CHAPTER

18

Event-Based Prospective Remembering: An Integration of Prospective Memory and Cognitive Control Theories

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Abstract

Event-based prospective memory refers to remembering to perform an intended action in response to an anticipated event at some point in the future. In this chapter, we describe the primary components that support prospective memory. These components include encoding, storage, and retrieval. For encoding, we consider one effective strategy, implementation intentions, and the mechanism(s) by which such intentions improve prospective remembering. For storage, we review research that examines whether individuals have privileged access to intention-related information during a retention interval, and the role of retrievals in fostering retention. For retrieval, we discuss theorizing regarding the role of monitoring and spontaneous processes in prospective memory. Throughout, we highlight several features that differentiate prospective and retrospective remembering. In a final section we emphasize one such feature, the need to coordinate ongoing activities with retrieval. To gain traction on such coordination, we propose an integration of cognitive control and prospective memory theories.

Key Words: prospective memory, implementation intentions, intention superiority, monitoring, spontaneous retrieval, cognitive control

Event-based prospective memory (PM) refers to remembering to perform an intended action in response to an anticipated event at some point in the future. PM challenges are ubiquitous in our everyday lives and include remembering to turn off your cell phone when you attend a lecture and remembering to stop at the local coffee shop on your way to work in the morning. Although the consequences of PM failures for such tasks may be relatively mild (e.g., you may feel embarrassed or suffer caffeine withdrawal), some PM failures have devastating consequences. Consider, for example, an airline pilot who must remember to set the airplane's wing flaps after an unanticipated holding pattern (see Nowinski, Holbrook, & Dismukes, 2003) or a surgeon who must remember to check a patient's body for surgical instruments prior to closing the incision (see Fig. 18.1; Dembitzer & Lai, 2003). For these types of PM challenges, and many others, failure to perform the intended action may be life threatening.

Consequently, it is important to understand the critical components that underlie both successful and unsuccessful prospective remembering. Three primary components have been emphasized in research studies over the past few decades. One component process is *encoding*. Taking the example from earlier, imagine that you awoke one morning to discover that you were out of coffee beans. Knowing you could not possibly make it through the day without caffeine, you formulate an intention (e.g., I will buy a cup of coffee at Café Espresso di Cincotta on my drive in to work). You long for a cup of coffee while showering and eating breakfast, and these additional reminders may serve to bolster the encoding of the intention. Upon hitting

Figure 18.1 Scan of a 16-cm clamp left in the abdominal area of a patient. (Reprinted with permission from Dembitzer, A., & Lai, E. J. (2003). Retained surgical instrument. New England Journal of Medicine, 348, 228.)

the highway you begin to think about the numerous items (i.e., additional PM intentions) on your to-do list (e.g., meet with a student, grade an exam, work on a manuscript). You reach your exit 30 minutes later and proceed toward the university. Thus, there is some delay between the formulation of the intention (i.e., encoding) and the occurrence of the event (passing the Café) that signals that the window of opportunity has arrived for execution of the intention. We refer to the processes that support maintenance of the intention over the course of this delay as reflecting a *storage* component. You now catch sight of Café Espresso di Cincotta, the intention of buying a cup of coffee pops into mind, and you head for the finish line. It is the occurrence of this final component, *retrieval*, which serves to complete a PM task.

As may be obvious from this example, there appears to be parallels between prospective remembering and the often-researched retrospective remembering. For purposes of organizing and describing the component processes that support prospective remembering, we have adopted the same framework that has frequently been used to organize and describe retrospective memory (RM) processes. Briefly, this framework recognizes that some information is *encoded* and following a delay during which it is *stored*, the information is subsequently *retrieved*. Although these surface similarities exist, deeper consideration of the primary components reveals a number of features that differentiate prospective and retrospective remembering (e.g., see McDaniel & Einstein, 2007). In this chapter, we will highlight the unique challenges and properties associated with PM tasks during encoding, storage, and especially retrieval.

Another aim of this chapter is to relate general theories of cognitive control to prospective remembering and, by so doing, extend current theoretical understanding of PM. This perspective further highlights a primary difference between prospective and retrospective remembering (i.e., the need to coordinate performance of ongoing activities with the recognition of a PM signal [i.e., target event] and retrieval of an intention), and additionally, it provides new directions for investigating the control processes that support the fulfillment of PM intentions.

Laboratory-Based Prospective Memory Tasks

Before considering the primary components involved in prospective remembering, it is useful to first briefly describe the typical laboratory paradigm used to investigate PM. In a typical laboratory paradigm (see Fig. 18.2), a participant is given an instruction to perform an ongoing activity (e.g., a lexical decision task in which she must judge whether a string of letters is a word or nonword) and an instruction to remember to perform an intention (i.e., the phase during which encoding occurs). For example, the participant may be asked to press the "Q" key if she encounters a target event such as the word "tornado" or the syllable "tor." Instructions often encourage participants to prioritize performance on the ongoing task and to characterize the PM task as secondary. The participant is then busily engaged in the ongoing activity. The storage demand is reflected by the fact that many (e.g., 100) trials of the lexical decision task can occur prior to the appearance of the first target event. Retrieval is measured by whether the participant remembers to retrieve the intention and press the Q key when the target occurs. In total there are often just a few targets (e.g., four)

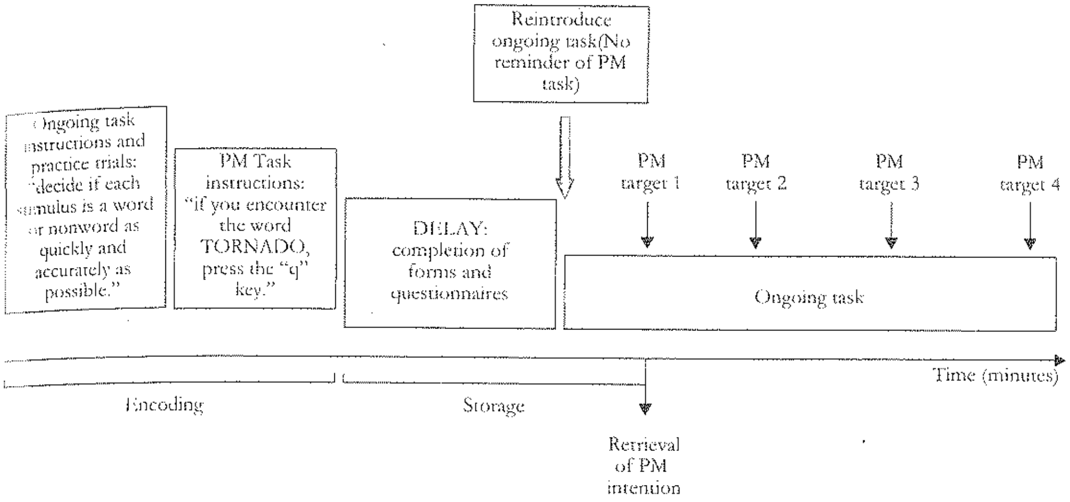

Figure 18.2 Primary components of a typical laboratory prospective memory (PM) paradigm.

among hundreds of lexical-decision trials. Spacing the targets in this manner is intended to simulate real-world remembering where PM target events may occur infrequently in the context of engaging ongoing activities. Participants are also typically questioned at the end of the experiment to help identify the source of any memory failures. Specifically, they are tested for their memory of the PM target and action to determine whether any forgetting was the result of a PM failure or a retrospective memory failure associated with forgetting the task demands.

Contributions of Encoding, Storage, and Retrieval Components

Encoding

A characteristic of PM challenges is that they often involve a priori knowledge of the cues that will be available to activate retrieval. Thus, for PM it is often possible to systematically formulate a strategy or plan during encoding that will maximize the likelihood of retrieval upon the onset of the expected cue. Perhaps the most clear-cut and well-researched example of use of such an encoding strategy in PM tasks is implementation intentions (Gollwitzer, 1999). Implementation intentions refer to "If Situation x, then Response y" statements. For example, "When I see the Café Espresso di Cincotta sign on my way to work, I will stop to buy a coffee." Note that the triggering situation is specifically indicated (and in good detail) in this statement relative to a general goal statement such as "I will buy a cup of coffee." The implementation intention entails a more contextualized cue-action plan in that it includes components such as where and when the intention will be carried out, and in some cases involves visualization of oneself performing the intended action upon onset of the cue (Chasteen, Park, & Schwarz, 2001; McFarland & Glisky, 2012).

Several studies have revealed that the additional effort applied at encoding to formulate an implementation intention is well rewarded, and the strategy appears applicable for a variety of PM challenges. For instance, Sheeran and Orbell (1999) found a 35% reduction in the rate with which participants forgot to take at least one vitamin C pill over a 3-week period for a group that formed an implementation intention relative to a group that formed a more general goal statement. Similarly, implementation intentions have been shown to effectively increase the proportion of individuals who engage in exercise in the week following formulation of the intention (Milne, Orbell, & Sheeran, 2002). About 29% of individuals who formed general goal statements and 39% of individuals who received motivational material engaged in exercise, whereas a whopping 91% of those who formed an implementation intention, in addition to being given motivational material, exercised.

A key theoretical question concerns why this particular type of encoding has such pronounced benefits. It appears several potential mechanisms may converge to benefit PM (Gollwitzer, 1999). One is that implementation intentions enhance the accessibility/activation of the anticipated PM situation, including the target cue. Supporting this idea, Gollwitzer (1996) found that words related to the implementation intention that were presented in the unattended ear during a dichotic listening task captured participants' attention as evidenced by disrupted processing of information in the attended ear.

A second proposed mechanism is that implementation intentions enhance the linkage between particular cues and the PM action such that the occurrence of the cue permits relatively automatic triggering of the intention. One type of evidence that would support this assumption would be that which shows high levels of PM performance in situations that might otherwise lead to a decrement, such as when attentional resources are consumed by other tasks. Providing support for this view, Cohen and Gollwitzer (2008) found that the formation of an implementation intention, relative to standard prospective memory instructions, bolstered PM performance. In addition, only the implementation intention condition was associated with an absence of cost to ongoing task performance. (As will be discussed in the *Retrieval* section, cost refers to the degree to which the presence of a PM intention interferes with ongoing task performance.)

Additional support for this view stems from a study in which attentional resources were further challenged by asking participants to sometimes perform a demanding secondary task (random number generation) in addition to the ongoing activity and the PM task (McDaniel, Howard, & Butler, 2008; Exp. 2). PM performance was evaluated for a standard instructional group, an imagery encoding group, and an implementation intentions group that read, imagined, and stated their intention of performing the action in response to the appropriate cue. PM performance was higher for participants in the implementation intention condition relative to either the standard instructional or imagery encoding conditions. The key finding was that for the implementation intentions condition, PM performance was not degraded by the presence of a high attentional load; by contrast, in the two conditions in which implementation intentions were not formulated, PM declined under high attentional load (but see, McDaniel & Scullin, 2010). Equally important, intact PM performance for the implementation intention group under conditions of high attentional load could not be explained by differential resource allocation policies (e.g., neglecting the ongoing task, or showing greater cost on the ongoing task) or reduced effort toward the secondary, random number generation task (relative to the other two conditions). These data support the idea that implementation intentions permit retrieval of a PM intention even in the face of high attentional demands.

A third mechanism that has been proposed to underlie the benefits of implementation intentions is efficient action initiation. In other words, implementation intentions may produce automatic initiation of the action, an "instant habit" of sorts (Gollwitzer, 1999, p. 499). Consistent with this idea, it was found that action initiation is equally fast following formation of an implementation intention and following habit formation (i.e., repeated and consistent practice with the action) (Aarts & Dijksterjuis, 1999). However, it is not clear that this mechanism underlies benefits to PM performance. Recently, McDaniel and Scullin (2010; Exp. 3) found that repeated practice performing the intended action in response to the target cue led to significantly better performance than implementation intentions in a subsequent PM test phase with high attentional load (a finding that could not be accounted for by differential resource allocation policies). If implementation intentions promoted PM through automatic initiation, then performance in the implementation-intention condition should have been comparable to the performance observed in the repeated practice condition (a condition that presumably created reflexive response initiation). Thus, these findings do not support the view that implementation intentions produce completely automatic prospective remembering.

Implementation intentions did, however, produce equivalent PM performance to that obtained in a generation-encoding condition, a condition that was expected to strengthen the association between the cue and intended action (McDaniel & Scullin, 2010, Exp. 2). Taken in concert, the current evidence is consistent with the conclusion that implementation intentions bolster linkages between cues and intentions. These linkages may stimulate retrieval of the intention upon presentation of the cue, but they need not produce automatized responding (i.e., automatic initiation of the action). We now consider storage characteristics of PM intentions.

Storage

HEIGHTENED ACTIVATION

An unresolved issue in the PM literature is whether prospective memories are stored with heightened activation relative to retrospective memories. In the preceding section we referred to changes in the activation level of intention-related information as a function of forming implementation intentions. The implication is that a by-product of effective encoding strategies may be a boost in the activation level of a PM intention. Even without these strategies, however, some researchers have suggested that intended actions are stored in a privileged state relative to other items in memory. One can imagine, for instance, a continuum of baseline activation levels with PM intentions falling toward the high end of the continuum such that less "triggering" may be needed (e.g., via a target event or cue) to bring the intention to mind (cf. Yaniv & Meyer, 1987). This idea has been empirically tested by comparing how quickly memory judgments are generated for PM intentions relative to other memory contents when similarly cued.

A series of experiments by Goschke and Kuhl (1993) provided initial support for what they called the *intention superiority effect*. In their paradigm, participants studied two scripts. Each script was composed of a short list of actions (e.g., sort the file cards, stack the articles) that was affiliated with a particular event (e.g., clearing a desk). Following study of both scripts, one was designated the prospective script and the other the neutral script. Participants were told that a recognition test would be given on both scripts, and that they would be asked to later execute the actions from the prospective but not the neutral script. Designating scripts as prospective or neutral following study ensured that any differences in the activation level of actions from each script were not attributable to differential encoding strategies. The recognition test, consisting of actions from the prospective and neutral scripts, as well as distracter actions, was administered next. Consistent with the idea that intention-related actions are stored at a higher baseline level of activation, and thus more accessible when cued, recognition judgments were faster for the prospective as compared to the neutral actions (for a similar finding using lexical-decision judgments, see Marsh, Hicks, & Bink, 1998).

Using variations of the aforementioned paradigm, Goschke and Kuhl (1993) ruled out alternative explanations of the intention superiority effect. In one variant, for example, participants were told that they would have to recall both scripts at the end of the experiment, and a distracter activity was inserted immediately after the prospective script was identified to prevent additional rehearsal. Speeded recognition of the prospective, to-be-executed actions was still found relative to the neutral actions, suggesting that the effect cannot be accounted for by differential strategies that were developed following designation of a script as prospective or neutral.

In another experiment, Goschke and Kuhl (1993) included a second group that was given identical instructions as in the original experiment except that the prospective script was now termed the observe script. This group was told that they would later be asked to determine whether an experimenter performed all actions from the observe script. Critically, then, participants in both the prospective and observe groups expected to use information from these scripts at a later point in the experiment. Thus, comparing the accessibility of actions from the prospective and observe scripts permits one to evaluate whether the activation level of prospective actions is higher (i.e., facilitated) than other information that is as relevant to an upcoming decision (i.e., the nonneutral observe actions). Further supporting the notion of intention superiority, recognition judgments were faster for the prospective relative to the observe actions (see Fig. 18.3). As for the neutral items, recognition judgments were slower in the presence of prospective as compared to observe actions (see Fig. 18.3). This suggests that the greater accessibility of prospective intentions likely reflects a combination of heightened activation of intention-related actions as well as suppression of actions that are not relevant to the intention.

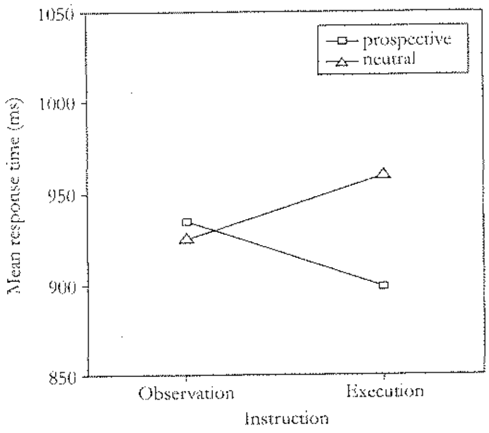

Figure 18.3 Mean recognition latencies for prospective and neutral items in the observation and execution conditions. (Reprinted with permission from Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *19*(5), 1211–1226.)

Whereas the work of Goschke and Kuhl (1993) is compelling, it is not without limitations. For present purposes, perhaps the most critical limitation is that this work differs in an important way from the large majority of PM research. That is, participants are never asked to self-initiate performance of the prospective script in response to a particular event or cue that signals retrieval of the intention-related actions. We are left to assume that a higher state of prospective intention-related activation would lead to better PM performance, which is reasonable, but an assumption nonetheless. Countering this concern somewhat, the work of Freeman and Ellis (2003) showed that the general level of activation of to-be-enacted information and the advantage for to-be-enacted items was still found when participants had to self-initiate retrieval (i.e., they did not expect to be cued by the experimenter).

A second limitation is that the possibility remains that the intention superiority effect reflects differential activation of motor information during encoding (i.e., an *action superiority* interpretation), and not privileged storage of information that is intended for later enactment. In support of this view, Freeman and Ellis (2003) found that recognition judgments were speeded for to-be-enacted (intended) actions (analogous to Goschke & Kuhl's, 1993, prospective condition) relative to neutral items, but the advantage for to-be-enacted actions disappeared when motor processing was prevented by an interference task that followed encoding. A verbal interference task did not disrupt the advantage. This combined pattern is contrary to the notion of privileged access to intention-related information. It appears then that participants may prepare for a prospective intention by developing a motor-based action schema that then facilitates access to the intention (but see Goschke & Kuhl, Exp. 4). In other words, at least some of the time, storage-related effects in PM paradigms may have their roots in encoding operations.

RETENTION INTERVAL

Regardless of the locus of the intention superiority effect, a critical question for both theoretical and practical purposes is how long the enhanced activation of intention-related information persists. This is a more specified version of the general question concerning the retention principles that underlie PM. In Goschke and Kuhl's (1993) work, the heightened activation persisted for at least 15 minutes. Similarly, in other work, it has been shown that PM performance does not decline with increasing retention intervals from 15 to 30 minutes (Einstein, Holland, McDaniel, & Guynn, 1992) or 4 to 20 minutes (Guynn, McDaniel, & Einstein, 1998). Note that the retention interval in these studies was defined as the time between the formation of the intention and the occurrence of the target cue. Retention interval might also be thought of as the time between the formation of the intention and the beginning of the ongoing activity during which a PM target cue is expected. When so defined, there is evidence that PM performance may actually increase as the retention interval increases. Hicks, Marsh, and Russell (2000) used filled retention intervals wherein participants performed a series of distracter tasks that were either 2.5 min or 15 min in length. In two experiments, PM performance was 17% and 21% better for the long- as compared to short-retention interval. One conclusion that can be drawn on the basis of this work is that, at least for retention intervals of these durations, PM does not appear to adhere to the same retention principles as RM, where classically a negatively accelerating logarithmic forgetting curve is observed as a function of the retention interval.

A possible reason for why PM performance may improve with a longer retention interval is that participants may have more opportunities to retrieve the intention (either spontaneously or intentionally). It is plausible, for instance, that retrievals of a PM intention during a retention interval help to maintain its heightened state of activation, and facilitate subsequent retrieval of the intention. Indeed, Kvavilashvili (1987) found that thoughts about the intention during the ongoing activity positively correlated with PM performance, and Kvavilashvili and Fisher (2007) found that throughout the retention interval (6 days in their experiments) people reported that chance encounters with cues related to the intention stimulated retrievals of the intention (e.g., seeing someone on a phone triggered recollection of the intention to telephone the experimenter at an appointed day and time). This dynamic likely pervades PM in everyday contexts. For instance, for the intention to get coffee, one is likely to experience both internal cues (feeling tired) and external cues (smelling the aroma of coffee when walking by someone's office) that would trigger retrieval of that intention.

In laboratory experiments, instructing participants to use breaks that were inserted during an ongoing activity to retrieve the intention significantly enhanced PM performance relative to an instruction to relax during breaks (Finstad, Bink, McDaniel, & Einstein, 2006, Exp. 1). The nature of the retrieval also seems to be important. Guynn et al. (1998) incorporated a retrieval prompt 1 minute prior to the appearance of a PM target cue. Relative to a control group that was not prompted, retrieving the complete intention (target + action) improved PM performance by an astounding 51%. Critically, however, it appears that not all retrievals are created equal. A significantly smaller benefit was observed for a retrieval prompt that cued only the action, and no benefit occurred as a result of a retrieval prompt that focused on the target cues alone (e.g., subjects were instructed "remember the three words that you studied at the beginning of the experiment," referring to the three target cues). Thus far the data indicate that the best kind of retrieval cue or reminder is one that includes thinking about the target and action together.

Further specification of the factors that yield a positive association between retrieval of intentions and PM performance will be both theoretically and practically fruitful. In this vein, Kvavilashvili (1987) found that thoughts about the intention (i.e., retrievals) during the retention interval were more frequent when the ongoing task was less absorbing and when the instructions emphasized that remembering to fulfill the PM intention was very important, with a higher frequency of thoughts associated with better PM. Additional factors that might be explored include the length of the retention interval and whether the interval includes sleep (e.g., Scullin & McDaniel, 2010).

Other relevant factors likely include the number of ongoing tasks as well as the number of currently activated intentions. Real-world PM is often characterized by having several concurrent intentions that are differentially prioritized, and that must be coordinated with constantly changing goals and activities. The fact that humans can continue to successfully perform PM tasks under these situations is impressive. This likely reflects, at least in part, the use of external reminders (Meacham & Leiman, 1982) and our ability to quite naturally deactivate performed intentions, which might otherwise produce interference. Supporting the latter possibility, Marsh, Hicks, and Bink (1998; cf. Scullin, Einstein, & McDaniel, 2009) showed that the intention superiority effect disappears once the prospective actions are performed (but see Scullin & Bugg, 2012; Scullin, Bugg, & McDaniel, 2012; Walser, Fischer, & Goschke, 2012, for evidence of the failure to deactivate previously relevant intentions).

Retrieval

Although there are clearly many interesting research questions regarding encoding and storage processes in PM, the majority of research in PM has addressed the retrieval properties of PM (for a detailed overview, see McDaniel & Einstein, 2007). Perhaps the most striking difference between RM and PM is retrieval. Unlike an RM task, where participants are directed to initiate a search of memory (e.g., in the laboratory, "Please recall the word that was associated with the cue PRANCE in the previous list," or in everyday life, "How do you get to Barberry Street?"), prospective remembering involves retrieval in the absence of a direct instruction to engage in a retrieval search. For example, after forming the intention to pick up bread at the store, there is no one present to prompt you to search your memory for what you are supposed to do when you pass the store. In other words, RM involves the adoption of a retrieval mode (but see Berntsen, 2009, for spontaneous RM in the absence of a retrieval mode), but PM does not (see Guynn, 2003, for an alternative view of PM). How, then, is retrieval of PM intentions accomplished? Research to date suggests two primary types of processes that support retrieval, attentional monitoring and spontaneous retrieval. We will describe each of these in turn.

MONITORING

Attentional monitoring entails resource-consuming processes that are engaged to support prospective remembering (Smith, 2003; Smith & Bayen, 2004). These "preparatory" attentional processes monitor events to determine whether the target event is present and, if so, the intended action can be initiated. According to Smith's preparatory attention and memory (PAM) model, attentional monitoring processes combine with memory processes that discriminate target events from nontarget events and recollect the intended action upon encountering the target event. In the context of a laboratory experiment, the idea would be that while performing an ongoing lexical decision task, the participant is actively checking each letter string (e.g., BRUB, THORN, FALLOT, TORCH) to determine whether it is the target (e.g., TORCH). This determination is made through a recognition check. Thus, in the preceding example, in turn, BRUB, then THORN, then FALLOT, then TORCH would be compared with the target in memory (i.e., TORCH), and once there is a match the participant will start to initiate the action.

Within this view, forgetting occurs because of a failure to maintain the preparatory attention process (i.e., a failure to initiate the recognition check) or because of a recognition failure (i.e., forgetting that TORCH is the target item). A primary signature of the preparatory monitoring process is cost, which refers to the decrement in ongoing task performance that is associated with the presence of a PM intention. Cost is typically calculated by comparing average reaction time (and/or accuracy) on the ongoing task in a control block that does not include the PM intention with average reaction time on the ongoing task in an experimental block where the PM intention is present.

The PAM theory makes several predictions. One is that PM performance should suffer with increases in the attentional demands associated with the ongoing task, as this would leave fewer resources for monitoring. Supporting this prediction, it has been shown that the addition of a secondary task to the ongoing task often interferes with PM performance (McDaniel, Robinson-Riegler, & Einstein, 1998; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997), particularly when the secondary task engages resources that overlap with those that are presumed to support monitoring (Marsh & Hicks, 1998).

A second prediction is that cost, the primary signature of monitoring, should always accompany successful PM performance. Smith (2003) was the first to evaluate cost by focusing solely on the nontarget trials of the ongoing task, rather than focusing on or including PM target trials. This is important because the interpretation of slowing for target trials is ambiguous, as these trials are expected to be slowed in an experimental block with a PM intention regardless of whether a participant is monitoring (Marsh, Hicks, & Watson, 2002). In contrast, according to Smith, slowing on nontarget trials decisively implicates the presence of monitoring, or in other words the deployment of attention toward checking for the PM target. Indeed, studies using a range of ongoing tasks (e.g., lexical decision, category judgment, color matching) have shown that the experimental block is often accompanied by significant cost relative to a control block (Einstein et al., 2005; Guynn, 2003; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Smith, 2003; Smith & Bayen, 2004). Moreover, on average, participants who perform better on the PM task show greater cost than those who perform more poorly on the PM task (Smith, 2003). Though such an effect has not consistently been reported, it is important because it suggests a functional relationship between monitoring and PM performance.

The aforementioned findings support the role of monitoring in facilitating retrieval of an intention in laboratory PM paradigms. However, one might question the degree to which a resource-consuming process would be utilized to support everyday PM challenges. Everyday PM challenges often involve retention intervals that are rather lengthy relative to those used in the laboratory and often filled with various tasks for which performance is at a premium. For example, would you actively monitor for a coffee shop as soon as you begin your commute to work? Would you continuously sacrifice the ongoing task (driving safely) to free up resources for monitoring? There is some laboratory-based evidence to suggest that the answer to these questions is "no."

Marsh, Hicks, and Cook (2006) gave participants a PM task (remembering to press a particular key if they encountered an animal word) and told participants in advance that the animal words would appear in Phase 3. The ongoing, lexical-decision task was given in Phase 1 and Phase 3, with Phase 2 consisting of questionnaires. This unique design permitted Marsh and his colleagues to evaluate cost for the context in which the target event was expected (i.e., Phase 3) as well as the context in which the target event was not expected (i.e., Phase 1). Here, continuous monitoring was not observed. Instead, the presence of cost, and by implication monitoring, was limited to Phase 3. This suggests that we tend to associate intentions with particular contexts and restrict monitoring to these contexts. Returning to the coffee shop example, then, the implication is that one might monitor at particular locations (e.g., a strip mall) where it seems likely that a coffee shop would be present, rather than continuously checking visible signs for the phrase "Coffee Shop." The idea that monitoring is contextually driven as opposed to continuous, thus, provides a reasonable account of how humans manage to remember everyday PM intentions.

MULTIPLE PROCESSES: SPONTANEOUS RETRIEVAL PROCESSES

The other major theoretical perspective that attempts to explain PM retrieval is the multiprocess theory proposed by McDaniel and Einstein (2000; see also McDaniel & Einstein, 2007). According to this theory, people can use spontaneous retrieval processes in addition to monitoring processes in order to accomplish PM retrieval. By spontaneous retrieval, they mean that the occurrence of a target event (or a related event) triggers retrieval under conditions in which no resources are devoted to monitoring the environment for the target event. McDaniel and Einstein (2007) have identified two spontaneous retrieval mechanisms. The *reflexive associative process* assumes that after forming an association between the target event and the intended action (and storing it in long-term memory), later processing of the target event will cause the intended action to be delivered to awareness.

The *discrepancy plus search process* follows from Whittlesea and Williams's (2001) view that people are sensitive to the discrepancy between the actual quality of processing of an event and the expected quality of processing. As applied to PM, the idea is that upon encountering a target event (at retrieval), a person experiences it with more or less fluency than is expected in that context and this discrepancy stimulates a search of memory to identify the source of the discrepancy (i.e., that the target event is a cue for an intended action). As described at the outset of this paragraph, neither of these processes requires monitoring or *preparatory* attentional processes in order to accomplish retrieval of an intention.

The multiprocess framework assumes that people prefer to rely on these spontaneous retrieval processes to support prospective remembering (cf. Bargh & Chartrand, 1999). In line with this assumption, participants often indicate that intentions simply "pop into mind" (Einstein & McDaniel, 1990), and participants report that they rarely (<5% of the time) think about the PM intention while performing the ongoing task (Reese & Cherry, 2002). It is important to note that the multiprocess theory also assumes that the process that the person relies on in a given situation (as well as the effectiveness of that process) depends on a number of factors, including the nature of the PM task, the nature and demands of the ongoing task, and individual differences. For example, research thus far has shown that participants are more likely to rely on spontaneous retrieval processes with one target event (Cohen & Gollwitzer, 2008), when the importance of the ongoing task is emphasized (and the importance of the PM task is deemphasized; Einstein et al., 2005; Kliegel, Martin, McDaniel, & Einstein, 2004) and when focal cues are used. As illustrated in Table 18.1, focal cues are those whose processing overlaps with the processing participants engage in as they perform the ongoing task, whereas nonfocal cues are those that require processing that does not overlap with that which is engaged during the ongoing task (see McDaniel & Einstein, 2007, for further elaboration of the distinction between focal and nonfocal cues).

Perhaps the most direct evidence in support of spontaneous retrieval processes in PM stems from experiments in which participants perform the PM task at high levels but with no evidence of cost (see Einstein & McDaniel, 2010). One critical experiment that provides this evidence was conducted by Einstein et al. (2005, Exp. 2; see also Scullin, McDaniel, & Einstein, 2010) in which a category judgment task was used as the ongoing task (i.e., decide whether the lowercase word presented on screen [e.g., tiger] was a member of the category written in capital letters [e.g., ANIMAL]) and a word (e.g., tortoise) served as the cue. Under these conditions, PM performance was very high (93%), and importantly significant slowing (cost) was not observed. This supports the idea that a spontaneous retrieval process, rather than monitoring, may underlie successful PM performance on some tasks. A key factor that was believed to stimulate such retrieval and bias participants away from monitoring in Experiment 2 is that the task entailed focal processing.

Additional evidence in support of spontaneous retrieval processes was obtained in a subsequent experiment by Einstein et al. (2005, Exp. 5). A lexical decision task was interleaved between the PM instructions and the ongoing image-rating task. Participants were told to press a particular key whenever they encountered the target word in the image-rating task. Furthermore, they were told to ignore the PM task during the lexical-decision task, which would occur following some trials of the image-rating task. The key manipulation was the inclusion of two types of words in the lexical decision task. One type was the target words that participants were instructed to respond to during image-rating. The second type was words that were presented in the initial, brief phase of the image-rating task prior to the beginning of the lexical decision task.

The predictions were as follows. Responding was expected to be slowed for the PM target words but speeded for the words for which an imagery rating was provided (due to priming) relative to matched neutral items in the lexical decision phase. These predictions were confirmed. For present purposes, the critical finding was slowed processing of the target words. This finding implicates spontaneous retrieval of the PM intention because the slowing occurred for targets that were presented in a context in which the intention was not relevant. A reader

Table 18.1 Representative Examples of Task Conditions, Some of Which Have Been Used in Published Research, That We Assume Reflect Nonfocal and Focal Processing

Processing	Ongoing Task	Prospective Memory Task
Nonfocal	Words were presented in the center of a computer monitor and participants had to learn them for recall tests that occurred at unpredictable times.	Respond when you see a particular background pattern (background pattern changes every 3 seconds).
Focal	Participants had to keep track of the number of occurrences of each background screen pattern.	Respond when you see a particular background pattern (background pattern is changed every 3 seconds).
Nonfocal	Lexical decision task	Respond to items from the "animal" category.
Focal	Lexical decision task	Respond to the word "cat."
Nonfocal	Pairs of words were presented, and participants decided whether the word on the left was a member of the category on the right.	Respond to the syllable "tor."
Focal	Pairs of words were presented, and participants decided whether the word on the left was a member of the category on the right.	Respond to the word "tortoise."
Nonfocal	Pictures of famous faces were presented, and the task was to name the face.	Respond when you see a face with eyeglasses.
Focal	Pictures of famous faces were presented, and the task was to name the face.	Respond when you see a face with the first name of "John."

Source: From Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science, 14*, 286–290.

might rightfully suggest that participants were perhaps monitoring during the lexical decision task even though instructions clearly noted that PM targets would not occur within this context. This seemed unlikely given the finding of context-specific monitoring (Marsh et al., 2006), which we reviewed earlier. Nonetheless, Einstein et al. evaluated this possibility and found no evidence of monitoring. The data, therefore, suggest that stimuli can elicit intention-related thoughts rather spontaneously, a process that may facilitate retrieval.

Recall that in a previous section we presented evidence that increasing the attentional demands of the ongoing task interfered with PM performance, and this was taken as evidence for the monitoring theory. However, the divided attention results are not as decisively in the favor of the monitoring theory as originally thought (Smith, 2003). First, dividing attention may interfere with spontaneous retrieval itself. For instance, dividing attention may compromise full processing of the target event, which in turn interferes with retrieval of the associated action (cf. Moscovitch, 1994). Dividing attention may also prevent a retrieved intention from reaching awareness (see Einstein & McDaniel, 2008).

Secondly, dividing attention may interfere with postretrieval processes (e.g., interrupting the ongoing task, holding the retrieved intention in mind, and coordinating the ongoing task and PM responses) that are necessary for ensuring that the PM intention is executed subsequent to retrieval (Einstein, Smith, McDaniel, & Shaw, 1997; McDaniel et al., 1998). These postretrieval processes have received relatively little attention in theories of PM. In the following section, we explore the fruitfulness of incorporating cognitive control theories into a comprehensive view of PM, a view that would embrace consideration of the postretrieval control processes necessary for PM execution.

Contributions of Control Processes

The view that PM retrieval is accomplished through multiple processes dovetails nicely with a range of dual-process theories in the cognitive literature (e.g., dual-process models of RM; Jacoby, 1991). The multiprocess theory also shares some striking similarities with the recently proposed dual mechanisms of control (DMC) account that provides a general theoretical framework for contextual influences on cognitive control (Braver, Gray, & Burgess, 2007). That very similar theories have emerged from a consideration of the cognitive processes that support performance in very different paradigms speaks to the ubiquity and fruitfulness of dual-process approaches.

The DMC account proposes two types of cognitive control, proactive and reactive, which have been examined primarily in classic cognitive control paradigms such as the Stroop, task-switching, and the AX Continuous Performance task (AX-CPT). According to Braver et al. (2007), *proactive control* involves preparatory establishment and sustained activation of goal-relevant attentional settings. These settings bias attention toward the processing of task-relevant information and prevent or minimize interference from goal-irrelevant information. In the AX-CPT, for example, participants are instructed to make a target response to an X probe when it follows a particular cue (an A stimulus) and a nontarget response otherwise. The AX trial type occurs frequently (e.g., 70% of trials) relative to all other trial types (e.g., 30% of trials are AY, BX, and BY). As such, processing of the A cue leads participants to expect an X probe, which permits them to prepare the target response in advance of the occurrence of the probe. Intact proactive control, thus, facilitates performance on AX trial types.

Reactive control, in contrast, is engaged as needed after the occurrence of a stimulus or target event. Reactive control is believed to be triggered by the occurrence of interference from goal-irrelevant information or other processing conflicts. In the AX-CPT, the BX trial type assesses reactive control. On these trial types, the occurrence of an X probe is unexpected (i.e., its occurrence is not predicted by the presentation of the B cue). Its occurrence triggers a tendency to produce the target response (because this is the correct response for most X probes due to the presence of a disproportionate number of AX trials), and participants must engage control to inhibit this prepotent response and make the nontarget response. Following the engagement of reactive control, the attentional settings decay quickly such that it is considered a relatively transient mode of processing. In the following sections, we discuss the similarities between the multiprocess theory of PM and the DMC account, then consider how applying a dual cognitive control perspective to PM might identify new directions for PM research.

Similarities Between the Multiprocess Theory of Prospective Memory and the Dual Mechanisms of Control Account

A key similarity between the multiprocess theory of PM and the DMC account pertains to the nature of the two processes that support PM, on the one hand, and performance on traditional cognitive control tasks, on the other hand. For both accounts, one process involves preparation (e.g., activation of a task set, biasing of attention toward goal-relevant information, adoption of a strategy for monitoring the environment for particular cues) prior to the imperative stimulus or event. For the multiprocess theory of PM, this process is attentional monitoring, and for the DMC account, this process is proactive control. Mechanistically speaking, both attentional monitoring and proactive control can be thought of as top-down influences on behavior. For both accounts, the second process they describe is more reflexive, as it is triggered by bottom-up influences such as the onset of imperative stimuli, cues, or events. For the multiprocess theory, this process is spontaneous retrieval, and for the DMC account, this process is reactive control.

In addition to specifying two distinct, but mechanistically similar processes, the multiprocess theory and DMC account are also similar in recognizing that contextual factors play an important role in modulating reliance on one versus the other process. Whereas both accounts have posited that the preferred mode for humans is to rely on the relatively more reflexive process (cf. Bargh & Chartrand, 1999), both also acknowledge factors that justify the use of a preparatory process. This reflects that there are trade-offs associated with each type of process. For example, in the AX-CPT, implementing proactive control in response to the occurrence of an A cue benefits performance on the AX trial type, but it can hinder performance on the AY trial type because processing of the A cue leads to an invalid expectancy. Next we highlight two contextual factors that have been addressed by both accounts, albeit using different terminology.

One such factor is the metabolic and/or capacity costs associated with use of proactive control and monitoring processes. As noted by Braver and colleagues (2007), such costs may not be justifiable when there are very long retention intervals (e.g., between a cue and probe in the AX-CPT; between a PM instruction and target event in PM paradigms) or when contextual cues do not reliably predict the occurrence of particular stimuli or events (Braver et al., 2007). When such factors are apparent, one would expect reliance on reactive control or spontaneous retrieval. This expectation finds support in the existing PM literature. For instance, Einstein and McDaniel (1996) have shown that performance of delayed intentions reflects use of episodic retrieval processes that are activated in response to the presentation of the target event. Recent work by Loft, Kearney, and Remington (2008) has shown that cost, the signature of preparatory monitoring processes, is significantly lower in contexts where participants have been told to expect PM cues, but they do not occur for up to 640 trials. One interpretation is that participants have begun to shift away from a proactive mode at this point, possibly because use of such an effortful process is not reinforced. In contrast, frequent presentation of PM targets is related to increased costs, thereby reflecting greater use of proactive processes such as monitoring (Cohen & Gollwitzer, 2008), and in tasks where reliable contextual cues predict the presence of PM targets, evidence of monitoring (i.e., proactive control) is robust (see Marsh et al., 2006).

Another contextual factor is the quality of cue, stimulus, or target event processing. Reactive control and spontaneous retrieval depend heavily upon cues, stimuli, and/or target events to trigger retrieval of attentional settings and facilitate prospective remembering. Thus, cues that are not salient, are difficult to detect perceptually (e.g., a coffee shop that is not right along the side of the road), or are not focally processed may not effectively trigger these reflexive processes. Such cues include those that have been considered to be nonfocal in prior PM studies, (e.g., a particular syllable is the PM target event, e.g., "tor," and participants are engaged in a lexical decision task) and the evidence to date suggests use of proactive monitoring processes to support PM performance for such cues (Einstein et al., 2005).

In contrast, when cues are salient, are easy to detect perceptually, or are focally processed, reliance on spontaneous retrieval is expected to produce high levels of PM performance in most situations. Indeed, for such cues, including those that have been considered focal in prior studies (e.g., a particular word is the PM target event [e.g., PARROT] and participants are engaged in a lexical-decision task), PM performance is high without significant cost (prior to the target cues), supporting the notion that a spontaneous retrieval process supported PM (Einstein et al., 2005).

New Directions for Prospective Memory Research Based on Considerations of the Dual Mechanisms of Control Account

One issue that remains to be fully explored is the extent to which reactive control processes, per se, are involved in PM tasks that are supported by spontaneous retrieval processes. Even when retrieval appears to be stimulated by a spontaneous as opposed to a preparatory monitoring process, it seems reasonable to assume that cognitive control mechanisms must be involved in facilitating task coordination and task switching (i.e., switching away from the ongoing task to performance of the PM intention). These mechanisms most likely involve reactive control. Indeed, as noted earlier, one factor that is believed to trigger reactive control is the occurrence of response conflict or interference, and spontaneous retrieval of an intention may produce response conflict. That is, the target event or cue elicits both the ongoing task response (e.g., if the ongoing task is lexical decision, responding "yes" it is a word) and the PM response (e.g., pressing the escape key on the keyboard). The implication of this view is that PM may always involve some cognitive control. In cases where retrieval of a PM intention is stimulated by spontaneous retrieval, the use of cognitive control may be reactive and follow retrieval. In cases where retrieval is stimulated by monitoring, the use of cognitive control is proactive in that it precedes and may also coincide with retrieval.

The assumption that PM involves reactive control processes leads to several interesting directions for future PM research. For instance, earlier we described the use of divided attention manipulations in studies aimed at investigating the role of monitoring versus spontaneous retrieval. The assumption has generally been that divided attention would interfere with performance on PM tasks that are supported by monitoring. However, on the view that performance on PM tasks that are supported by spontaneous retrieval also requires control, of the reactive type, then one might anticipate performance decrements as a result of dividing attention. For example, a cue could trigger the retrieval of an intended action into working memory, but divided attention conditions could interfere with selecting and executing the action while it is still accessible (Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003; Einstein et al., 1997; Guynn et al., 2001).

Another direction for future research on PM that is stimulated by consideration of the DMC account is to examine the neural activation patterns that characterize spontaneous retrieval and preparatory monitoring processes. According to Braver et al., (2007), activation patterns differ for reactive control and proactive control. Because reactive control is often triggered by processing conflicts, activation of the anterior cingulate cortex is expected, as is activation of medial temporal areas, which may facilitate retrieval or reactivation of control settings. While an overlapping region, the lateral prefrontal cortex, characterizes both proactive and reactive control, reactive control is reflected by transient activation in this region, while proactive control is reflected by sustained activation in this region (see De Pisapia & Braver, 2006). The activation patterns that characterize preparatory attentional monitoring processes do in fact overlap with those associated with proactive control (Burgess, Scott, & Frith, 2003; Reynolds, West, & Braver, 2009). However, no studies to date have examined the activation patterns for PM tasks that entail contextual factors that bias participants toward use of spontaneous retrieval mechanisms (e.g., focal processing, emphasis on ongoing task performance) (but see Gordon, Shelton, Bugg, McDaniel, & Head (2011) for evidence that the volume of medial temporal regions including hippocampus correlates with PM performance on a focal task presumed to be supported by spontaneous retrieval). Thus, it is not yet clear whether these patterns overlap with those associated with reactive control. Similar patterns would provide converging evidence for the role of reactive control processes in PM tasks that are stimulated by spontaneous retrieval.

Everyday Prospective Memory: Multiple Goals, Multiple Processes

Finally, we return to the topic of everyday PM challenges. Unlike in most laboratory studies, PM challenges in everyday life are just one of many simultaneously activated goals. Thus, it is not unusual for individuals to be faced with the *shielding-monitoring dilemma* (e.g., Goschke, 2000; Goschke & Dreisbach, 2008). The dilemma is that while it may be beneficial to tightly shield one's current goal from interference (e.g., environmental distraction, internalized interruptions), doing so may prevent one from monitoring the environment, including aspects that would be considered irrelevant to one's current goal, for imperative events or cues. This dilemma speaks directly to the trade-offs that are associated with proactive control processes in the context of ever-changing environments and goals. Let us illustrate with an example.

Imagine that you have been invited to give a talk in an unfamiliar city. You are staying at a downtown hotel and have been invited to a dinner party at the home of a faculty member. You have a rental car at your disposal, but before leaving the hotel you decide to pick up a few bottles of wine as a gift to the hostess and consult the concierge for the location of a wine shop. The concierge indicates that there is a wine shop "somewhere" on Purchase Ave., a street that the directions indicate you will be driving on for 3 miles. Traffic is hectic and you are focused on driving, somewhat defensively, and not getting lost. In this situation, your primary goal is to drive safely and to follow the directions accurately. To achieve this goal, a proactive, sustained approach may be quite useful whereby you filter out the many bits of irrelevant environmental information (e.g., signs, lights, people along the sidewalks) that you encounter. Indeed, it is easy to see how proactive control would benefit driving-related goals but may come at a cost to other, simultaneously activated goals such as purchasing wine. This secondary goal, after all, requires the detection of a cue (e.g., a sign advertising a wine shop) whose location is uncertain, and which you may inadvertently filter.

Recently, Bugg, McDaniel, Scullin, and Braver (2011) explored the potential costs to PM that may be associated with the use of proactive control during performance of an ongoing task. The ongoing task they used was a Stroop color-word task where participants were asked to name the ink color of congruent (e.g., BLUE written in blue ink), incongruent (e.g., BLUE written in red ink), and neutral (e.g., WINDOW written in green ink) stimuli. Participants were instructed that their primary task was to name the ink colors as quickly and accurately as possible. They were also told that the researchers had a secondary interest in their ability to remember to press a key on a response box whenever they encountered the word "HORSE." Neutral stimuli (which included HORSE) occurred infrequently (15% of trials).

The primary manipulation pertained to the remaining 85% of the trials. In the mostly congruent condition, 70% of these trials were congruent and 15% were incongruent. In the mostly incongruent condition, 70% of these trials were incongruent and 15% were congruent. In the latter condition, then, interference was frequent. Based on a rich literature on proportion congruence effects in Stroop paradigms (see e.g., Lindsay & Jacoby, 1994; Logan &

Zbrodoff, 1979), we predicted that the proportion congruency manipulation would bias participants in the mostly incongruent condition to adopt a proactive control mode when performing the Stroop task. By this view, participants would be expected to engage a sustained process for blocking out the irrelevant, distracting words. In contrast, in the mostly congruent condition, word reading would largely be permitted, and reactive control activated as needed to block out word reading on the occasional incongruent trial.

The key predictions were as follows. The adoption of a proactive control mode was expected to enhance performance on the Stroop task such that Stroop interference, the reaction time slowing on incongruent relative to congruent trials, would be attenuated in the mostly incongruent as compared to the mostly congruent condition (e.g., Lindsay & Jacoby, 1994). However, it was expected that this benefit would come at the cost of lower PM performance. That is, use of a sustained process for proactively blocking out the irrelevant words was expected to decrease the likelihood that the word HORSE would be detected and the PM response performed. The results were precisely as anticipated. There was significantly less Stroop interference in the mostly incongruent as compared to the mostly congruent condition, consistent with the idea that proactive control processes were operating to filter words in the mostly incongruent condition. The use of proactive control, however, came at the cost of missing PM cues. PM performance was significantly higher in the mostly congruent condition (*M* = .96), where word reading was permitted, compared to the mostly incongruent condition (*M* = .85). These contrasting interference and PM patterns demonstrate, respectively, the benefits and drawbacks of goal shielding in the context of a multigoal environment.

Conclusion

The overarching framework presented throughout our chapter suggests that PM performance depends on an interrelation among encoding components, storage components, and components in the retrieval environment. The retrieval components seem especially dynamic, as they can depend on preparatory monitoring (proactive control processes), spontaneous retrieval, or both; furthermore, reactive control processes may support these components to ensure PM execution. We suggest that a complete specification of these components is needed in order to achieve a full understanding of everyday PM challenges.

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We dedicate this chapter to the late Rich Marsh, who died at the prime of his career. A gifted teacher, mentor, and scholar, he played a pivotal role in developing the field of PM.

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