ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Current Directions in Psychological Science
21(4) 215–220

DOI: 10.1177/0963721412447621
http://cdps.sagepub.com
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Prospective Memory in Workplace and Everyday Situations

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Abstract

Forgetting to perform intended actions can have major consequences, including loss of life in some situations. Laboratory research on prospective memory—remembering (and sometimes forgetting) to perform deferred intentions—is growing rapidly, thanks to new laboratory paradigms that are being used to uncover underlying cognitive mechanisms. Everyday situations and workplace situations in fields such as aviation and medicine, which have been studied less extensively, reveal aspects of prospective remembering that have both practical and theoretical implications, which are discussed here. Several types of situations in which individuals are vulnerable to forgetting intentions, but which have not been studied extensively in laboratory research, are described, and ways to reduce vulnerability to forgetting are suggested.

Keywords

prospective memory, intentions, paradigms, workplace, countermeasures

An airliner taxies onto the runway and the captain advances the throttles to take off. Suddenly, a loud alarm sounds, startling the two pilots and confusing them for a moment before they realize that the alarm is coming from the takeoff-configuration warning system. The captain retards the throttles and taxies off the runway. The pilots realize that they had forgotten to set the wing flaps to takeoff position and are embarrassed but thankful for the warning system—several airline catastrophes have occurred when the warning system failed.

A surgical team closes an abdominal incision, chatting happily after successfully completing a difficult operation. Several weeks later, the patient comes into the emergency room complaining of abdominal pain. An X-ray reveals that one of the forceps used in the operation was left inside the patient.

Why would highly skilled professionals forget to perform a simple task they have executed without difficulty thousands of times previously? Often, such oversights are regarded as evidence of carelessness or lack of skill, but a rapidly growing field of research on what is called *prospective memory* (PM) has begun to reveal that such failures are predominantly the result of the way task characteristics interact with normal cognitive processes.

PM refers to situations in which an individual intends to perform an action at a later time. The term is something of a misnomer, given that what it refers to involves the cognitive processes of planning, attention, and task management as much as it involves memory. After forming an intention, individuals often become engaged with various ongoing tasks and, in most everyday situations, cannot hold the deferred intention in focal attention. A central distinction between PM and retrospective memory is that with PM, no agent explicitly prompts the individual to remember the deferred intention when execution becomes appropriate—one must "remember to remember"—therefore, much PM research has focused on what enables the retrieval of intentions from memory and why this retrieval so often fails.

Until about 20 years ago, only a handful of PM papers had been published, most of them naturalistic studies. This changed when Einstein and McDaniel (1990) published an experimental paradigm that allows repeated measures with well-controlled manipulations. The field is now burgeoning, with dozens of reports from studies using variations on the Einstein-McDaniel paradigm published each year in mainstream journals.

In this review, I will focus on PM in workplace situations in fields such as aviation and medicine and in everyday tasks such as taking medications. Little PM research has addressed these situations, yet they are important, both for practical reasons and because of their implications for laboratory studies and cognitive theory. To set the stage, I will start with a thumbnail sketch of some laboratory findings most directly relevant to everyday situations. (For full reviews, see Dismukes, 2010; Kliegel, McDaniel, & Einstein, 2008; McDaniel & Einstein, 2007.)

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Laboratory Settings

In the Einstein-McDaniel paradigm, participants are instructed that, while performing an ongoing task such as rating the pleasantness of a series of words, if a particular target cue should appear, they should perform a separate action, such as pressing the keyboard space bar. The cue might be specific ("dog") or categorical (any animal name). PM performance is typically measured as the percentage of trials on which the participant remembers to perform the separate action.

Cues that are distinctive, salient, or unusual produce better PM performance than do cues that are not, presumably because these cues attract attention and elicit more extensive processing (Einstein, McDaniel, Manzi, Cochran, & Baker, 2000). Cues that are highly associated with a deferred intention are generally more effective at prompting its retrieval from memory than are unassociated cues, probably because they provide more activation to the stored intention (McDaniel, Guynn, Einstein, & Breneiser, 2004).

PM performance is substantially affected by the way in which ongoing tasks direct attention—either toward or away from target cues. Performance is also affected by the way in which the ongoing task causes stimuli to be processed. In one study, participants were given the ongoing task of deciding whether one word in a pair of words was a member of the same category as the other word and an additional (PM) task of pressing a key. Some participants were told to press the key if they encountered the word *tortoise*; other participants were told to press the key if they encountered the syllable *tor* (both groups encountered the same words). PM performance was substantially better for the group told to respond to *tortoise*, presumably because the ongoing task required them to focus on words rather than syllables (Einstein et al., 2005).

PM researchers have debated whether the retrieval of deferred intentions occurs automatically when a target cue appears (Scullin, McDaniel, & Einstein, 2010) or requires the individual to maintain some sort of preparatory state, such as active monitoring for the occurrence of target cues (Smith, Hunt, McVay, & McConnell, 2007). Beyond its theoretical aspects, this issue has major practical implications. If a preparatory state is necessary for successful PM in everyday settings, it is crucial to determine how this state functions and how it is maintained over periods, from seconds to months, during which the individual performs diverse ongoing tasks while holding multiple deferred intentions and may encounter unanticipated opportunities to execute the deferred tasks.

Although the debate has not been entirely settled, the preponderance of evidence currently supports a multiprocess view (Einstein & McDaniel, 2010): An automatic process reflexively retrieves stored intentions to awareness, with the probability of retrieval varying depending on task and cognitive conditions; at the same time, individuals may consciously or unconsciously employ some sort of preparatory state that draws upon the severely limited resources of attention or working memory. This as-yet-undefined preparatory state increases individuals' probability of remembering to perform a deferred intention in some situations, but it is not necessary in others, such as when a highly salient cue closely associated with the intention is encountered.

The studies described above involve *event-based* PM. One example of event-based PM would be an intention to give a message to a friend at your next meeting—in this case, the meeting with this friend would be the specific event. Far fewer studies have examined *time-based* PM, whereby an individual intends to perform an action at a specific time or after some amount of time has passed—for example, to take cookies out of the oven (d'Ydewalle, Luwel, & Brunfaut, 1999; Glicksohn & Myslobodsky, 2006). The central findings from the latter studies are that participants typically increase the rate at which they check the time as the target time approaches, and that if they fail to increase rate of checking, they are more likely either to forget to make the intended response or to be late in making it. People generally remember to perform time-based intentions less reliably than they remember to perform event-based intentions (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Sellen, Louie, Harris, & Wilkins, 1997).

Both event-based and time-based PM are episodic—involving one-time intentions—but much of what we intend to do in everyday and workplace settings involves habitual tasks, and forgetting to perform habitual tasks can have serious consequences. In contrast to episodic tasks, the intentionality of habitual tasks may be only implicit in the overall task. For instance, I do not form an explicit episodic intention to insert the key in the ignition when I set out to drive my car. The performance of habitual tasks also depends on the personal experience of the individual. For these reasons, habitual forms of prospective remembering have seldom been studied in the laboratory.[1]

Factors Contributing to PM Failures in Aviation and Other Workplace Settings

Some studies have examined PM in workplace and everyday settings, using ethnographic observations, analyses of accident reports, diary reports, and related methods. Studies using these methods of course lack the power of well-controlled laboratory studies, but they are essential for identifying phenomena not suggested by lab studies, for understanding the constraints and affordances of natural situations, and for exploring strategies individuals use in these situations.

These studies have revealed that the categories of event-based and time-based PM do not capture the range of situations in which individuals forget to perform intended actions. For example, my colleagues and I found prospective forgetting in four types of aviation situations not often studied in the laboratory: interruptions, the absence of cues that normally prompt performance of habitual tasks, habit capture, and multitasking (Loukopoulos, Dismukes, & Barshi, 2009).

Interruptions

Interruptions are often unavoidable; irritating in everyday life, they can be fatal in some occupational settings. Several airline catastrophes have occurred when pilots were interrupted while performing the critical sets of steps required to prepare a large aircraft for flight (Dismukes, Berman, & Loukopoulos, 2007). After the interruption, the pilots skipped to the next task, not realizing that the interrupted task had not been finished.

After reviewing aviation accident reports and diary observations of everyday PM lapses, Rahul Dodhia and I hypothesized that individuals forget to resume interrupted tasks for several reasons: (a) interruptions so abruptly demand attention that the individual fails to encode an explicit intention to resume the interrupted task, even though an intention is implicit in the individual's general schema for accomplishing tasks; (b) new task demands draw attention immediately after interruptions end, so the individual does not pause to check the status of previous tasks; and (c) cues may not be present to remind the individual of uncompleted tasks.

We designed a laboratory paradigm in which participants were abruptly interrupted during their performance of a task on a computer; after they took care of the interruption, the computer led them on to new tasks without explicitly reminding them of the interrupted task they were supposed to complete first. Under these conditions, people often forgot to resume the interrupted task, but when participants were given a short pause or a reminder to complete unfinished tasks at the beginning of an interruption, or when they were given a pause or an explicit cue when the interruption ended, performance improved significantly (Dodhia & Dismukes, 2009). We interpreted these findings as supporting our hypotheses; however, more research is needed to determine the underlying cognitive processes.

Disrupted habitual tasks

Much of the work of pilots, mechanics, surgeons, and other skilled professionals—as well as many everyday tasks—involves executing the sequential steps of highly practiced procedures. Normally, performance of these procedures is quite reliable, but we found that individuals risk inadvertently omitting steps when their normal sequence is disrupted (Loukopoulos et al., 2009). For example, one crucial step in preparing a large aircraft for flight is to set the wing flaps to takeoff position; this step is embedded in one of several procedural sequences, which is executed from memory but backed up with a checklist and cross-checked by both pilots in the cockpit.

In several aircraft accidents, external circumstances, such as freezing rain, have forced pilots to defer setting the flaps to their proper position and completing the associated checklist until just before takeoff. Later, under time pressure to accept a takeoff clearance, the pilots have forgotten both the deferred setting of the flaps and the incomplete checklist. It seems likely that attempting to perform an action out of its normal sequence prevents the action from being cued by the preceding action in the sequence, and it may also remove supporting environmental cues that are normally present. For example, the procedure at some airlines is normally to set the flaps before starting to taxi; delaying setting the flaps removes the visual cues present when the aircraft is at the gate.

Habit capture

Sometimes one must substitute an atypical action for one or more of the steps in a highly practiced procedure; for example, pilots may be given a departure routing with a sequence of climbs and turns that starts out the same as the normal routing sequence but differs later in the sequence. Busy with the multiple, overlapping tasks involved in flying the aircraft during departure, pilots may unwittingly revert to the normal sequence. As an everyday example, individuals heading out on a weekend trip may find themselves instead driving their habitual route to work. Similarly, Sugimori and Kusumi (2009) found that 16% of PM errors by computer programmers were caused by habit intrusions. Highly practiced procedures are executed as sequences of actions retrieved from procedural memory; this process is largely automatic, which frees up the effortful processes of attention and working memory for other tasks. If an individual does not consciously monitor his or her execution of the atypical action, automatic processes may revert to the normal sequence of actions (Reason & Mycielska, 1982).

Multitasking

Professionals often must juggle several tasks concurrently; for example, while performing one task, pilots must monitor several other aspects of their situation, periodically switching attention back and forth among tasks. With experience, pilots can usually do this reliably, but if problems arise in the current task, pilots are vulnerable to *cognitive tunneling*, whereby they forget to switch attention (Ververs & Wickens, 2000). This situation—similar to distracted driving—differs from most laboratory paradigms for studying task-switching in that the pilot is not explicitly prompted to switch attention; instead, the situation concerns time-based PM. Research is needed to uncover the cognitive mechanisms that enable successful multitasking in some situations and make it vulnerable in others. (See Kliegel, Martin, McDaniel, Einstein, & Moor, 2007, for one promising laboratory paradigm.)

Medical Practice

PM probably plays a role in some of the hundreds of thousands of patient deaths caused by medical errors (Institute of Medicine, 2000), but few studies have explicitly analyzed that role. For example, Rothschild et al. (2005) found that 79 of 420 patients admitted for intensive care suffered one or more adverse medical events, of which 45% were judged to be preventable. Most of these medical errors were slips or lapses—failures to carry out intended plans of action. The four types of PM situations in aviation described above all exist in health care; interruptions and multitasking, for example, are pervasive in emergency rooms (Chisholm, Collison, Nelson, & Cordell, 2000). Grundgeiger, Sanderson, McDougall, and Venkatesh (2010), in a report of their study of intensive-care nursing, suggested that to understand PM in workplace settings, we must consider tasks, coworkers, and environments to constitute a distributed system that may support or challenge PM. A coworker, for example, may interrupt a colleague, creating a PM task (to remember to resume the interrupted task later); on the other hand, physical objects may serve as useful reminders to support prospective remembering. Recently, the medical community has started drawing upon tools, such as checklists, that have long been used in aviation as defenses against PM failures (Gawande, 2010).

Everyday Settings

Many studies in everyday settings have examined either age effects or medication adherence. Older participants have shown impaired PM in many, but not all, laboratory studies, and—paradoxically—have generally shown superior performance in personal everyday tasks (Ihle, Schnitzspahn, Rendell, Luong, & Kliegel, 2012). In laboratory studies, PM is apparently not impaired by age when target cues that draw attention (e.g., boldfaced words) are used, but PM is impaired by age otherwise (McDaniel, Einstein, & Rendell, 2008). However, this cannot explain the age-based benefit to PM in everyday settings, which may involve strategic planning, the deliberate use of reminders, or the importance of personal goals. Surprisingly, the medication adherence of seniors is better than that of younger adults, perhaps because seniors lead more routine lives that support habitual behavior (Wilson & Park, 2008).

Diary studies have revealed aspects of PM that are difficult to study in laboratories. My colleague John Holbrook and I (Holbrook & Dismukes, 2009) found that individuals often fail to adequately encode conditions for executing deferred intentions, which contributes to PM failures. Kvavilashvili and Fisher (2007) found that participants given the task of calling an experimenter after a week frequently remembered the intention during the week, sometimes after being prompted by happenstance cues related to the intention and sometimes without any apparent prompt. These diary studies merit follow-up laboratory studies; current theories all revolve around cue-based retrieval, and few experimental studies have examined individual differences in the encoding of intentions or the role of happenstance cues.

Reducing PM Failures

Everyday PM performance improves substantially when individuals are instructed to form *implementation intentions* to identify when and where they will execute an intention and what cues will be present in the environment (Gollwitzer, 1999) and are also told to visualize themselves executing the intention. Implementation intentions have been shown to improve PM performance by as much as two to four times in tasks such as exercising, medication adherence, breast self-examination, and homework completion.

McDaniel and Einstein (2007, pp. 194–204) and I (Dismukes, 2010) suggested a range of measures to protect PM performance (Table 1). Although these measures are derived from empirical research, most have not been validated in everyday settings and deserve further study. Rather than blame individuals for inadvertent lapses in PM, organizations can improve safety by supporting the use of these measures.

A Research Agenda

Natural settings diverge from experimental paradigms in numerous ways (Table 2). Specifically, retention intervals are often far longer; intentions are self-generated and may be encoded differently; and multiple, complex ongoing tasks are engaged. In laboratory paradigms, tasks are typically structured in multiple, closely spaced discrete trials; in everyday situations, individuals often have a fairly broad window of opportunity to perform an intention, and that opportunity may be defined by a conjunction of several situational aspects (e.g., I may intend to give a message to Mary after the meeting, if I see her alone). Unplanned, happenstance cues play a major role in helping us remember to perform our everyday intentions, and individuals often employ external reminders. Laboratory research has focused mainly on simple episodic PM tasks within a single ongoing task, but in everyday situations,

Table 1. Measures to Improve Prospective Memory Performance

Avoid deferring crucial tasks if possible.
Form explicit implementation intentions and plan execution.
Create reminder cues and place them where they are likely to be encountered when the deferred task is to be executed; choose cues that are salient, distinctive, unusual, and/or highly related to the deferred intention.
When interrupted, pause to encode an explicit intention to resume the interrupted task as soon as the interruption ends.
Avoid concurrent performance of multiple tasks if one of the tasks is vital.
Link prospective memory tasks to established habits (e.g., brushing teeth).
When elements of habitual tasks must be performed out of their normal sequence, treat this situation as an event-based prospective-memory situation and use the countermeasures above.
Use external memory aids, such as notes, paper and electronic calendars, and pill organizers; establish daily routines of using these aids.
Use checklists for critical procedures.
For team operations, establish formal procedures for monitoring and cross-checking.

Table 2. Comparison of Laboratory and Natural PM Aspects

Aspect	Laboratory paradigms	Natural settings
Intention formation	Instruction to participant specifies condition for execution; little relation to individual's personal goal structure	Self-generated intention embedded in overall goal structure; may be explicit or implicit; the individual may or may not identify potential cues
Tasks	Mostly episodic tasks	Often habitual tasks
Retention interval	Usually seconds to minutes	Seconds to years
Ongoing tasks	Usually simple lab tasks	Constantly varying; sometimes concurrent complex tasks
Cues	Defined by experimenter	Unanticipated cues may be encountered
Opportunities for the execution of intention and cues	Usually a series of closely spaced, discrete trials	Narrow to broad time frame; single or multiple opportunities, sometimes defined by situational aspects

individuals must plan and execute diverse intentions in a milieu of constantly shifting activities, and in habitual undertakings, much of what we intend to do is implicit rather than explicit.

These differences, which have theoretical as well as practical implications, deserve study. For example, how do self-generated intentions relate to individuals' overall goal structure, and how does this relate to the effects of happenstance cues and external aids? How does the use of external aids change the nature of PM tasks? PM is defined as a task rather than a particular cognitive process; thus the roles of planning, prioritizing, managing goals, and managing attention deserve much more study. Computational models of task switching and multitasking might be adapted to PM.

Naturalistic studies of PM, though essential, cannot replace empirical research; each must inform the other. Simulation studies may provide a bridge, allowing some aspects of naturalistic behavior along with some degree of experimental control (Grundgeiger, Liu, Sanderson, Jenkins, & Leane, 2008). Laboratory paradigms, such as the six-element task, can be used to examine the planning and execution of intentions in more complex settings (Kliegel et al., 2007). PM, by its nature, blurs the distinction between basic and applied research—to the betterment of both.

Recommended Reading

Dismukes, R. K. (2010). (See References). Aimed at a human-factors audience, this review links laboratory and field studies of PM.

Kliegel, M., McDaniel, M. A., & Einstein, G. O. (2008). (See References). A comprehensive resource volume on PM comprising individually authored chapters and commentaries.

McDaniel, M. A., & Einstein, G. O. (2007). (See References). An excellent overview of the field that is both well-suited to students and accessible to nonscientists.

Acknowledgments

Thanks to Barbara Burian, Jon Holbrook, and Kim Jobe for their helpful comments on an early draft of this article.

Declaration of Conflicting Interests

The author declares that he has no conflicts of interest with respect to his authorship or the publication of this article.

Note

1. Some PM researchers have argued that performing habitual tasks is not a form of prospective remembering because it involves somewhat different cognitive mechanisms—nevertheless, individuals sometimes forget to perform habitual tasks, and these failures deserve study.

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