals with compromised resources such as older adults. PM tasks that rely on spontaneous retrieval tend to show minimal or no age-related decline, supporting the integrity of these processes in older adults (Einstein et al., 2012; Kliegel et al., 2008; McDaniel & Einstein, 2007, 2011). Because it is proposed that repetition stimulates retrieval via a discrepancy-plus-search process (i.e., sustained monitoring is arguably not necessary for detecting the target event), the expectation is that the target repetition benefit should be found for older adults. If this pattern were to be obtained, then it would provide compelling evidence for the proposed theoretical mechanisms of the effect of target repetition within a set. Moreover, the finding would be of considerable practical relevance as it would have identified an easily instantiated intervention for overcoming PM failures in older adults.

Furthermore, an exciting possibility, and one that surely merits investigation, is that target repetition may be particularly beneficial in contexts in which monitoring is difficult to sustain (e.g., at the heart of a busy day). For instance, by stimulating retrieval through spontaneous retrieval processes, target repetition might boost PM performance against situations known to impair target detection such as when attentional demands of ongoing tasks are high (e.g., Marsh, Hancock, et al., 2002; Marsh et al., 1998, 2005; Smith & Bayen, 2005; R. West et al., 2006). Alternatively, highly cognitively demanding ongoing tasks (e.g., divided attention tasks) might limit the extent of the target repetition benefit on PM performance. Specifically, although retrieval processes can be spontaneously initiated by the target occurrence, it is assumed that other aspects of PM retrieval and execution might be effortful (e.g., Einstein & McDaniel, 2010; McDaniel & Einstein, 2007; see Chapter 1). For example, resources might be required for verifying that a PM response is appropriate, interrupting the ongoing task, coordinating the execution of the PM task with the demands of the ongoing task once the intention is retrieved, and so forth (Marsh, Hicks, et al., 2002; McDaniel & Einstein, 2011). Consistent with this suggestion, McDaniel et al. (2013) found that the widely distributed pattern of increased transient activity observed on correct focal PM trials (i.e., trials where a PM action was executed) included the anterior prefrontal cortex, a region which is associated with controlled processing. Hence, ongoing tasks that are high in cognitive control might pose additional challenges in executing the spontaneously retrieved intention. Depending on how modest these resource demands are, it is possible that individuals' WM capacity may moderate the benefit of target repetition within a set with highly demanding ongoing tasks.

Experiment 8 additionally suggested that although high levels of intention retrieval can be achieved in response to a well-practiced target, a momentary change in the target event (even if to a related target) may cause a dramatic drop in the ability to remember to execute the intention. To appreciate the potential implication of this finding for applied settings consider, for example, the domain of health. It is possible that retrieving the intention to take medication from the sight of a pill bottle might be impaired if the label associated with the intention has changed (e.g., new brand prescribed). Given the importance of succeeding in prospective remembering with a less frequent, but equally relevant, target it seems important at this point to at least speculate how high levels of detection for a nonpracticed target can be achieved. An obvious strategy would be to increase the amount of costly monitoring processes devoted to performing the PM task. However, given the uncertainty associated with the presentation of a new, not yet presented target and our limited-capacity attentional resources, adopting such a strategy over an extended period of time might be problematic. Alternatively, previous research has shown that salient or distinctive targets can improve PM performance (e.g., Brandimonte & Passolunghi, 1994; Harrison & Einstein, 2010; McDaniel & Einstein, 1993) suggesting that perhaps making the infrequent target salient (e.g., placing a £10 note next to the pill bottle) might be an efficient strategy to capture attention and achieve high levels of performance. Examining this question could be yet another fruitful avenue for future research.

Concluding remarks

An important question at the start of this thesis was whether (relevant and irrelevant) events that are related to the PM intention have the potential to influence performance, and whether they would do so differently depending on individual differences in the availability of attentional resources. Valuable goals for future research will be to continue delineating the circumstances under which intention-related events can help individuals to maintain PM functioning (e.g., by setting up PM situations to include appropriate cues), as well as unraveling the mechanism(s) underlying the effect of intention-related distractor information on PM as a function of age. Given the impact that PM failures can have on normal everyday functioning, these are issues of considerable practical concern.

Another principle focus of this thesis was to move forward our understanding about the nature and dynamics of the monitoring processes. Overall, the present findings suggested a course of investigation relating to the neural underpinnings of the components of strategic monitoring that could be far-reaching in its impact. Furthermore, it will be essential that future studies focus on understanding age-related changes in the neural mechanisms that support PM (and how these changes are related to performance impairments), as well as on identifying the particular neurological systems that support spared PM performance in older adults (e.g., Burgess et al., 2011; McDaniel & Einstein, 2011). Pinpointing these neural mechanisms should ultimately be useful in identifying PM components that are declining most strongly and in informing the design of effective PM interventions.

Some of the findings in this thesis also spoke more directly to the theoretical debate regarding the processes that support PM retrieval, and pinpointed the value of examining spontaneous retrieval and monitoring processes in combination. The dynamic interaction of the two types of processes could ultimately lead to optimized PM performance and ensure good levels of success (see also Einstein & McDaniel, 2010; Scullin et al., 2013). Identifying the particular strategies for enhancing prospective remembering with minimal cost to the individual's resources could be paramount for overcoming PM difficulties in individuals with greater resource limitations. PM tasks of high importance could then be set up so that they rely on strategies that promote successful PM retrieval, but which rest primarily on spontaneous retrieval processes.

The findings in this thesis provide a sound empirical basis from which to move forward on a number of levels. Understanding how to boost PM performance for individuals with limited attentional resources, refining the theoretical understanding of monitoring processes, and focusing on the dynamics of spontaneous retrieval and monitoring processes are all lines of research that if continued to be pursued hold the potential to extend the scientific community's understanding of PM.

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Appendix 1

The Digit Symbol Substitution task (DSST)

The DSST (Wechsler, 1981) is a paper-and-pencil measure of perceptual-motor processing speed. In this task, participants are required to copy a series of symbols as quickly as they can into an array of empty boxes. The task is presented on a sheet of paper (see Figure i), with a key comprising the digits one to nine and the symbol corresponding to each digit presented at the top. Below this key, four rows of digits and empty boxes are presented, for a total of 93 digits/boxes. Participants are required to use the key at the top of the page to copy the correct symbol into the empty box below each digit. Participants are first asked to complete the sample section comprising seven digits, while being informed that they must do so from left to right. Following practice, participants are instructed that they will next be given 90 s to complete as many of the empty boxes as they can. It is again stressed that they need to do so in order, that is, from left to right along each row in turn without leaving any gaps. At the end of the 90 s, the experimenter instructs the participant to stop. The task is scored as the number of symbols completed correctly in the allowed time.

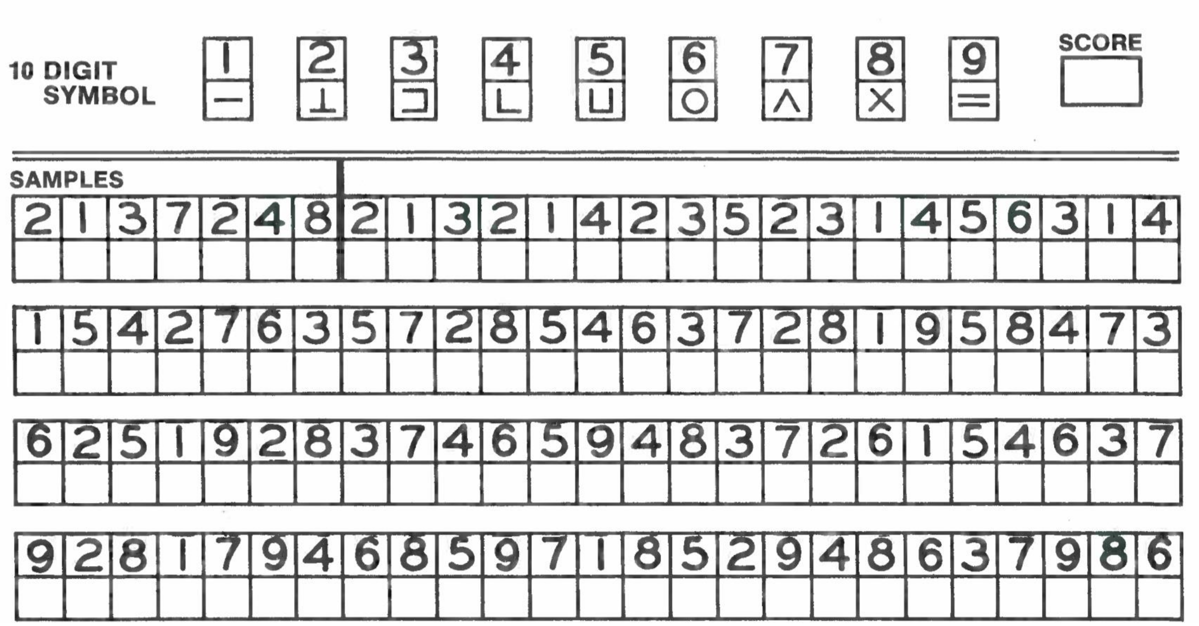

Figure i. Example of a DSST sheet.

The Mill Hill vocabulary test (MHVT)

The MHVT (Raven et al., 1988) is a paper-and-pencil measure of crystallized intelligence. In the multiple-choice format of this task, participants are presented with 34 multiple-choice questions, arranged in order of ascending difficulty. Each question has a word in bold and, below it, six words with a box next to each of them. For each question, participants are required to choose the most accurate synonym for the word in bold by making a tick in the box next to the word (out of the six given options) that is the closest in meaning to this word. For example, for the word *rage* the options are: *crease*, *invite*, *rain*, *love*, *anger*, and *hoist*, where *anger* is the correct answer. The answer to the first question is provided as an example; the test is thus scored out of a maximum of 33. In all administrations of the MHVT in this thesis, participants were encouraged to guess if unsure about the correct answer and given as long as required to complete the test.

Automated version of the operation span (Aospan) task

The Aospan task (Unsworth et al., 2005) is a measure of WM. It consists of a computer-administered, mouse-driven task, that allows participants to complete the task independently of the experimenter. The Aospan task requires participants to solve a series of math operations (e.g., 1*2) + 1 = ?) and judge whether their answer matches a given alternative (e.g., = 3, True or False?) while trying to remember a set of unrelated letters (F, H, J, K, L, N, P, Q, R, S, T, and Y). Each letter is presented for 800 ms and followed immediately by a math operation (see Unsworth et al., 2005). The set sizes range from three to seven letters, with three trials of each set size presented (for a total of 75 letters and 75 operations); order of the set sizes is randomized for each participant. At recall, participants attempt to recall letters from the current set in the correct order by clicking the box next to each appropriate letter. Participants are given feedback about the accuracy of their math operations during recall, with initial instructions encouraging them to keep this accuracy at or above 85% throughout the task. Note that the task includes a practice phase split into three sections: recall the letters only, solve the math operations only, and practice the letters and math operations tasks together (i.e., practice for the actual Aospan task). Most importantly, in order to prevent participants from rehearsing the letters during the Aospan task, the presentation duration of the math operations is automatically calibrated for each individual on the basis of how long it took them to solve the math operations during the corresponding practice section. At the end of the task, the program provides the experimenter with the results for the Aospan task for the corresponding participant. Two span scores are provided: total score (i.e., total number of letters recalled in the correct position) and absolute score (i.e., sum of all perfectly recalled sets). For example, if the participant correctly recalled 3 letters in a set size of 3, 4 in a set size of 4 and 3 in a set size of 5, then the total score would be

10 (3 + 4 + 3) and the absolute score would be 7 (3 + 4 + 0); the number of math errors is also reported (see Unsworth et al., 2005, for details).

End