PROSPECTIVE MEMORY IN EVERYDAY TASKS

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Everyday situational factors may substantially affect individuals' success or failure in remembering to perform deferred tasks (i.e., prospective memory). We designed a diary study to explore the types and dimensions of prospective memory situations in everyday life that have not been well examined in laboratory investigations. Eight participants recorded intentions for a week. Results suggest that differences between how study participants framed their real-world intentions and how intentions are framed in typical experimental paradigms have significant implications for prospective memory performance, including the role of the natural environment. Our results further suggest ways individuals can improve performance in everyday prospective memory tasks.

A student forgets to return a library book, a professor forgets to attend a committee meeting, a senior citizen does not remember to take heart medication, a surgeon forgets to check that all surgical instruments are removed before closing up a patient, a pilot forgets to set wing flaps to takeoff position. What these diverse incidents have in common is an individual forgetting to perform an intended action—a failure in *prospective memory*. The defining characteristics that distinguish prospective memory from other forms of memory are: (1) the individual must form an intention to perform an action at some later time, (2) the interval until execution is usually filled with unrelated tasks, and (3) no agent overtly prompts the individual to retrieve the intention to act from memory at the appropriate time—he or she must somehow "remember to remember."

Rarely studied twenty years ago, prospective memory is now a rapidly growing field of research, aided by new experimental paradigms that allow systematic exploration of underlying cognitive processes (McDaniel & Einstein, 2007). Despite considerable progress, there is reason to think that existing experimental paradigms do not capture all facets of prospective memory and all situational aspects that determine whether an individual remembers to act at the intended time. The great majority of experimental studies have focused on *event-based* prospective memory, in which participants are instructed to take a particular action during an ongoing task, such as pressing the computer backspace key if a particular word is encountered (the event) while rating the familiarity of a series of words presented on the screen (the rating task is the ongoing task). Far fewer studies have addressed *time-based* prospective memory, in which, for example, participants might be asked to press the back-space key every five minutes during the ongoing task.

In field studies we have identified several situations in which individuals are vulnerable to forgetting intended actions that do not fit either event-based or time-based paradigms (Loukopoulos, Dismukes, & Barshi, 2009). For example, when individuals are interrupted while performing one of a series of routine tasks they are vulnerable to forgetting to finish the interrupted task before going on to the next task after the interruption. Similarly, when individuals must "multitask," interleaving steps of one task with steps of another, they are vulnerable to becoming absorbed in one task, forgetting to switch attention to the other at critical moments. Also, Reason (1990) coined the term *habit capture* to describe situations in which an individual intends to substitute an atypical action for an habitual one but absent-mindedly reverts to the habitual action.

Both event-based and time-based prospective memory tasks are defined in terms of the conditions that form the window of opportunity for executing a deferred intention. Kvavilashvili and Ellis (1996) identified other types of prospective memory, also defined in terms of conditions for execution, for example tasks to be executed when the individual is at a particular location or when performing a particular activity. Ellis (1996) also divided time-based prospective memory into *pulse* types (intention to be executed at a specific time) and *step* types (to be executed during a broader time window), however, little experimental work has explored these other types of prospective memory.

Practical considerations restrict experimental paradigms from exploring the full range of parameter values that may affect prospective memory. For example, the retention interval in most experiments ranges from seconds to at most a few minutes, multiple trials are generally used for a given deferred intention, and a discrete event or specific time determined by the experimenter signals the opportunity to execute the intention. In contrast, real-world retention intervals are often hours or days or longer, only one "trial" occurs, and the window of opportunity of execution may be quite broad or ill-defined.

Everyday and workplace situational aspects may substantially affect individuals' success or failure to remember to perform deferred tasks. Thus, we designed a diary study to explore the types and dimensions of prospective memory situations in everyday life that have not been well examined in laboratory investigations. Studying these everyday aspects can provide a foundation for developing prospective memory aids.

METHOD

Eight participants with at least some graduate-level training in psychology were recruited on the assumption that they would be better able to recognize and describe prospective memory situations than untrained individuals. Participants were instructed to keep a record of their prospective memory successes and failures over the course of one week. Each participant received a digital voice recorder

and worksheets with questions designed to elicit the following information:

- a detailed description of the intention,
- prior experience performing the intention,
- how the intention was encoded,
- length of the retention interval,
- whether the intention came to mind during the retention interval, and
- the window of opportunity for executing the intention.

The voice recorders were used to make brief notes at the time the intention was retrieved; these notes helped participants fill out the worksheets at the end of the day. The two authors coded the reports independently and settled differences through discussion.

RESULTS

Sixty-nine intention worksheets were collected, describing 29 successes and 40 failures to remember to perform a task at the intended time. Little weight should be given to the absolute number of events reported, or the relative number of successes and failures, because these reports are likely highly biased toward noteworthy events. Individuals perform many intended actions during the course of a day, and post-experiment interviews suggested that participants were more likely to note successes in situations in which they recognized considerable vulnerability to forgetting. However, the reported events indicate a wide range of circumstances in which individuals attempt and often fail to remember to perform intended actions.

For each incident, participants were asked to indicate which of four statements best described how they framed their intention. The great majority did not develop a specific plan for how, where, and when to perform deferred intentions (rated as the highest level of encoding), and many participants indicated that they just assumed they would remember to perform the intended task (the lowest level of encoding; see Table 1). However, more specifically planned intentions were significantly more likely to be remembered ($p = .005$, $r = .339$).

Table 1
Level of Encoding

	Number of reports	
	Successes	Failures
1. Didn't think much about intention, just assumed you would remember to perform it.	2 (7%)	14 (35%)
2. Made a "mental note" to perform intention, but didn't think specifically about *how*, *where*, *when* you would perform it.	10 (34.5%)	14 (35%)
3. Thought about *how* or *where* you would perform intention but didn't identify exactly *when* you would perform it.	10 (34.5%)	7 (17.5%)
4. Developed a specific plan for *how*, *where*, and *when* you would perform intention.	7 (24%)	5 (12.5%)

Participants also assigned a level of importance to an intention. That rating was significantly correlated with the level of planning/encoding ($p = .007$, $r = .320$), the likelihood participants would create a cue to remind them of the intention ($p = .049$, $r = .238$), and the likelihood of remembering to perform the intention ($p = .034$, $r = .256$). Participants created reminder cues for 48% of successfully executed intentions and for 38% of failures.

The intervals between encoding and intended retrieval ranged from 30 seconds to three weeks (Table 2). Participants reported one or more spontaneous retrievals before the window of opportunity for executing the intention for 59% of successful intentions and 33% of failures. Spontaneous retrieval was defined as recollection of the deferred intention during the retention interval and without deliberate search of memory or prompting. Successes were more likely to be accompanied by spontaneous retrievals ($p = .0310$, $r = .260$), as were intentions assigned a greater level of importance ($p = .026$, $r = .267$).

Table 2
Retention Interval

	Number of reports	
	Successes	Failures
Less than 1 hour	3 (10%)	12 (30%)
1 to 12 hours	14 (48%)	14 (35%)
12 to 24 hours	4 (14%)	3 (7.5%)
More than 24 hours	8 (28%)	11 (27.5%)

Participants were also asked to identify the interval during which they would have had to execute their intention to consider it a success—the window of opportunity for execution. These windows ranged from one minute to three weeks, and the majority of intervals were greater than one hour (Table 3).

Table 3
Execution Window

	Number of reports	
	Successes	Failures
Less than 1 hour	6 (20.5%)	17 (42.5%)
1 to 12 hours	17 (59%)	14 (35%)
12 to 24 hours	0	3 (7.5%)
More than 24 hours	6 (20.5%)	6 (15%)

Categorization of the 69 prospective memory reports was challenging for several reasons. In many cases the participant only partially specified in his or her own mind the conditions for executing the deferred intention (i.e., the window of opportunity). For example: "To email some files to a colleague" does not specify when or where the task is to be performed. In some cases the intention was implicit rather than explicit. For example, in the reported failure: "To close the top on my contact lens solution after putting in my contacts," the participant did not explicitly encode an intention; rather the intention was implicit in the individual's habitual action schema for putting in contact lenses. Also, the window of opportunity for many intentions was defined conjointly by more than one variable. For example, the most

common intention was to bring an item from home to work or vice versa. Here the window is defined (somewhat implicitly) by the activity of gathering things to take from one site to another, the location at which the activity is performed, and the time frame.

Drawing on Kvavilashvili & Ellis (1996), we decided to sort the reports into 12 categories: event-based, time-based pulse, time-based step, activity-based, location-based, combined (four types), implicit-habitual, implicit-interruption, and implicit-subordinate element (Table 4). The combined categories involved some combination of activity, location, and/or time. Nine of these categories are defined in terms of the window of opportunity for performing the intention. In the other three categories, the intention was implicit – the participant did not form an explicit intention to perform a deferred action at all, but rather relied on habit or the implicit action schema for performing the task of which the action was part. For example, when individuals are interrupted while performing a task, they sometimes get caught up in new tasks after the end of the interruption and forget to finish the interrupted task. In this situation the individual may not explicitly encode an intention to resume the interrupted task, relying on the original intention of performing the task (Dodhia & Dismukes, 2009). Also, an intended action may be a subordinate element of an ongoing task but not separately encoded as an intention.

Only three of the reports were event-based, and five were time-based pulse, the categories toward which the vast majority of laboratory research has been directed (Table 4). The largest single category (20 reports) was time-based step (broad time window). Twenty-three reports involved some combination of activity, location, or time, and 12 were based on the participant's ongoing activity during the window for execution. Looking across categories, in 24 reports the window was defined at least partly in terms of activity.

Table 4
Category of Intention

	Number of reports
Event	3
Activity	12
Location	0
Time-Pulse	5
Time-Step	20
Combined Activity/Location	4
Combined Activity/Location/Time-Step	2
Combined Activity/Time-Step	6
Combined Location/Time-Step	11
Implicit-Habitual	4
Implicit-Interruption	1
Implicit-Subordinate Element of Task	1
Total	**69**

Twelve of the 29 reports of successful remembering identified an environmental cue that triggered recollection of the intended task; in eight of these instances the cue had been created by the participant, and four were happenstance encounters with cues directly or indirectly associated with the intention. Five reports indicated that an awareness of time prompted recollection (an internal mental cue), and in two instances the participant conducted a deliberate memory search of things remaining to be accomplished. In the remaining ten instances no external or internal cue was reported.

Nineteen of the 40 reports of failure to remember identified an environmental cue that belatedly triggered recollection of the intended task; only two of these cues had been created by the participant, and 17 were happenstance encounters with direct or indirect cues. In four instances the participant's chain of thought led to recollection of an intention, and in four instances someone explicitly reminded the participant of the forgotten intention. In the remaining 13 instances no external or internal cue was reported.

DISCUSSION

This study reveals aspects of prospective memory that affect performance in natural conditions, but which have been sparsely examined in experimental studies. The extent and nature of encoding of intentions varied substantially, from simply deciding to perform an action at some unspecified time and place to identifying when, where, and how to perform it. The level of planning/encoding was positively correlated with remembering to perform intentions. In most experimental studies the intention is given to participants in the form of instructions that identify precisely the circumstances for performing the deferred intention, either a well-defined discrete event or a specific time, thus largely eliminating this important source of variability.

We categorized the 69 prospective memory incidents to give a sense of the wide range of encoding and retrieval conditions involved. The 12 categories we used are somewhat similar but not identical to the retrieval contexts identified by Ellis (1996) and Kvavilashvili and Ellis (1996). The relative number of incidents in each category and the relative number of successes and failures are probably not meaningful because some incidents were more noteworthy than others to the participants. For example, one participant reported failing to put the top back on a contact lens solution bottle, but did not report the several successes in this task that occurred during the week. However, it is striking that the majority of the incidents in this diary study were not event-based or time-based pulse, the two categories of intention used in almost all experimental studies.

Gollwitzer (1999) developed an *implementation intention* technique that improves participants' execution of deferred intentions in naturalistic studies. In this technique, participants are instructed to identify specifically where and when they will execute the intention and to explicitly link those situational cues with the intended action through imagery and verbal rehearsal at encoding. Recently, this technique has been shown to improve performance in prospective memory laboratory paradigms (Cohen & Gollwitzer, 2008; McDaniel,

Howard, & Butler, 2008). The results of our diary study are consistent with these findings and demonstrate an opportunity to improve prospective memory performance in everyday situations through explicit planning. For the most part our participants did not form implementation intentions. Planning was minimal for 70% of failed intentions, but significantly better for most successful intentions.

The retention intervals in our study were highly variable, from seconds to weeks, in contrast to experimental studies, which rarely examine intervals beyond a few minutes at most. It is important to study these longer intervals, not just to examine memory decay, but also because individuals may use different strategies as a function of the length of the interval and the nature of ongoing tasks during retention. For example, one prominent, though controversial, theory holds that individuals must use attentive processes to monitor for cues that would signal when to execute a deferred intention (Smith, 2003). It is not clear how individuals could attentively monitor for intention-related cues for long periods during which diverse and demanding ongoing tasks are performed or how individuals would monitor for ill-defined windows of opportunity to execute intentions (see discussion below).

Participants reported spontaneous recollection of 43% of intentions during the retention interval, and the probability of successful execution of intentions was positively correlated with spontaneous retrievals, which is consistent with and extends findings from previous diary studies (Ellis & Nimmo-Smith, 1993; Kvavilashvili & Fisher, 2007). In these previous diary studies, prospective memory performance was at ceiling, preventing correlation with number of spontaneous retrievals, however Kvavilashvili and Fisher found a positive correlation between spontaneous retrievals and whether deferred intentions were performed on time or late.

A large body of experimental research reveals that prospective memory performance hinges on noticing cues associated in memory with the deferred intention, although theories differ in their accounts of the roles of attention and memory (see Einstein & McDaniel, 2007 for a review). In almost all experimental studies, the participant is instructed to execute a deferred intention in response to a well-defined cue, such as a word encountered during an ongoing task or at a specific time or time interval. These studies have shown that performance is better with cues that are salient, distinctive, unusual, and/or highly associated with the intention. Performance is also affected by the extent to which the ongoing task directs attention toward or away from relevant cues.

Our results show that prospective memory tasks in everyday settings rarely involve well-defined cues. Participants typically framed broad windows of opportunity for performing intentions, such as "while I am at the office tomorrow." And, as this example illustrates, the window was often defined by a conjunction of two or more parameters (in this case, a location and a time frame). This suggests that it will be important for experimental studies to investigate the effectiveness of broad and conjointly-defined windows of opportunity in cueing individuals to remember deferred intentions. On the one hand, cues may be more weakly associated with intentions than in event-based tasks, on the other hand, more cues may be encountered over a broader window.

In many cases the window of opportunity was defined in terms of an activity the participant would be performing when the intention was to be executed, rather than in terms of an external event. Here, too, experimental evidence is lacking for the relative effectiveness of personal activity as a retrieval cue.

Another striking aspect of our results was that in many cases the window of opportunity was encoded implicitly rather than explicitly. In the frequently reported example of intending to take items from one location to another, the participants did not explicitly frame the activities of gathering items to carry to the new location but rather framed only the goal to be achieved. The conditions that defined the window of opportunity for execution were thus implicit in the goal of getting the intended item to the new location and in the action schema the participant normally used in going from home to work or vice versa.

The differences between how our participants framed their intentions and how intentions are framed in typical experimental paradigms have major implications for prospective memory performance. Consider an intention to be performed when one is at the office tomorrow. No one environmental cue defines the window of opportunity for execution. Being in the office is defined by a constellation of perceptual cues that must be conjointly present, and being in the office is associated with many tasks and habitual activities, with which the deferred intention must compete for retrieval from memory. Further the broad time frame of "tomorrow" may not elicit the time monitoring behavior seen in studies in which a discrete time pulse defines the moment to execute the intention (Kvavilashvili & Fisher, 2007; see Dodhia & Dismukes, 2009, for more detailed discussion of ill-defined windows of opportunity).

Although most of the intentions reported in our study were instances of failure, in one sense these failures resemble the successes: eventually the participant did remember to perform the intention, though belatedly. In 19 of the 40 failures the participant later noticed an environmental cue that reminded her or him of the intention; in only two of these 19 cases was this a planned cue, the others were happenstance. Planned cues played a larger role in successfully implemented intentions. Of the 14 (out of 29 total) successes for which planned cues were created, ten were triggered by the planned cue and four were triggered by happenstance cues. These results emphasize the role of the natural environment in everyday prospective memory performance, and they suggest that creating cues can enhance performance.

Participants were more likely to remember to perform deferred intentions they rated as more important. Our data further suggest that importance operates, at least in part, by motivating individuals to plan more explicitly and to create reminder cues, and perhaps to rehearse intentions when spontaneously retrieved during the retention interval.

Our results also suggest ways individuals can improve performance in everyday prospective memory tasks. By recognizing vulnerability to forgetting to perform even simple

tasks, individuals can develop countermeasures, in particular forming implementation plans that specify where, when and how the intention is to be performed. During planning, specific cues that will be present in the environment should be identified or such cues should be created, and the cues should be associated in memory with the intended action through rehearsal. Laboratory exploration of these strategies and their efficacy in real-world settings would represent a valuable contribution to the prospective memory literature, as well as provide practical utility to populations that rely heavily on prospective memory success (e.g., the elderly, pilots, surgeons).

As previously mentioned, one must use caution in interpreting the relative frequencies of prospective memory events reported by study participants. It is highly likely that other prospective memory events went unreported, either because they were not recognized as such or were not salient enough to be recalled when participants completed their worksheets. In fact, many real-world prospective memory tasks may not be recognized as such unless a failure occurs, because these tasks are performed successfully out of habit (e.g., locking the door when leaving the house, putting the cap back on the toothpaste, etc.). Although success or failure in performing these habitual tasks may seem of little consequence in everyday settings, failure to perform habitual tasks may have serious consequences in airplane cockpits, hospital operating rooms, and other work domains in which experts perform highly proceduralized tasks. The vulnerabilities and countermeasures associated with performance of habitual tasks has received little attention in the literature and is an area that warrants further study.

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