9

Prospective Memory as It Applies to Work and Naturalistic Settings

Although the pilot had set the flaps on his plane to takeoff position thousands of times as part of a well-scripted routine, following a series of interruptions, he forgot to do so. Tragically, the warning system also failed on this occasion, and the plane crashed, killing all but one person.

Eight months after hernia surgery, the patient complained of abdominal pain and nausea. A scan of his abdominal area revealed that a 16-cm clamp had been left from his surgery. Despite the best intentions of a conscientious surgical team of doctors and nurses, they had forgotten to remove the clamp.

The errors above represent true to life failures of prospective remembering (Holbrook, Dismukes, & Nowinski, 2005; Gawande, Studdert, Orav, Brennan, & Zinner, 2003). Although these errors highlight the possible dire

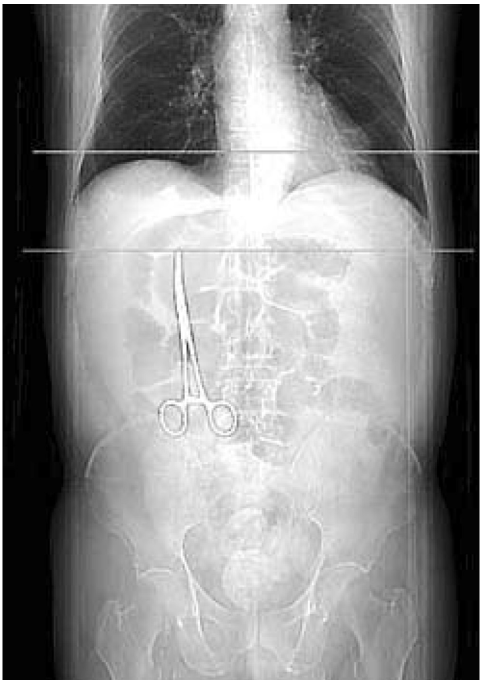

Figure 9.1 Scan of a 16-cm Clamp Left in the Abdominal Area of a Patient

SOURCE: From Dembitzer, A., & Lai, E. J. "Retained Surgical Instrument," in *The New England Journal of Medicine*, *348*, p. 228.

consequences of prospective memory errors in work contexts, it is important to realize that our everyday lives are also filled and sometimes overflowing with prospective memory demands. From managing our work activities (for example, remembering to attend committee meetings) to coordinating our social relations (remembering dinner engagements) to handling our health-related needs (remembering to monitor blood pressure or take medication), good prospective memory is essential for normal functioning.

To get a sense of the pervasiveness of prospective memory demands relative to retrospective memory demands, we have over the years asked our students on the first day of class to list the last thing they remember forgetting. We then categorize their memory failures as either prospective or retrospective in nature. For example, renting a video and then discovering that you have already seen it would be classified as a retrospective memory failure, whereas forgetting to give a friend a message would be classified as a prospective memory failure. Interestingly, with groups of both younger and older adults, we consistently find that over 50% of the reported failures were prospective memory lapses.

Prospective memory failures, such as forgetting to take your lecture notes with you when you drive to work in the morning, can cause problems in effectiveness and efficiency. They can also lead to a great deal of embarrassment, as one of the authors painfully realized after he forgot to attend his first department meeting as chair of the department. (He had been called to the lab by one of his research students and then gotten absorbed in discussions there.) The other author was equally embarrassed when he forgot his first faculty meeting after arriving at his new institution, despite reminders on both his wall calendar and his desk calendar.

As noted in the introductory vignettes, consequences of prospective memory lapses can be devastating. Reason (1990), in his classic book on human error, argues that human frailty is the cause of many catastrophic work accidents. Moreover, he proposes that "failures of prospective memory . . . are among the most common form of human fallibility" (p. 107). Consistent with this impression, Nowinski, Holbrook, and Dismukes's (2003) analysis of the database of self-reported errors by airline pilots revealed that 74 of the 75 errors involving memory failures were prospective in nature. Thus, it seems that insight into the prospective memory conditions that are especially sensitive to failure can have important implications for improving safety conditions in work settings.

Consider also adherence to prescribed medication schedules. The majority of medications are taken by older adults (Park & Morrell, 1991), many of whom take three or more medications on a daily basis (Morrell, Park, Kidder, & Martin, 1997). Adherence to medication regimens is often problematic, with some estimates of nonadherence being as high as 50% (Dunbar-Jacob et al., 2000; Haynes, McDonald, Garg, & Montague, 2003; Stilley, Sereika, Muldoon, Ryan, & Dunbar-Jacob, 2004). Nonadherence may be particularly problematic for patients with asymptomatic conditions like hypertension. In one study, Insel and Cole (2005) found 65% adherence with an antihypertensive medication over an 8-week period in the absence of any intervention. Although there are probably many causes of nonadherence to medication regimens, it seems likely that at least part of the problem is prospective memory failure (Insel & Cole).

In this chapter, based on existing laboratory research, we develop general recommendations for improving prospective memory in work and everyday situations, and in doing so we also highlight those conditions that are particularly prone to prospective forgetting. Some aspects of complex real-world prospective memory demands may be difficult to capture in the laboratory, and we explore limitations of current paradigms. Finally, in an effort to stimulate thinking about profitable new directions for future research on prospective memory in work and naturalistic contexts, we describe nonlaboratory paradigms.

We agree with Loukopolous, Dismukes, and Barshi (2003a, 2003b; see also Dismukes, in press; Reason, 1990) that most of the prospective memory errors that occur in work contexts are not the result of negligence on the part of uninterested, careless, or "bad" people. Instead, most errors arise from conscientious people who are in contexts that place challenges on the human cognitive system. Thus, an understanding of the underlying cognitive demands is essential for improving safety conditions in critical work contexts. Loukopolous et al. (2003a) say it this way:

> The question of why errors happen to well-trained, experienced, and conscientious pilots may seem quite perplexing to anyone who is not a cognitive psychologist. Countless examples of "carelessness" or "complacency" errors during routine operations are reported by pilots who, surprised to have made errors in tasks at which they are quite skillful, cite fatigue, distractions, high workload, or schedule pressures. In incident reports, pilots often resolve "to be more careful" when encountering similar situations in the future. We argue that labels such as "carelessness" and "complacency" do little to help understand and prevent these errors and that merely resolving to be more careful will not improve safety. Rather, these errors can be understood by analyzing task characteristics in detail, identifying associated forms of error, and relating these task characteristics and error forms to underlying cognitive processes. This approach can provide a meaningful foundation for developing countermeasures to prevent errors and to catch them before they lead to accidents.

General Recommendations for Improving Prospective Memory

As we explained when we first attempted a definition of prospective memory in Chapter 1, the unique challenge in remembering delayed intentions (relative to remembering in retrospective tasks like free recall and recognition) is that there is no external request to remember. For example, after planning to pick up milk on the way home, at a later time we somehow have to switch from focusing on driving home to thinking about stopping at the grocery store to get milk. As we indicated earlier (Chapter 4), our belief is that prospective memory is more difficult in situations in which there are few cues that can serve to trigger spontaneous retrieval. In these situations, successful prospective memory is more dependent on developing and maintaining a monitoring strategy—something that is difficult for the human cognitive system to sustain over extended periods of time (see Bargh & Chartrand, 1999; Einstein et al., 2005). Our recommendations therefore focus on identifying those prospective memory situations that are likely to be especially problematic and also on how to make it more likely that cues can serve to produce spontaneous retrieval of the intended action.

Remove the Delay in Delayed Intentions: Do It or Lose It

One factor that contributes to real-world memory lapses is that we sometimes create unnecessary delays in prospective memory situations. For example, in casual conversation with a patient's relatives, a nurse may learn some important information that needs to be communicated to the attending physician. Instead of finding the patient's chart and writing this immediately, the nurse may decide to complete a couple of chores along the way—and then forget to update the chart. Or, we may form the intention to send an e-mail attachment to a friend. However, upon opening the e-mail, we may become absorbed in writing a clever cover note and fail to remember to include the attachment, which was the main point of sending the e-mail in the first place. Incidentally, failing to include the attachment occurs more often than we two prospective memory researchers care to admit!

Laboratory studies with younger adults (Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003) and especially with older adults (Einstein, McDaniel, Manzi, Cochran, & Baker, 2000; McDaniel, Einstein, Stout, & Morgan, 2003) have shown that retrieved intentions can be forgotten over surprisingly brief delays. In one study with younger adults under very demanding divided-attention conditions, there was approximately 25% forgetting after just 5-second delays (Einstein et al., 2003). In another study, when older adults had to delay their intended action by 5 seconds, they forgot to perform the intended action about 50% of the time (McDaniel et al., 2003). These results indicate that maintaining an intention over a brief delay before executing the intended action is not a trivial task for the human cognitive system.

Our suspicion is that people in general do not realize that retrieved intentions that cannot be realized immediately are quite fragile. Often, retrieved intentions are so salient at the moment that they create the misimpression that they are indelible, at least over very brief delays. We suspect that most people are unaware of the research of Muter (1980) and Schweickert and Boruff (1986), showing that thoughts, without refreshing or rehearsal, fade from focal awareness (consciousness) in about 2 seconds. To test our impression that people do not appreciate the ephemeral nature of currently activated intentions, we recently gave 34 participants the following assignment:

> Imagine that you are working on an easy essay question and get the thought to add an argument to a previous question. Before adding that argument, however, you first want to finish answering the question. Based on what you know about how your own memory works, rate how likely (from 0% to 100%) you will be to remember to add the argument to the earlier question when it takes you 5, 15, or 40 seconds to finish the current question.

Participants were asked to make their ratings for both "normal exam conditions" and "very hurried exam conditions." The results indicated that participants viewed the 5-second delay as minimally problematic and expected to remember 98.3% and 90.4% of the time under normal and hurried conditions, respectively. Participants had lower estimates of 91.2% and 79.1% at the 15-second delay and still lower estimates of 81% and 62.9 % at the 40-second delay. Interestingly, our research (Einstein et al., 2000) showed that forgetting occurs quickly, and there was no difference between prospective memory performance after a 5-second delay and performance after a 40-second delay. Thus, people do not seem to realize that brief 5-second delays are just as problematic as 40-second delays.

In light of this research, we believe that whenever possible it is important to perform an intended action as soon as we think about it and not take the chance of forgetting it over a delay. For example, when you are in the bedroom and get the thought to take your medication, which is in the kitchen, you ordinarily might decide to complete a few chores in the bedroom before going to the kitchen to take your medication. The current research suggests that it is important to interrupt your current activities and act on the intention right away. In a similar vein, both of the authors have gotten in the habit of attaching documents to their e-mail messages before writing the cover note.

There are many situations, however, in which we are not able to perform the action immediately. The time may simply not be appropriate, or interruptions or delays over which we have no control may be introduced. For instance, an air traffic controller who gets the thought to reroute an airplane may first have to finish her current conversation with the pilot of another airplane before she can act on her intention. For those situations, the recommendations listed below are likely to be effective.

Use Good External Cues

The research is clear in showing that good cues for prospective memory retrieval are salient or distinctive ones that attract focal processing and are meaningfully connected to the intended action. Under these conditions, prospective memory retrieval has been shown to be very high and to be insensitive to the effects of divided attention (McDaniel & Einstein, 1993;

McDaniel, Guynn, Einstein, & Breneiser, 2004). In one experiment, for example, when the prospective memory target was a common word that occurred among other common words in the ongoing task, subjects remembered to perform the prospective memory task 31% of the time. However, when the prospective memory target was an uncommon word in the context of common items in the ongoing task, subjects remembered the prospective memory task 100% of the time (McDaniel & Einstein, 1993).

It is important to consider all three of these factors in designing a maximally effective cue. A cue that is meaningfully related to the intended action but goes unnoticed will not be effective. For example, if you want to remember to buy milk in the morning, adding one more sticky note to a refrigerator cluttered with sticky notes is unlikely to work because the note is not distinctive and therefore unlikely to be attended to. A better cue would be an empty milk carton (a cue that is related to the action of buying milk) placed in the middle of the kitchen floor or on the driver's seat of your car. The milk carton will be distinctive in both of these locations and is likely to be focally processed, assuming that you walk through your kitchen or get in your car in the morning, and thus is very likely to get noticed. Figure 9.2 lists the characteristics and some examples of effective prospective memory cues.

Anticipate the Triggering Cues: Use Implementation Intentions

We believe that good external cuing is critical for successful prospective remembering. If you are not in a position to create distinctive external cues,

Characteristics of Good Prospective Memory Cues

- Salience or distinctiveness
- Ability to attract focal processing
- Meaningful association with the intended action

Examples of Good Prospective Memory Cues

- To remember to take out the trash when you get home in the evening, lean a small indoor trash bucket against your bedroom door.
- To remember to take your lunch to work, tape a sticky note with "lunch" written on it to the front of your briefcase.

Figure 9.2 Characteristics and Examples of Effective Prospective Memory Cues we recommend anticipating the triggering cues that are likely to be present in the retrieval context (cf. Mantyla, 1993). In Chapters 3 and 5, we described several processes by which cues can stimulate spontaneous retrieval of prospective memory intentions, and it is important during planning to associate the intended action with the possible cues. This recommendation emanates also from the perspective that we often fail to remember to perform actions because we tend to formulate only general intentions (Gollwitzer, 1999). Gollwitzer and others (Cohen & Gollwitzer, in press; Sheeran & Orbell, 1999) believe that the reason we sometimes do not follow through on our intentions in the real world is that we often form broad intentions that tend to focus on the action and not on the triggering events (see Chapter 6 for an extensive discussion). Thus, we might form the intentions to "send an e-mail to a colleague," "buy stamps," "exercise more often," and "take vitamins." The problem here is that we do not clearly specify the triggering conditions for these actions, and thus we are more dependent on controlled processes for actively maintaining our goal intentions or on fortuitous reflection on our future plans and unfulfilled activities at appropriate times.

By using implementation intentions, which take the form of, "When situation x arises, I will perform response y" (Gollwitzer, 1999, p. 494), we specify in advance the cues that signal the occasion to perform the intended action (where and when the intended action will occur) and directly associate the cues to the action. In this way, we make it possible that later processing of the cue will spontaneously lead to retrieval of the intended action. For example, by thinking through, "When I get back to my office and sit in my chair and look at my monitor, I will send an e-mail to my colleague," I increase the probability that the seeing of my office, chair, and monitor will trigger remembering of the intended action. As described in Chapter 6, there is compelling evidence that implementation intentions are effective in improving prospective memory.

Further evidence for the value of anticipating cue conditions comes from the research of Kvavilashvili and Fisher (2007), who have recently shown that spontaneous cuing of intentions occurs frequently in the real world. They gave subjects (on a Monday) the task of remembering to give a telephone call to the experimenter 1 week later (on a Sunday). They also gave them a diary and asked them to make an entry in the diary whenever they thought of the intention to make the phone call over the 1-week delay period. In the diary, subjects were asked to give their impression of what led to the recollection of an intention. Specifically, they were asked to indicate whether they thought there was a triggering cue, and if so, to indicate, among other things, whether it was an incidental external cue (for example, seeing a telephone pole), an incidental internally stimulated cue (for example, thinking about making a phone call to a friend), or self-initiated thoughts related to reviewing of future plans (for example, pausing to reflect on and review the activities for the day ahead). Across three studies, Kvavilashvili and Fisher found that a substantial proportion of prospective memory recollection (about 54% when averaged across studies) was triggered by incidental external or internal cues associated with the intended action. Although these data rely on subjective interpretations of the cuing conditions, they indicate that cues do stimulate retrieval of prospective memory intentions and suggest that anticipating the triggering cues in advance and associating them with the intended action should lead to frequent remindings of the prospective memory intention later.

One other feature of implementation intentions that enhances their usefulness is their effectiveness with a variety of populations, including drug addicts going through withdrawal (Brandstatter, Lengfelder, & Gollwitzer, 2001), people with schizophrenia (Brandstatter et al.), frontal lobe patients (Lengfelder & Gollwitzer, 2001), and older adults (Chasteen, Park, & Schwarz, 2001; Liu & Park, 2004). Interestingly, all of these populations have been characterized as having problems with controlled attention and with keeping current concerns activated. According to Gollwitzer, the benefits of implementation intentions extend to these populations because anticipating the cues in advance leads to relatively automatic retrieval of the intention (a process assumed to be preserved in these populations) when the cues are later encountered.

In closing this section, we note that it generally takes time and mental effort to form implementation intentions, and thus this strategy may not be useful in all situations. For example, in the midst of a very demanding and unrelenting work schedule, it may be difficult for an air traffic controller to take the time to form an implementation intention for every intended action (cf. Einstein et al., 2003).

Beware of Busy and Demanding Conditions

A classic finding in the prospective memory literature is that demanding situations interfere with prospective memory. Marsh and Hicks (1998) found that adding a concurrent task that engages central executive resources to the ongoing task significantly lowers prospective remembering. Although the effects of dividing attention seem to be larger on prospective memory tasks that are more dependent on monitoring than they are on those that are more likely to be remembered through spontaneous retrieval (see Chapter 4), dividing attention seems to compromise prospective memory performance in most situations. Thus, it is important to realize that prospective remembering is likely to suffer under busy and demanding conditions (as both of us demonstrated when we forgot important departmental meetings) and to take appropriate steps, such as using reliable external cues (highly salient ones, such as alarms) under these conditions.

Beware of Interruptions

Recent research has shown that brief interruptions can dramatically interfere with prospective remembering (Einstein et al., 2003; McDaniel, Einstein, Graham, & Rall, 2004). Interruptions are prevalent in everyday life. For example, while in the kitchen, I may form the intention to cull clothes I no longer wear from my closet. Just then, however, the phone may ring, and my brief conversation may interfere with my remembering to clean out my closet. Interruptions are also frequent in demanding work contexts like aviation settings and can be a significant source of forgetting (Loukopoulos et al., 2003b). In one example, an air traffic controller was in the process of giving instructions to a light aircraft on a course for a final approach. At the point at which the controller would normally give the pilot clearance to make the final approach, he was interrupted by an emergency involving another aircraft. In responding to the emergency, the controller forgot to return to the pilot to change the path and issue the final clearance, thus leaving the aircraft flying in the direction of mountainous terrain (R. K. Dismukes, personal communication, February 20, 2003).

To examine the effects of interruptions on prospective memory, Einstein et al. (2003) involved participants in a demanding and dynamic series of 1-minute tasks lasting a total of 32 minutes. Subjects were given the prospective memory task of pressing a designated key whenever they saw a red screen, but they were instructed not to press the key until they completed the current task and started a new task (that is, until they encountered a task change). All of the delays were 40 seconds long, but some included a 15-second interruption during which participants had to perform a new task. Interestingly, despite the fact that both conditions had 40-second delays, the results revealed that including a 15-second interruption during the delay lowered prospective memory by 25% (relative to not including an interruption). This disruptive effect of interruptions has been found repeatedly (Cook, 2005; McDaniel, Einstein, et al., 2004), and although there is no generally agreed upon explanation for this effect, one interpretation is that task switching requires resources (see, for example, Monsell, Sumner, & Waters, 2003). The idea here is that the extra resources required to apprehend the new task could interfere with active maintenance of the intention.

A recent experiment conducted in our laboratory strongly suggests that external cues can be highly effective in overcoming interruption-related forgetting of intentions (McDaniel, Einstein, et al., 2004). In a follow-up of the experiment described in the above paragraph, the onset of the prospective memory intention was associated with turning on a noticeable blue light in the corner of the computer monitor, and this remained on throughout the retention interval. The presence of this cue completely eliminated the negative effects of an interruption. One potential application of this finding is that people might be trained to alter some aspect of their environment when they form an intention and believe that they are likely to encounter an interruption. For example, when I am in the kitchen and form the intention to clean the closet, as I encounter the interruption of the telephone call, I could put a book in the middle of the kitchen floor as a reminder that I have an unfulfilled intention. To leave an even better cue, one that is related to the intended action, I could take off my shirt or a sock and put it on the kitchen floor. In aviation contexts, perhaps the display monitor in front of an air traffic controller or pilot could include a "prospective memory light" that can be turned on whenever something interrupts an active intention.

In a recent set of experiments, Cook (2005) showed that the negative effects of an interruption were dramatically more pronounced (causing forgetting on an additional 25% of the trials) when the interruption served to change the context at retrieval so that it no longer matched the one at encoding. The idea here is that forming an intention in a particular task context causes the context to become associated with that intention, and thus the presence of that task context periodically prompts retrieval of the intention. Thus, if the interruption in some way changes the context at retrieval so that it no longer matches the one during which the intention was formed or in which it is typically retrieved, prospective remembering is especially likely to suffer. For example, if I form the intention to clean out my closet when I am in the kitchen but then go to the den to answer a phone call, while I am in the den I am more likely to forget to remember the intention to clean out my closet. For another example, imagine a pilot who forms the intention to perform the pre-takeoff checklist at a typical point in the taxiing process. Imagine also that the pilot receives a call from the ground controller and continues to taxi to the runway during the conversation. After the call, the context has changed, and to the extent that it is different from the context that normally triggers performance of the pre-takeoff checklist, remembering is likely to be more vulnerable.

Address the Special Problems of Habitual Prospective Memory Tasks

In this section, prior to describing methods for improving habitual prospective memory, we first describe some special problems associated with it. Habitual prospective memory tasks are those in which the action is performed repeatedly and in a routine manner (Meacham & Lieman, 1982). Taking vitamins or medication on a regular basis, turning off the oven, closing the fireplace flue, shampooing your hair in the shower in the morning, and, if you are an experienced pilot, setting the flaps on an airplane to takeoff position are all examples of habitual prospective memory tasks. A common habitual prospective memory task with important health implications is taking medication. As mentioned earlier in this chapter, adhering to a prescribed medication regimen is a significant problem in health care (Park & Kidder, 1996), as estimates for chronic illnesses suggest that adherence is only 50% (see Vedhara et al., 2004). Although some of the nonadherence is likely to be due to disinterest in complying with medical prescriptions, some of it is due to cognitive failures (Okuno, Yanagi, & Tomura, 2001). This is especially likely for older adults, who are the largest consumers of prescription medication and who also tend to experience cognitive decline. One problem is that a person may fail to think of taking the medication at the proper time, and the suggestions listed in the previous sections should be useful for developing effective measures to counter this.

At least two other factors conspire to produce problems on habitual prospective memory tasks—problems that could lead either to performing the action again or to mistakenly not performing the action. One factor is that when we perform an action on a frequent basis, we are also likely to often think about the action. According to Johnson and Raye's (1981) work on reality monitoring, this is a situation that creates confusion regarding the source of a memory, especially for older adults (Hashtroudi, Johnson, & Chrosniak, 1990; Johnson, Hashtroudi, & Lindsay, 1993; see also McDaniel, Butler, & Dornburg, 2006). For example, a person might confuse a thought about a dose of medication with the act of taking it or vice versa, and thus may end up missing a dose or repeating it. Another potential problem is that actions performed on a routine basis may be carried out automatically and during execution of other activities, and this may interfere with your ability to consciously recollect whether or not you have performed the action. Because output-monitoring problems have generally been shown to be exacerbated with age (Koriat, Ben-Zur, & Sheffer, 1988), these kinds of problems would be expected to be more pronounced in older adults.

To examine prospective memory problems that can arise in habitual prospective memory tasks, Einstein, McDaniel, Smith, and Shaw (1998) developed a laboratory paradigm in which participants were given a series of 11 tasks to perform, with each task lasting 3 minutes. In addition, subjects were asked to perform the prospective memory task of pressing a key on the keyboard once and only once during each task. In order not to strictly tie the prospective memory response to the start of each task, subjects were told to press the key some time during the task but not within the first 30 seconds of each task. Subjects were also told that if they were unsure whether or not they had already made the prospective memory response for a given task, it was better to press the key a second time than it was to omit it (see Chapter 7 for a detailed presentation of this experiment). Our main interest was in seeing if some confusions concerning whether or not the response had already been made would arise by the later trials (that is, after the task had become habitual). We tested both younger and older adults. For younger adults, there were relatively few (5%) repetition errors on both the early and later trials—although, depending on the situation, even a 5% error rate could be problematic in real life. For older adults, there were modest levels of repetition errors on the early tasks (11%) but high rates on the later tasks (18%), particularly in the divided-attention condition (28%). Indeed, on the final task, in the divided-attention condition, over 40% of the older adults made a repetition error. A similar pattern of repetition effects was found by Ramuschkat, McDaniel, Kliegel, and Einstein (2006). A related finding was that older subjects were more likely than younger subjects to omit a response during a task but then to mistakenly indicate at the end of the task that they had performed the response during that task. Taken together, these results suggest that source-monitoring and/or output-monitoring errors can develop in habitual prospective memory tasks and that older adults are more susceptible to these kinds of confusions.

Use external aids. Research has shown that external organizers (pill organizers into which one is able to load a supply of medication for a given period of time) are effective in improving adherence to medication regimens (e.g., Park, Morrell, Frieske, & Kincaid, 1992). Although it is unclear which of the above-mentioned cognitive processes benefit from these devices, external organizers can potentially facilitate cuing and can eliminate source-monitoring errors (that is, if your pill is there, you have not yet taken it, and if it is not there, you have taken it). In a laboratory analogue of a medication adherence task, subjects had to make the same response on each of 20 blocks of trials (Vedhara et al., 2004). External cues (an auditory cue signaling when the response should be performed along with a visual cue on the appropriate response key) dramatically reduced omission errors (from 52% in the control condition to 6% in the condition with both cues). Although most of this improvement was probably due to the auditory and visual cues serving as a reminder to perform the prospective memory action, it is likely that the external cues served also to reduce source- and output-monitoring confusions (for example, if subjects tied the performance of the action to the occurrence of the auditory cue, thoughts about performing the action at other times would not lead to an additional response). Supporting this interpretation, repetition errors were reduced by over half in the conditions with an auditory cue.

Increase the complexity of the action. Ramuschkat et al. (2006), using a paradigm very similar to that of Einstein et al. (1998), conducted a laboratory experiment in which subjects were asked to press a response key sometime during each of twelve 3-minute tasks. A novel aspect of this experiment was that it included a complex motor action condition in which each subject was required to put one hand on top of his or her head while pressing the key with the other hand. Making the action more complex (relative to requiring subjects to simply press the key with one hand) significantly reduced repetition errors for older adults (from 17% to 6%). The more elaborate response could have reduced repetition errors by improving output monitoring (that is, by making subjects pay more attention to performing the response) and/or by improving source monitoring (by making the response more distinctive so that it could be more easily distinguished from a thought about performing the action). These initial results suggest that training people to perform a complex and distinctive action when they execute a habitual prospective memory task (for example, to swirl the pill around in their mouth when they take medication) might, in the absence of external cues, be an effective way to reduce repetition errors.

Use the Spaced-Retrieval Technique

Spaced retrieval is a technique that has been successfully used in prospective memory situations by people who are experiencing mild to moderate deficits from Alzheimer's disease (Camp, Foss, Stevens, & O'Hanlon, 1996). The basic idea is to get people to practice retrieving the intended action, with each retrieval occurring after a delay longer than the previous one. Let's say, for example, that you want to train your uncle to take his medication with dinner. Initially you tell him, "You need to take your medication with dinner"; you then wait 20 seconds and ask, "What is it that you are supposed to do?" Given that the delay has been so short, he should be able to remember. Then you gradually increase the length of the delay by 20-second intervals (first you wait 20 seconds, then 40 seconds, then 60 seconds, and so on), asking your uncle at the end of each interval what it is that he is supposed to do. If he ever forgets, you remind him, then decrease the length of the delay by 20 seconds. Eventually, your uncle should be able to remember on his own.

Camp and his colleagues (Camp, Foss, Stevens, & O'Hanlon, 1996) have used this exact technique to help people with mild to moderate dementia remember to check a calendar in the morning to determine their chores for the day. The participants were given 30- to 45-minute training sessions each day over a 2-week period, at the end of which 61% of them were able to remember what it was they were supposed to do. With additional training and practice, 75% of the patients were eventually able to effectively check the calendar to determine their chores (see Chapter 5 for a more detailed description of this work).

The story in Figure 9.3 illustrates the nature and usefulness of this technique. As you can see, its effectiveness is not limited to prospective memory situations.

An Analysis of a Prospective Memory Failure and Possible Interventions

We believe that the basic principles described above are useful for discovering those situations that are especially susceptible to prospective memory failure and also for designing effective countermeasures in those situations. To provide one illustration, we analyze below a particularly shattering prospective memory failure.

In 2003, Mark, a university professor and a loving father, carefully and securely strapped his 10-month-old son in the car seat in the back of his car. His son, Mikey, who had been conceived only after heroic efforts with in

> I drive my mother to the Alzheimer's center each weekday. Since we live on the north shore (of Lake Pontchartrain) and the center is on the south shore, this is a long drive (about 35 miles one way). All the way to the center my mom would keep asking, "Where are we going?" I'd tell her, "We're going to the school" (that is the name the family uses to refer to the center). Then she'd ask again, and again, and again. It used to drive me crazy. Well, after your talk I decided to try the thing you were talking about. So, the next day when we got into the car, I said, "Mom, we're going to the school now." Then I waited a few seconds and asked her, "Where are we going?" and she answered, "You said we were going to the school." Then I waited a couple of minutes and asked her, "Where are we going?" She looked at me like I was a little crazy and said, "We're going to school!" Then I waited a few more minutes and asked, "Where are we going?" Mom seemed a little mad, but said, "We're going to school, like you said." That was the last I brought up the subject, but you know, she never asked me that question the whole trip. Now I ask her when we get in the car, she answers, and that's that. I just thought you'd like to know that it actually works.

Figure 9.3 A True Story Illustrating the Effectiveness of the Spaced-Retrieval Technique

SOURCE: From Camp, Foss, and O'Hanlon (1996, p. 193).

vitro fertilization, was the joy of his life. Mark was preparing to drive to work, but on this particular morning he was also planning to drop his 10-month-old son off at day care on the way in. Although his usual routine was to drive to work alone, over the previous several months he had occasionally taken his son to the day care center on the way to work. The drive to the day care center and the drive to his office were very similar except for a different turn at the last intersection. On this day, Mikey fell asleep in the backseat. Mark "lost his concentration" and probably got absorbed in thinking about other things (such as the demands awaiting him at work). Instead of making the turn to the day care center, he drove straight to work, parked his car, and got out and walked to his office. It was 80 degrees outside that day, and Mikey died of heat stroke several hours later (see www.4rkidssake.org/mikeysstory.htm for more information about this tragic event).

How could this happen? How could a man described by his wife as "the most adoring, doting, and devoted father in the world" forget that his child was in the backseat? Rather than thinking of this as a failure of conscientiousness on the part of the father, we see this error as a memory lapse, albeit a heartbreaking one, that is an inherent consequence of normal cognitive functioning. We see it as an error that all of us are capable of making under the same circumstances. Although he was sleep deprived that morning, Mark was initially very aware of the intention to take Mikey to day care, and in the early stages of the ride, while Mikey was still awake, there were external cues that kept this intention activated. After Mikey fell asleep, however, there were no longer external cues that triggered the intention, and therefore it was up to Mark to maintain this goal or intention in memory. As we have indicated, this can be difficult to do, and the intention can be lost surprisingly quickly, especially if pressing work demands start to occupy one's mind. It is also important to realize that Mark did not normally drive Mikey to the day care center on his way to work. Thus, the habitual set of actions involved in driving to work was carried out. At work, there again were no cues, and Mark followed the normal set of actions—getting out of his car and walking to work (see "An atypical action is required instead of a habitual action" below).

What can be done to avoid tragic accidents like this? In our view, given that it is generally difficult to continuously use capacity-consuming resources to maintain intentions in mind (Bargh & Chartrand, 1999; Einstein et al., 2005), it is important to create good external cues that can serve to trigger remembering of the intention. As Mark states on his Web site (www.4rkidssake.org/mikeysstory.htm), "Put a diaper bag in the front seat every time your baby is in the car. Or put your purse, briefcase, wallet, or cell phone in the back seat where you will have to retrieve it before leaving the car." It may also be possible to develop alarms in car seats. Given the vicissitudes of our mental thoughts, it's important to have these kinds of external cues in place so that they can support prospective memory retrieval.

As stated at the beginning of this section, it is clear that current laboratory research is useful in identifying those conditions that are particularly vulnerable to prospective memory failure and for designing procedures for reducing failures. Nonetheless, it is also clear that existing laboratory paradigms do not fully capture all real-world and work-related prospective memory demands. We examine some of these limitations now.

Limitations of Existing Laboratory Experiments

Good prospective memory is critical to many work settings. For example, a mechanic who is performing maintenance on a complicated system must remember to perform a complex set of actions in the proper sequence (Reason, 1990). A nurse who has recently learned that a patient has an allergy not listed in the chart must remember to tell this information to the anesthesiologist. And, after a grueling 5-hour operation, the surgical team must remember to search for instruments and sponges that may have been left in the body—an error that occurs about once in 13,000 operations (Gawande et al., 2003).

In aviation settings, prospective memory failures can be similarly catastrophic. Although airline accidents that result in death or hull loss are extremely rare (1 in 1.4 million flights), especially in developed countries (1 in 5 million flights) (Dismukes, in press), accidents often have severe consequences. Thus, the cognitive demands of airline crews in safely launching, flying, and landing aircraft have been extensively analyzed (see, for example, Dismukes, in press, and Loukopoulos et al., 2003b). One approach used by scientists to understand these demands has been to carefully analyze reports from accidents as well as the more frequent voluntary reports from pilots about crew errors. In examining these data, Dismukes has identified several prospective memory demands that pilot crews encounter and that have not been examined in typical laboratory experiments (see also Loukopoulos et al., 2003b). In the sections below, which are based mainly on Dismukes's analysis, we describe prospective memory demands that are rarely captured in laboratory prospective memory experiments. The intention here is not to denigrate existing research but rather to inspire further thinking about the adequacy and limitations of current paradigms for investigating prospective memory as well as to stimulate creative development of new paradigms for capturing important processes.

Real-World Prospective Memory Demands Are Embedded in Meaningful Events

Imagine that an air traffic controller requests that the crew of an airplane, while making a descent from an altitude of 15,000 feet, report when the plane passes through 10,000 feet of altitude. Although the prospective memory demand ostensibly resembles prospective memory demands present in nonfocal event-based prospective memory tasks studied in the laboratory (see, for example, Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997), the fact that an experienced pilot performs this in the richer context of a familiar sequence of actions may change the nature of the task. For example, the crew can anticipate that they will descend through 10,000 feet in about 5 minutes, and knowing their upcoming tasks and the duration of them (something that is rare in the laboratory), they can associate the altimeter reading with tasks that are likely to occur in 4 to 5 minutes. One indication that strategies change in well-known contexts comes from the work of Ceci and Bronfenbrenner (1985), who found that children's monitoring strategies were more efficient when a time-based prospective memory task was performed in the more familiar home context than they were when the same task was performed in the laboratory.

Real-World Habitual Prospective Memory Tasks Are Deeply Cued

Dismukes (in press) points out that pilots perform a complex set of procedures very often, usually in the same sequence, and that the execution of these actions eventually becomes automatic. Each individual action in the sequence is cued by the previous action and/or the perceptual context. For example, a pilot's normal sequence may be to set the flaps to takeoff position after performing a given checklist and prior to taxiing to the runway. Thus, completion of the checklist as well as the perceptual environment prior to taxiing are powerful cues for setting the flaps, and these serve the pilot well under normal conditions. Occasionally, however, because of weather conditions, the pilot may be asked to defer setting the flaps until after taxiing. At the runway, the normal kinesthetic and perceptual cues for setting the flaps to takeoff position are no longer available, and the pilot may be highly vulnerable to omitting this step. Dismukes convincingly argues, and we would agree, that the deeply cued nature of habitual prospective memory tasks has not been captured in laboratory prospective memory tasks—even in those studies examining habitual prospective memory (see, for example, Einstein et al., 1998)—which thereby underestimate the potential challenges and pitfalls of habitual tasks in the real world. In theory, by giving subjects extensive training with a sequence of tasks, it would be possible to mimic these characteristics in the laboratory. Another approach would be to develop laboratory paradigms that capitalize on already well-learned complex action sequences (for example, preparing a meal) (see Craik & Bialystok, 2006).

Interruptions can interfere with habitual actions. Another consequence of working in a highly proceduralized and sequential environment is that interruptions can disrupt the conditions that normally serve to trigger an action. According to Loukopoulos et al. (2003b), interruptions from flight attendants, ground personnel, and others are common in cockpit settings. Often these are in the form of requests that must be attended to. Also, interruptions remove the crew from the normal sequential and perceptual cuing conditions. During the interruption, the perceptual environment continues to move forward, so that the normal and routine cues for triggering the interrupted action may no longer be present. As Dismukes (in press) points out, these conditions are different from those in typical laboratory experiments examining the effects of interruptions on prospective memory. In these laboratory studies, subjects are given an action to perform (for example, "Press a key at the next task change") and then receive an interruption during the delay. Here, the interruption does not remove the subject from the typical cuing conditions for performing the action. That is, after the interruption, the cue which triggers performing of the action still occurs (although see Cook, 2005, for a paradigm in which the cue occurs during the interruption).

An atypical action is sometimes required instead of a habitual action. Another problem in real-world habitual prospective memory tasks is that a person may occasionally be asked to perform a novel action in a complex sequence of actions but because of habit will instead perform the old action. For example, you may decide that you will no longer put sugar on your breakfast cereal to reduce caloric intake, and then, out of habit, sprinkle sugar on your cereal the next morning (Reason, 1990). Or, after a long day at work, you may have the goal of getting home as quickly as possible. This goal is antagonistic to the intention to stop at the store to purchase bread on the way home. Still another example is the situation described earlier, in which a father who was taking his child to day care instead drove his usual route to work. Given that prospective memory researchers have tended not to examine well-ingrained sequences of actions in the laboratory, existing laboratory research has done little to help us understand these intrusions upon habit.

Monitoring for Low-Frequency Events May Be Required Over Extended Periods of Time

Dismukes (in press) points out that pilots often have to monitor for low-probability events while busily engaged in other tasks. For example, under certain weather conditions, pilots need to visually monitor the airspace for planes that are on a conflicting path. Although most of the laboratory research on prospective memory has not directly examined the ability of people to monitor for very low probability events, this prospective memory ability seems likely to be quite amenable to laboratory study.

Complex Sets of Actions Need to Be Planned and Initiated

A characteristic of many real-world prospective memory demands (although not necessarily in cockpit situations) is that we may have several actions to perform within a period of time without there being an inherent order to performing these tasks. Instead, we must plan to perform the actions within the parameters of our life space and later activate the plan and execute it. Complex planning and initiation are rarely captured in laboratory studies of prospective memory. Typically, the prospective memory demand is fairly simple and the experimenter makes the plans for the subjects by asking them to perform an action whenever they see a presented stimulus (event-based prospective memory task) or at a particular point in time (time-based prospective memory task). The one exception is the six-element task developed by Shallice and Burgess (1991) and modified by Kliegel, McDaniel, and Einstein (2000) to examine performance on the planning, initiation, and execution processes. For this task, subjects were given instructions regarding six subtasks as well as rules for sequencing the subtasks and maximizing performance. Maximum points could be earned by performing the tasks correctly and by performing the early items on a subtask and then moving on. Also, some subtasks could follow a given subtask and others could not (see Chapter 6 for more details about this research). Although rarely used in experimental research, this laboratory task is an initial attempt to capture planning and initiation strategies that occur in the real world when we are faced with carrying out multiple intentions within the constraints of our life space.

Real-World Retention Intervals Are Often Long

A characteristic of most laboratory prospective memory tasks is that the delay between the presentation of the prospective memory demand and the occurrence of the target item is fairly brief (typically on the order of 5 to 20 minutes). In the real world, the delays are often several hours (for example, the delay involved in planning to go to the gym later in the day), several days (planning to shop for a camera next weekend), or several weeks (planning to attend a friend's soccer game next month). Theoretically, we would expect prospective memory retrieval to be less reliant on monitoring and more dependant on spontaneous retrieval processes with longer delays. Although there have been several studies that have examined long-term prospective memory by asking subjects to mail cards to the experimenter on designated days (see, for example, Dobbs & Rule, 1987; Kvavilashvili & Fisher, 2007; Meacham & Leiman, 1982), there has been little research examining prospective memory after long delays under tightly controlled laboratory situations. Thus, delays extending beyond an hour or so, which occur frequently in the real world, have rarely been captured in laboratory experiments.

Nonlaboratory Methods for Investigating Prospective Memory

Our firm belief is that laboratory research on prospective memory is extremely useful not only for testing theoretical positions but also for predicting the real-world prospective memory situations that are especially susceptible to failure and for designing interventions that improve prospective memory in these situations. We believe the laboratory is a simplified reality that captures important aspects of real-world prospective memory demands. For example, extrapolating findings from the laboratory to real-world and work contexts, it is very reasonable to assume (based on the principles presented at the beginning of this chapter) that prospective memory is more likely to fail when a delay is introduced between the initial retrieval of an intention and the opportunity to perform the intended action, when interruptions are presented during the retention interval, when the work environment is stressful (for example, when attention is divided), and when prospective memory cues are not salient, distinctive, and related to the action. And existing research shows that removing delays and using better external cues improves prospective memory.

Even so, there may be important aspects of real-world prospective memory tasks that are difficult to capture in the typical laboratory paradigms that have thus far been used in prospective memory research. To increase awareness of less frequently used methods as well as to stimulate thinking about novel uses of these paradigms, below we briefly describe general classes of methods that have been used to study prospective memory in the real world. It is important to consider both ecological validity and the ability to control extraneous variables in evaluating the usefulness of these paradigms.

Incident Reports

As noted in an earlier section, Dismukes and his colleagues (Nowinski et al., 2003) have effectively analyzed airline accident reports as well as pilot reports of errors in order to document prospective memory errors and to assess the conditions that contribute to them. This technique was also used by Gawande et al. (2003) to examine the conditions in surgical cases that lead to failure to remove foreign objects (for example, sponges or clamps) from a patient's body. They compared problem surgeries (obtained from incident reports over a 6-year period) to control surgeries (surgeries in which the same procedures were performed but no foreign objects were left in the body) and found that leaving a foreign object in the body was nine times more likely when operations were performed on an emergency basis, four times more likely when there was an unexpected change in procedure, and also more likely with patients who had larger body mass indexes.

Clinical Assessment Techniques

Given that memory researchers have until recently tended to ignore prospective memory research, it is not surprising that traditional memory batteries (Wechsler, 1997) have not measured prospective memory. The earliest inclusion of a prospective memory task in a clinical assessment test was in the Rivermead Behavioral Test (Wilson, Cockburn, & Baddeley, 1985). This test contained two items measuring prospective memory, and both appeared in the context of performing retrospective memory tasks. Each prospective memory item required the respondent to remember to perform a simple action some time later in the experiment (one action was to be performed at the end of the session and the other when an alarm was heard). One problem with these test items is that they have not been shown to predict performance on real-world prospective tasks (Mills et al., 1997). A more recent test, called the Cambridge Test of Prospective Memory (Wilson et al., 2005), assesses both time-based prospective memory (three items) and event-based prospective memory (three items). Early indicators suggest that this may be a reliable and valid instrument for clinical assessment (Thöne-Otto & Walther, in press; Wilson et al., 2005).

In principle, the development of a valid and reliable clinical assessment of prospective memory ability could serve several important purposes. For instance, such a test would be useful in diagnosing patients with extensive prospective memory problems, who are thus at risk if they live independently. Given some initial indication that those with genetic liabilities for Alzheimer's disease are especially susceptible to prospective memory failures (Driscoll, McDaniel, & Guynn, 2005), such a test could also potentially serve as an early detector of dementia. In addition, this type of test could be useful in individual-difference research (for example, to see if prospective memory ability is independent of retrospective memory ability, as suggested by Salthouse, Berish, & Siedlecki, 2004).

Existing efforts to develop a clinical assessment technique for measuring prospective memory performance have assumed that prospective memory ability can be captured as one or possibly two constructs defined by the nature of the prospective memory task (for example, the event- and time-based items in the Cambridge Test of Prospective Memory). In light of the analyses presented throughout this book suggesting that different processes become prominent in different prospective situations (for example, different processes are recruited for focal and for nonfocal event-based tasks [see Chapter 4]), we suspect that the next generation of clinical assessment tools will benefit from additional analysis of the kinds of processes involved in different prospective memory tasks (for example, making a distinction between spontaneous retrieval and monitoring processes involved in focal and nonfocal event-based tasks, respectively). In addition to suggesting the kinds of prospective memory tasks that are most risky for a particular individual, this deeper analysis could suggest different pathologies.

Observational Studies

In an effort to understand the prospective memory demands that occur in cockpit situations, Loukopoulos et al. (2003b) have conducted observations from the jump seat of Boeing 737 airplanes. Sitting in the jump seat allowed clear observation of the cockpit controls, the cockpit displays, and the actions and interactions of both pilots. Although in the ideal situation pilots follow well-scripted routines in a serial fashion during flights, Loukopoulos et al.'s observations of 60 flights revealed that the pilots often handled several tasks simultaneously and that there were frequent disruptions to normal operating procedures. Thus, they discovered that interruptions, delays, and changes in the normal sequence of actions, all of which increase the probability of prospective memory errors, were common during the flights.

Simulations

Dieckmann, Reddersen, Wehener, and Rall (2003) conducted a study in which they asked fourth- and fifth-year medical students to perform action sequences typical of those involved in operations. They performed these on simulator manikins, which allowed authentic procedures (for example, blood pressure monitoring) to be performed, in a room that realistically simulated an operating theater. The scenarios lasted about 15 minutes each, and each contained between one and five prospective memory intentions. Working with realistic procedures in a simulation situation allows an ecologically valid method for assessing prospective memory under conditions that are highly controlled and amenable to the manipulation of variables (for example, stress levels). Simulations also allow people to bring well-learned skills into highly realistic prospective memory contexts, and thus hold great promise for identifying real-world prospective memory demands that are especially vulnerable to prospective memory failure.

Naturalistic Studies

Some of the earliest research on prospective memory was conducted using semi-naturalistic approaches in which the prospective memory demands were embedded into the person's ongoing life activities. For example, Meacham and Singer (1977) asked participants to mail in postcards on designated days and found that incentives were associated with greater use of external cues (for example, calendars) and better prospective memory.

Another approach to examining prospective memory in natural contexts is to examine the participants' success in carrying out their own intentions. Marsh, Hicks, and Landau (1998) conducted a classic set of studies of this type in which they asked participants to list their upcoming activities for the next week and rate the importance of each. Then, 1 week later, they asked the participants to indicate which actions had and had not been completed and to explain why the uncompleted intentions had not been performed. They also assessed the participants' memory and attentional capacities as well as their beliefs about these capacities. In addition, they manipulated variables, such as the presence of a "reminder" wristband over the delay interval. As Marsh, Hicks, and Landau point out, this method, although dependent on subjects' self-reports, enables researchers to examine how people handle multiple prospective memory demands that they themselves have established over an extended period of time. It also enables researchers to examine planning and reprioritizing processes that have been difficult to study in the laboratory.

As noted earlier, naturalistic studies often produce different results from those of laboratory studies (Ceci & Bronfenbrenner, 1985). For example, in performing a meta-analysis of the prospective memory and aging literature, Henry, MacLeod, Phillips, and Crawford (2004) found that younger adults generally outperform older adults on laboratory tests of prospective memory (although see Chapter 7 for variables that affect the presence and magnitude of age differences), yet older adults outperform younger adults in naturalistic studies. It is not clear why this is. It may be that older adults in naturalistic settings have greater control over the pacing of the ongoing activities (that is, they can perform their ongoing activities at their own pace, whereas in the laboratory, the pacing is usually equivalent for younger and older adults), use better external devices, or place greater emphasis on the prospective memory task than do younger adults. Also, it may be that the processes we rely on for remembering in naturalistic settings are different from those we rely on in laboratory settings. Though we do not know which of these factors explains the discrepancy between laboratory and naturalistic studies, at least some of these possible explanations are amenable to empirical investigation.

Naturalistic studies with a diary. One limitation of naturalistic studies is that it is very difficult to control and assess the strategies that participants use in their natural environment as well as the rehearsals that occur over the delay period. Kvavilashvili and Fisher (2007) have developed an interesting technique in which they ask participants to record information relevant to the prospective memory intention in a diary over the retention interval. As described earlier in this chapter, participants were asked to make a phone call to the experimenter 1 week later and to record in the diary any thoughts about the intention (the time of rehearsal, the participant's current location, the activity in which he or she was engaged, impressions of what triggered the thought, etc.) during the 1-week delay period. Although there are important questions regarding subjects' abilities to accurately identify intention-related thoughts as well as to identify the triggering stimuli, this technique holds promise for enhancing our understanding of how and when intentions come to mind over a retention interval.

Naturalistic studies with recording devices. One potential problem with naturalistic studies is that the researcher is often dependent on subjects' reports for assessing the accurate fulfillment of prospective memory intentions. In Marsh, Hicks, and Landau's (1998) research, for example, it was the participants who reported whether or not they had accomplished their prospective memory intentions in a satisfactory manner. Current technology allows us more objective and detailed recording of the accuracy of responding. For example, Park and Kidder (1996) describe the Medication Event Monitoring System, which is an electronic bottle cap system that records the date and time a medication bottle is opened over a period as long as 6 months. Thus, one could use this system to evaluate the extent to which a patient has complied with a medication regimen (see also Insel, Morrow, Brewer, & Figueredo, 2006).

An effective use of this type of technology was recently reported by Liu and Park (2004). They trained participants to use glucometers to monitor blood glucose levels on a regular basis (four times per day) over a 3-week period. Use of the glucometers was electronically recorded, and when they were turned in, the researchers could download how often and when the glucometers had been used. The results showed that implementation intentions (described earlier in this chapter) improved adherence to the glucose-monitoring regimen.

Sellen, Louie, Harris, & Wilkins (1997) developed a particularly clever use of technology to begin to investigate how and when thoughts about intentions come to mind (Chapter 5 elaborates on this work). Participants in the study were employees in a company who agreed to wear special badges, and there were sensors in their building that could identify the location of the badges and when the button on the badges had been clicked. For the time-based prospective memory task, participants were asked to triple-click their badge at designated times for each of 5 days. For the event-based prospective memory task, they were asked to triple-click their badge whenever they happened to be in a certain room over a 5–day period. Also, they were asked to single-click their badge whenever the prospective memory intention came to mind. The researchers found that participants were more likely to think about the prospective memory task when they were in transition (for example, in a stairwell walking from one room to another) than they were when they were settled in a particular location (for example, their office). These results suggest that we are more likely to review our plans and think about intentions when we are not busily engaged in an ongoing task and instead are having a "down" time, such as when we are taking a break or pausing after completing a task. As wireless computer technology advances and becomes more prevalent, this technique appears to hold great promise for monitoring of peoples' thoughts and actions and therefore for informing theories of prospective memory.

External Reminding Devices

Before closing this chapter, we briefly consider creative attempts to develop external aids that take advantage of current technology for improving prospective remembering. From setting the timer on the oven to using calendars, all of us have used external devices to help us remember to perform actions in the future. These have the potential to help us initiate retrieval of the intention at the appropriate time, remember the retrospective memory component of the intended action (that is, what it is that has to be done), and/or monitor performance of the action so that it is not repeated later on.

In recent years, there has been considerable interest in developing electronic memory aids for improving prospective remembering in individuals with memory impairments. Problems in living independently tend to be correlated with the severity of memory impairment, and the idea is that external memory aids can help give autonomy to people with these kinds of problems. Palm organizers, pager systems, and mobile phones with an agenda mode have been shown to be effective for patients with brain injuries (see, for example, Wilson, Evans, Emslie, & Malinek, 1997). For example, Thöne-Otto and Walther (2003) tested the utility of palm organizers and mobile phone systems for helping subjects remember to perform 20 experimental tasks over a 2-week period. These devices sounded an alarm at the appropriate times and also displayed the intended action. Although these devices generally improved prospective memory (see also Oriani et al., 2003, for evidence that this type of external aid is helpful with mildly to moderately impaired Alzheimer's patients), one limitation is that programming of these devices is not simple, and Thöne-Otto and Walther found that this was too difficult for some of the patients. Another limitation is that these devices mainly facilitate the initial retrieval of the intended action along with recollection of the specific action. They do not guide the person through the actual execution of the intended action or protect the person against untimely distractions or interruptions that could interfere with the execution of the intended action.

One memory aid that seems to be easier for patients to use and that also appears to facilitate execution in addition to retrieval is the Mobile Extensible Memory Aid System (MEMOS) (Schulze, Hoffmann, Voinikonis, & Irmscher, 2003; Thöne-Otto, Schulze, Irmscher, & von Cramon, 2001). MEMOS allows caregivers or patients to enter appointments on a central server. Patients can set up an appointment simply by speaking into their personal memory assistant (PMA), which is similar to a mobile phone. The central server then sends an alarm, as well as the steps for the appropriate execution of the action, to the PMA at the proper time. Additionally, because the communication between the central server and the PMA can be bidirectional, the system can be programmed so that the patient has to confirm performance of each step of the action protocol. Thus, there can be feedback about whether or not the action has been executed. In light of continuing technological advancements, it seems that external reminding devices have tremendous potential for improving prospective memory in a variety of work and everyday settings.

Summary

As noted in the first part of this chapter, the past two decades of prospective memory research have advanced our understanding to the point where the field has much to offer in terms of identifying conditions that are especially prone to prospective memory failure and designing effective interventions. We have reviewed a number of potentially valid interventions in this chapter. Nevertheless, given the variety of prospective memory tasks that exist in the real world and the complexity of the processes involved in prospective memory (including planning, memory, and attention), we agree with Dismukes (in press) and others that the prevalent laboratory paradigms do not fully capture all flavors of prospective memory tasks as they exist in naturalistic and work settings.

Often, when reducing a phenomenon into something that can be experimentally studied in the laboratory, we strip it, at least initially, of some important processes. One approach to closing this gap is to analyze critical aspects of real-world prospective memory tasks that are not represented in laboratory paradigms and to creatively develop new laboratory tasks. Another is to continue to develop and refine nonlaboratory approaches for studying prospective memory. We have offered examples of different kinds of tasks that may help us understand at least some components of prospective memory. In general, we believe that there is a healthy interplay between the laboratory and nonlaboratory approaches. Naturalistic studies can often suggest interesting processes and results, which can then be examined under more controlled conditions in the laboratory. Also, conducting laboratory and nonlaboratory studies has the potential for providing converging evidence which can be used to more convincingly support theoretical and empirical positions. This chapter illustrates the value of both laboratory and naturalistic research in developing useful applications of prospective memory research.