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Does Prospective Memory Decline With Age?

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Articles on prospective memory traditionally begin with some everyday examples of prospective remembering, and this one is no exception. Remembering to pay an electricity bill on time, to take medicine every 4 hours, and to pass a message on to a friend, would generally be regarded as prospective memory tasks. These contrast with retrospective memory tasks, such as recognizing a familiar face, recalling the details of an accident, or retrieving the name of a country's capital city. The psychological literature is dominated by studies of retrospective memory. However, both prospective and retrospective memory abilities are required for successful functioning in everyday life, and this is no less true of the elderly (at least those living independently) than of the young.

WHY ARE THERE SO FEW PROSPECTIVE MEMORY STUDIES?

There are probably many reasons why prospective memory was rather neglected as an area of investigation. For example, an emphasis in the past on laboratory controlled studies made it impractical to address questions such as whether or not subjects would remember to perform an action at some distant point in the future (bill-paying or pill-taking analogues). However, it is now acknowledged that more naturalistic studies conducted outside the laboratory can be informative (see Gruneberg, Morris, & Sykes, 1988; Poon, Rubin, &

Wilson, 1989), and some recent examples on aging are reviewed later. Another explanation for the existence of few prospective memory studies in the literature is that it may have been assumed that prospective and retrospective memory are not qualitatively different and that similar principles apply to both (see Hitch & Ferguson, 1991; McKitrick, Camp, & Black, 1992). Evidence for dissociations (e.g., in terms of the effects of aging) would obviously question this assumption. (Note that evidence from aging was used as support for multiple systems within retrospective memory; e.g., Mitchell, 1989.)

Perhaps the most significant factor in accounting for the small prospective memory literature is the difficulty in designing tasks that provide pure measures of prospective memory, uncontaminated by other factors such as compliance (Levy & Loftus, 1984), or motivation (Meacham, 1982). If we consider the everyday examples mentioned earlier, it is clear that a number of components are involved in prospective memory tasks (see Brandimonte, 1991; Brandimonte & Passolunghi, 1994; Payne, 1993). First, there is an encoding phase during which a future intention is formed. This may include the setting-up of a cue, either internal or external (Harris, 1980; Intons-Peterson & Fournier, 1986). The necessary information (task content) must then be retained until the appropriate moment or occasion arrives for performing the task. Note that the content of the task comprises what has to be done, and when (or in response to what). Successful performance depends on the retention of both elements, and this must be achieved while carrying out other activities. When the specified time or situation occurs, it must be recognized as such (i.e., associated with the original intention) and then acted upon (retrieval and execution). Finally, there is a cancellation phase in which some record of having performed the task is stored so that it is not repeated. Again, this could include the use of an external aid.

MEMORY FOR INTENTION AND MEMORY FOR CONTENT

If prospective memory is defined as remembering at some point in the future that something has to be done, without any prompting in the form of explicit instructions to recall, then it should be apparent from the previous analysis that a person could fail a prospective memory task for any number of reasons, only some of which would be considered as pure failures of prospective memory. Compliance and motivation were already mentioned as other possible factors (e.g., one may remember that the electricity bill is due but have insufficient money to pay). However, a more significant complication is probably that of retrospective memory. It is important to distinguish between remembering that something has to be done (*prospective memory*), and remembering what has to be done and when or where (*retrospective memory*). In other words,

the contrast is between memory for intention and memory for content (see Kvavilashvili, 1987). To take the example of passing a message on to a friend, it is possible to remember (a) both the intention and the content, (b) the intention but not the content (by meeting the friend but getting the message wrong), (c) the content but not the intention (by failing to pass the message on until prompted by the friend's question, "Was there a message for me?"), and (d) neither the intention nor the content.

This discussion suggests that performance in prospective memory tasks may not necessarily be informative about the functioning of the prospective memory component itself. For example, poor performance could be due to a lack of compliance or to a failure of retrospective memory, whereas good performance could be achieved by enlisting the help of another person to act as a reminder, thus eliminating the prospective memory component. Nevertheless, the results from studies in which components other than prospective memory may play a role still have practical relevance. Obviously some caution is necessary in interpreting the evidence.

AGING AND PROSPECTIVE MEMORY

A simple answer to the question, "Does prospective memory decline with age?" is unlikely, not only for the reasons already outlined, but also because of enormous differences between prospective memory tasks (see Kvavilashvili, 1992; Reeves & Dobbs, 1992). For example, the three tasks described earlier differ in terms of the "conditions for action" (a particular date, a particular time, and meeting a particular friend, respectively), whether or not the task must be repeated, the retention interval, and so on. Age-related changes in retrospective memory are determined by many factors, including the method and parameters of testing (e.g., see Wiggs, 1993, on direct vs. indirect tests; Craik & McDowd, 1987, on recognition vs. recall; Craik, 1977, on primary vs. secondary memory), and this may also be the case for prospective memory.

SOME PARADIGMS EXCLUDED FROM THIS REVIEW

A prospective memory task is defined here as one that contains a prospective memory component, that is, the requirement to remember to perform an action at some point in the future (thereby interrupting ongoing activity), in the absence of any prompting by the experimenter. This excludes from the present discussion a number of studies in the literature. For example, Sinnott (1986) tested subjects aged 23 to 93 as part of a longitudinal study of aging. Her conclusion was that age adversely affected retrospective memory but had no sig-

nificant effect on prospective memory. However, the prospective items examined memory for information such as knowing the date of the next visit to the research center, rather than whether or not subjects actually turned up for their next appointment. Similarly, Hitch & Ferguson's (1991) study of students' memory for films they intended to see and films they had already seen is not regarded in the present definition as a comparison of prospective and retrospective memory.

Tasks in which subjects are presented with phrases describing actions to be performed after some retention interval ("lift the ashtray," "touch the cup," etc.) are not considered here if recall is explicitly requested by an instruction such as, "Now perform all the assignments you remember" (Koriat, Ben-Zur, & Nussbaum, 1990, p. 574; see also Brooks & Gardiner, 1994). Another case for exclusion is that of "remembering to deliver a message" from the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, & Baddeley, 1985). This item was used as a measure of prospective memory in studies of aging (Cockburn & Smith, 1988, 1991), brain damage (Cockburn, 1993), and dementia (Huppert & Beardsall, 1993). The testing procedure is as follows: The experimenter asks the subject to "watch what I do, and when I have finished, do the same thing." He or she then traces a short path around the room, describing each action en route ("I am going to start from this chair, and take this envelope with me. From here I am going over to the door. And from the door to the window. From the window to the table. I am going to leave this envelope on the table, and from here I am going back to the chair.").

The subject's performance is scored in terms of (a) remembering to take and deliver the message (i.e., picking up the envelope at the start and placing it down at the end), and (b) remembering each stage of the route in the correct order (i.e., chair, door, window, table, chair). As noted, several authors adopted the former as a measure of prospective memory and the latter as a measure of retrospective memory. For example, Huppert and Beardsall (1993) found that the difference between mildly demented patients and controls was greater for the message than for the route and therefore concluded that "prospective memory tasks are particularly sensitive to the early stages of dementia" (p. 805). However, remembering to take and deliver the message is not strictly a prospective memory task because the subject is prompted by the experimenter's instruction to recall. Moreover, there are no logical grounds for distinguishing between the prospective and retrospective elements of the task, which could alternatively be described as a serial recall test of retrospective memory for a list of actions, some of which may simply be more difficult to remember than others.

Finally, there is the issue of whether or not the literature on sustained attention, or vigilance, is relevant to prospective memory. In a vigilance task, subjects are required to monitor an information source for the infrequent occurrence of a specified target event—for example, double jumps of a clock hand

TABLE 9.1
Summary of Craik's Functional Account of Age Differences in Memory Tasks (adapted from Craik, 1986, p. 412). Reprinted with permission.

Task	*Environmental Support*	*Self-Initiated Activity*	*Age-Related Decrement*
Prospective memory	Low	Maximal	Large
Free recall	|	|	|
Cued recall	|	|	|
Recognition	|	|	|
Relearning	|	|	|
Priming	High	Minimal	Small

that moves once per second (Mackworth Clock test). Although there may be an element of vigilance in some prospective memory tasks, particularly in recent laboratory paradigms (Einstein & McDaniel, 1990; Maylor, 1993a), the vigilance literature is not included in this discussion for a number of reasons. First, vigilance is a single task that does not involve the interruption of other activities whenever a target event occurs. Second, a failure to detect a target in a vigilance study is usually perceptual–attentional in origin, whereas a failure to respond to a target in a prospective memory study is usually attributable to a memory lapse. Thus when questioned later about misses, subjects in prospective memory tasks rarely claim that the target event did not occur (as they would in vigilance tasks)—instead, they report that they "simply forgot" (Einstein & McDaniel, 1990). Third, the possible influence of vigilance can probably be ignored in the present context in view of evidence that suggests that vigilance is actually unaffected by aging (see Giambra, 1993, for a summary). For example, Giambra & Quilter (1988) used the Mackworth Clock test with targets occurring approximately every 3 min. There was no overall effect of age on target detection. Although the likelihood of detection decreased over the course of 1 hr, this vigilance decrement was the same for all age groups.

PREDICTIONS FROM CURRENT MODELS

Before reviewing the evidence in detail, it is worth considering why we might or might not expect age-related changes, both in the purely prospective memory component and also more broadly in prospective memory tasks, on the basis of current models of aging. First, of most relevance to the prospective memory component itself is Craik's (1986) framework as summarized in Table 9.1. In this account, performance is determined by an interaction between external factors such as cues and context, and the type of operation required. Functions and processes are emphasized rather than structures or systems. The claim is that self-initiated mental activities become more difficult to execute

with increasing age. However, age-related deficits are reduced in situations in which environmental support is high. Table 9.1 presents the resulting hierarchy of memory tasks, "drawn up on an intuitive basis" (Craik, 1986, p. 411), with prospective memory and priming at opposite ends of the scale (large and small age-related decrements, respectively).

By definition, prospective remembering places a heavy demand on self-initiated retrieval processes. Nevertheless, it is recognized that some prospective memory tasks may place heavier demands than others (see Einstein & McDaniel, 1990; McDaniel & Einstein, 1992). For example, compare the task of remembering to take medicine in 4 hrs' time with that of passing a message on to a friend. In the former case, successful performance may be entirely dependent on self-initiated activity (such as looking at the clock every few minutes), whereas in the latter case, seeing the friend may act as a trigger for remembering. These can be described as time-based and event-based prospective memory tasks, respectively. A clear prediction is that age-related impairments should be more apparent in time-based tasks than in event-based tasks (which contain environmental support in the form of some external cue event).

It is generally assumed that aging is associated with a reduction in processing resources (see chap. 8 of Salthouse, 1991, for a summary). This is viewed in terms of limitations on speed (Cerella, 1985), working memory capacity (Salthouse, 1992), and attention (Hartley, 1992). Several components of prospective memory tasks would therefore be expected to decline with increasing age as a result of reduced processing resources. First, consider the encoding phase during which the requirements of the task are presented and a future intention is formed. Under timed conditions, older adults would be less able to perform elaborative encoding, such as forming a mental image of the target in an event-based task. Second, the content of an intention is obviously more likely to exceed the working memory capacity of an older adult than of a younger adult. Third, a prospective memory task must be "kept in mind" until the appropriate moment for action; in the meantime, other activities must be performed. In other words, the retention interval can be regarded as a divided attention or dual task situation. There is clear evidence for age-related impairments under such conditions (see Hartley, 1992, and Madden & Plude, 1993, for reviews). Most cognitive tasks become more demanding in terms of attentional resources with increasing age. If older and younger adults are asked to perform the same intervening activities, then the elderly's performance on the prospective memory task would be expected to suffer more as a consequence. (See Brandimonte & Passolunghi, 1994, on the detrimental effects of demanding interpolated activity on prospective memory performance; also Ellis & Nimmo-Smith, 1993, on the reduction in spontaneous recollections of a prospective memory task when concentrating on concurrent activity.)

A further possibility is that there are age-related deficits, not only in attentional capacity, but also in attentional allocation. For example, the central executive (Baddeley, 1986) or the supervisory attentional system involved in the control and coordination of tasks (Shallice, 1982) may be compromised in old age as a result of frontal deterioration (Moscovitch & Winocur, 1992). This would make it particularly difficult to switch attention from the intervening activity to the prospective memory task. However, recent evidence argued against this because older adults appear to be no worse at performing tasks concurrently than would be expected on the basis of an overall increase in task complexity (e.g., McDowd & Craik, 1988; Somberg & Salthouse, 1982). In other words, the elderly are impaired in dual task situations, but not disproportionately so.

There are two further deficits associated with aging that have implications for performance in prospective memory tasks. The first is in *reality monitoring* (Johnson & Raye, 1981), that is, the ability to distinguish between real and imagined events (or perceived vs. generated memories). Thus, older adults may fail a prospective memory task as a result of mistaking the memory of an intention to perform an action for the memory of performing that action, leading to an omission error (see Cohen & Faulkner, 1989). The second deficit is in *output monitoring,* that is, memory for subject-initiated activity. A study by Koriat, Ben-Zur, & Sheffer (1988) concluded that the elderly are more likely than the young to forget that a planned action has already been performed and therefore repeat it, leading to a commission error.

With the possible exception of event-based tasks, the predictions so far are not encouraging for the elderly. But are there any grounds for taking a more optimistic view of the effects of aging in prospective memory tasks? Perhaps an obvious point to note is that as people get older, they gain more experience in using prospective memory in everyday life. This is often accompanied by useful feedback on performance (see Rabbitt, 1990, on the importance of awareness of errors). For example, failing to pay an electricity bill on time results in a final demand. Thus the ideal conditions exist for the development of compensatory strategies (Salthouse, 1990) or cognitive support systems (Bäckman, 1989) to overcome possible deficits in ability.

If older people do indeed use their experience and feedback to develop effective strategies that can compensate for failing prospective memory ability, then at least three predictions follow:

1. Reliance on external memory aids to solve prospective memory tasks outside the laboratory should increase with age.
2. Self-rated ability in everyday prospective memory tasks should not decline with age.
3. Performance in prospective memory tasks conducted outside the laboratory should be unimpaired by age.

However, based on the earlier arguments, prospective memory tasks conducted under laboratory conditions should produce age deficits (prediction 4), particularly if they are time-based, rather than event-based, tasks. The evidence relating to each of these predictions is now reviewed.

AGING AND THE USE OF CUES

A distinction is often drawn between internal and external cues for remembering future intentions (Harris, 1980, 1984). Internal cues involve the internal manipulation of information and include encoding mnemonics (e.g., imagery) and retrieval strategies (e.g., alphabetic search). External cues involve the external manipulation of the environment, such as writing notes in diaries or setting alarm clocks. However, the distinction may not be so clear. For example, the activity required in producing an external cue may influence the internal representation of the intention (Conway & Gathercole, 1990; Intons-Peterson & Fournier, 1986). Also, the effectiveness of an external cue may depend on an internal strategy to remember to consult it. For present purposes, it is sufficient to note that benefits from adopting external rather than internal cues were repeatedly demonstrated (Maylor, 1990; McEvoy & Moon, 1988; Meacham & Colombo, 1980; Meacham & Leiman, 1982).

If the elderly are aware of their failing cognitive abilities, they should rely less on internal cues and more on external cues, in comparison with the young. Indeed, this was found to be the case in a study by Jackson, Bogers, & Kerstholt (1988) in which students and older adults were questioned about their use of memory aids in everyday prospective memory tasks. The older subjects reported that they relied more on external cues than on internal cues, whereas the students reported the opposite. Similarly, Lovelace & Twohig (1990) reported an increase with age in the "subjective frequency of using external aids, most notably writing notes to oneself and placing items where they will be seen to trigger memory" (p. 118). Finally, a study by Moscovitch & Minde (described in Moscovitch, 1982) concluded that the elderly's superior performance in a task in which subjects were asked to telephone the experimenter was due to using mnemonic devices. In contrast, the young simply relied on their memory.

Others, however, failed to observe an effect of age on cue choice. Patton & Meit's (1993) older subjects did not use external aids significantly more frequently than did their younger subjects in a mailing task. A diary study by Cavanaugh, Grady, and Perlmutter (1983) found no difference between old and young subjects in their reported use of external and internal cues for remembering. In experiments to be described in more detail later, both Einstein & McDaniel (1990) and Maylor (1990) noted that older subjects were no more likely to construct an external cue than were younger subjects.

Finally, two studies suggest that the elderly rely less on external cues than the young, contrary to prediction. First, Dobbs & Rule (1987) asked volunteers aged 30 to 99 to rate their "use of memory aids" on a 7-point scale ranging from 1 (always) to 7 (never). The greatest use was reported by those in their 40s (who may have had more to remember). Second, West (1988) found that younger subjects used external cues more than did older subjects in a task requiring them to make a telephone call and mail a postcard. (Unfortunately, information on cue use was not available for all subjects, particularly in the older group.)

This confusing picture is probably the result of several factors, including small sample sizes in some studies and missing data in others. More importantly, consistent results are unlikely to emerge from asking questions such as, "How often do you use a memory aid?," without defining either the task or the memory aid. Even subtle differences between prospective memory tasks, such as whether an action must be performed at an exact time (9:18) or between two times (8:00–12:00), were shown to influence the choice of cue (see Ellis, 1988; Maylor, 1990). It is therefore worth emphasizing the results of a preliminary study by Reeves and Dobbs (1992). Subjects were presented with everyday examples of four types of prospective memory task. These were either time-based or event-based, and either episodic (infrequent) or habitual (frequent). For example, remembering to "pass a message on to someone next time you see them" was defined as an event-based episodic task, whereas remembering to "take out the garbage every Monday night" was defined as a time-based habitual task. For each scenario, subjects were asked to indicate which method they would typically use to remember to perform the task, from a list that included both internal cues (e.g., "rehearse instructions") and external cues (e.g., "mark on calendar").

First, the results demonstrated that the choice of cue was determined by the type of prospective memory task. For example, external cues were preferred for time-based episodic tasks, whereas internal cues were preferred for event-based habitual tasks. Second, there was no difference between older and younger subjects in their choice of cue for both time-based episodic and event-based habitual tasks. However, older subjects were significantly more likely than were younger subjects to select external cues for event-based episodic and time-based habitual tasks. Although there is no obvious explanation for this precise pattern, the results provide at least partial support for the prediction that the reliance on external cues to solve everyday prospective memory tasks should increase with age.

SELF-RATED PROSPECTIVE MEMORY ABILITY

In memory questionnaires, subjects are often asked to rate themselves in absolute terms on prospective items such as "How often do you forget appointments?." There is no evidence that self-rated prospective memory ability measured in this way declines with increasing age (see Maylor, 1993b, for a review). Studies demonstrated either no effect of aging (Cohen & Faulkner, 1984; Dobbs & Rule, 1987), or even improvement (Harris & Sunderland, 1981, as reported in Harris, 1984; Martin, 1986; Rabbitt & Broadbent, as reported in May-

lor, 1993b). The data are therefore consistent with the argument that self-rated ability in everyday prospective memory tasks is preserved in old age due to an increased reliance on external memory aids. But, of course, other interpretations are possible (see Abson & Rabbitt, 1988; Rabbitt & Abson, 1990; on the limitations of questionnaire studies in cognitive aging). For example, older adults may forget fewer appointments because they have fewer appointments to forget. We must turn instead to experimental studies in which older and younger subjects are required to perform the same prospective memory task.

"NATURALISTIC" PROSPECTIVE MEMORY STUDIES

Experiments conducted outside the laboratory usually involve time-based telephone or mailing tasks in which subjects are free to adopt their own strategy for remembering. To summarize the evidence on aging: Older adults are at least as good as younger adults (and sometimes better) at remembering to mail postcards or questionnaires back to the experimenter as requested (Maylor, 1990; Patton & Meit, 1993; West, 1988; Woolf, 1993). With just one exception (see later), the same is true of remembering to telephone the experimenter at particular times and on specified dates (Kerr, 1992; Moscovitch & Minde, as reported in Moscovitch, 1982; Poon & Schaffer, 1982; West, 1988). An examination of attendance records at a research laboratory by Martin (1986) revealed that older subjects are less prone to miss appointments unexpectedly than are younger subjects (no surprise to researchers involved in aging studies!).

The largest naturalistic study of aging and prospective memory was by Maylor (1990) who tested 222 subjects, aged 52 to 95. They were selected from a well-documented panel of middle-aged and elderly volunteers participating in a longitudinal study of cognitive aging. Subjects were women, most of whom were living alone; all had previously expressed a willingness to be included in further studies. Thus there was good reason to suppose that the influence of social and motivational factors was minimal (see Meacham, 1982, 1988; Patton & Meit, 1993).

Subjects were required to telephone the experimenter once a day from Monday to Friday, either between two times or at an exact time. At the end of the week, they had to complete a questionnaire and mail it back as soon as possible. One of the questions asked subjects to describe how they remembered to make the telephone calls. Another asked them to indicate why they thought they forgot to make a telephone call (if indeed they did).

The most important influence on performance in the telephone task was the method chosen for remembering. Consistent with the implications of Craik's (1986) model, the best performance was from subjects (n = 30) who essentially converted the task from a time-based to an event-based task. Thus

they telephoned either in conjunction with another routine event ("Tied it in with an after-breakfast coffee") or engaged in some form of advanced planning of the daily schedule ("Normally I start getting tea ready around 4:45 p.m., so waited until after making the telephone call"). These were termed *conjunction cues.* The worst performance was from subjects (n = 57) who used *internal cues* ("I tried to condition myself to remember without any aid"). Finally, performance was intermediate from those who used *external cues* (n = 135) such as notes or diary entries. As already noted, the three groups did not differ significantly in age (means of 70, 71, and 69, respectively).

A weak but positive effect of age was observed on performance in both the telephone and mailing tasks (in sharp contrast with significant negative effects of age on retrospective memory measures such as digit span). However, the effect of age in the telephone task was influenced by the type of cue. For subjects using internal cues, those who forgot were slightly older than those who remembered, whereas for subjects using conjunction and external cues, those who forgot were slightly younger than those who remembered.

Prospective memory studies conducted outside the laboratory are therefore consistent in showing no age-related impairments, with the exception of internal cue-users in Maylor's (1990) study. (There remains the question of why these subjects did not adopt a more effective strategy, but note that they produced significantly lower scores on an intelligence test than did the external cue users.) Superior performance by the elderly in naturalistic prospective memory studies is usually attributed to their greater probability of using external cues compared with the young (Moscovitch, 1982). But Maylor (1990) observed positive effects of age even within groups of subjects apparently using the same cues. Older subjects may be better at using external or conjunction cues than are younger subjects, perhaps because they are more practiced (see Martin, 1986). However, each category of cue covered a variety of different methods, some probably more helpful than others. In other words, the positive effect of age could be the result of older subjects choosing more effective cues within either the conjunction or external cue category. Individuals vary enormously in the way they use identical cues (see Payne, 1993).

Although these prospective memory studies conducted outside the laboratory have several advantages over self-rated questionnaires, including control over the task required of subjects, there is still the problem of possible age differences in intervening activity. Older adults tend to be engaged in less demanding activities outside the laboratory than are younger adults. Prospective memory performance is influenced by the demands of the tasks carried out in the period between forming and executing an intention (Brandimonte & Passolunghi, 1994; Wichman & Oyasato, 1983; Kvavilashvili, 1987). Note that in Maylor's (1990) study, the younger subjects using conjunction and external cues were more likely to give being absorbed or distracted by other activities as their excuse for forgetting than were the older subjects using internal cues.

LABORATORY-CONTROLLED PROSPECTIVE MEMORY STUDIES

Although the study of behavior in context is important, it cannot be a replacement for the systematic study of behavior under laboratory conditions (Ceci & Bronfenbrenner, 1991). This section therefore reviews in detail the experimental evidence on aging and prospective memory. To summarize, there is not a single laboratory study in the literature in which the elderly significantly outperformed the young, although there are some studies in which older and younger subjects did not differ. In contrast, there are several reports of age-related impairments.

A common paradigm is the single observation event-based prospective memory task embedded within an interview or a battery of tests. Dobbs & Rule (1987) instructed subjects early in the testing session that they would be asked later to draw a circle and a cube, at which point they should ask for a red pen. Subjects in their 30s, 40s, 50s, and 60s performed at or near ceiling, whereas subjects in their 70s were significantly worse at remembering to ask for the red pen. Cockburn & Smith (1991) administered the Rivermead Behavioural Memory Test to 94 subjects aged 70 to 93 and found significant age-related decline on the two items that fit the present definition of prospective memory, namely, remembering to ask about the next appointment when an alarm clock went off, and remembering to ask for the return of a hidden belonging when told that the session was over. (Note that in neither case were subjects explicitly prompted to recall, in contrast to remembering to deliver a message, as discussed earlier.) West (1988) asked subjects to remind the experimenter to check her tape recorder and take a pen out of a folder when prompted by the verbal cue: "That is the end of the passage recall test." Students were more successful at remembering the prospective memory task within 2 min of the verbal cue than were elderly subjects, that is, 81% compared with 31%. Finally, Woolf (1993) observed age deficits among subjects aged 18 to 92 in a number of tasks, such as remembering to write down their town of birth after proofreading a passage of text.

To date, there is just one study of aging and prospective memory using a single observation time-based paradigm. Patton & Meit (1993) asked 24 students and 17 elderly volunteers to view a film on videotape and note the scene in which there was a Dalmatian dog (though, in fact, no such dog appeared). Subjects were also required to stop the videotape after 30 min, using a clock located behind them to monitor the time (cf., Ceci, Baker & Bronfenbrenner, 1988; Harris & Wilkins, 1982). Contrary to the prediction that age impairments should be more apparent in time-based than in event-based tasks, there was no significant effect of age on performance. Unfortunately, the mean deviations from the target time of 30 min were less than 30 sec for both age groups, so ceiling effects cannot be ruled out.

memory tasks (if ceiling effects are avoided), despite only trivial demands on retrospective memory. However, single observation paradigms are criticized for their unreliability. So what of multiple observation paradigms? In an experiment by Schonfield & Shooter (reported by Welford, 1958), subjects had to remember to press a particular key before providing each response in a perceptual judgment task. The probability of failing to press the key prior to responding steadily increased from teenage to elderly subjects.

Mäntylä (1993) presented subjects with single words at a rate of 10 sec per item. The task was to write down one association to each word that would later enable subjects to recall the originally presented word when given their own association as the cue. The prospective memory component was to mark with a cross the corresponding page of the response booklet whenever a word belonging to one of four semantic categories was presented (*liquids, parts of the body, vehicles,* and *parts of buildings;* two from each category). Students (n = 16; *M* age = 26) marked significantly more of the eight targets than older subjects (n = 16; *M* age = 72)—73% vs. 44%. Students (n = 16; *M* age = 72)—73% vs. 44%. It could be argued that the elderly performed poorly because they forgot the target categories (i.e., retrospective memory failure). However, in a final unexpected recall test, all subjects in both age groups were able to name the four categories.

A similar task was used by Maylor (1993a) in which middle-aged and elderly subjects were repeatedly presented with slides of 30 famous faces, at a rate of 10 sec per item. They were asked to name each celebrity and also to respond to two targets (a beard and a pipe) by marking the trial number on the response sheet. In contrast to Mäntylä's (1993) design, the same two targets each appeared four times during the session. Younger subjects (n = 43; *M* age = 57) marked significantly more of the eight targets than older subjects (n = 43; *M* age = 75)—83% vs. 69%.

Perhaps the most influential laboratory paradigm for investigating prospective memory is that of Einstein and McDaniel (1990). In their study, subjects were presented with lists of words that they had to recall (short-term retrospective memory task). Some time before the task began, they were instructed to press a response key whenever a specified word (a single prospective memory target event) appeared in the list. In their first experiment, Einstein and McDaniel (1990) examined the effects of age (24 students, 24 elderly volunteers) and the opportunity to form an external aid using two conditions—no aid (in which subjects simply were told to press the response key whenever they saw the target word) and external aid (in which subjects were allowed to construct a memory aid out of material provided, such as paper and pens). As expected, the younger subjects performed significantly better than did the older subjects on the nonprospective memory task (which was also the case in the studies by Mäntylä, 1993, and Maylor, 1993a). Performance in the prospective memory task was not at ceiling (M number of responses to the target's

three occurrences = 1.8). Although there was a significant benefit in using a memory aid, there was no effect of age, and no interaction.

In their second experiment, Einstein and McDaniel (1990) again examined the effect of age, but also manipulated target event familiarity (see McDaniel & Einstein, 1993, for further investigations on the latter). Performance was nearly three times better when the target event was an unfamiliar word than a familiar word. As in the first experiment, neither an effect of age nor an interaction with target event familiarity were seen. Thus Einstein and McDaniel demonstrated the absence of an age effect on prospective memory, in the context of both significant effects of other manipulations (memory aid and target event familiarity) and a significant negative effect of age on retrospective memory. Their conclusion was that "prospective memory seems to be an exciting exception to typically found age-related decrements in memory" (p. 724).

This surprising result was replicated in a further study by Einstein, Holland, McDaniel, and Guynn (1992). There were two prospective memory conditions: Subjects were asked to respond either to a single target word (which occurred three times) or to four target words (only three of which actually appeared). As before, no significant effect of age was found in the single-target condition. However, older subjects were significantly worse than students in the four-target condition. When prospective memory was conditionalized on retrospective memory for the target events (from a final recall test of the targets), this age deficit disappeared. In other words, "age-related performance differences, when they occurred, were associated with poorer retrospective memory for the target events" (p. 471).

An unpublished study by Einstein, McDaniel, Cunfer and Guynn (1991; described in McDaniel & Einstein, 1992) directly compared the effects of age in time-based and event-based prospective memory tasks. These were embedded in a running retrospective recall task in which words were presented at a rate of 2 seconds per item. When the stream was interrupted by a beep, subjects were required to recall as many of the last 10 words as possible. In the time-based version, the prospective memory task was to press a key after 10 and 20 min had elapsed; to keep track of the time, subjects had to turn around to look at a clock positioned behind them. In the event-based task, subjects had to press a key whenever they encountered a particular word. Older subjects were significantly less accurate than were younger subjects in the time-based prospective memory task, and this was associated with age differences in clock-monitoring frequency (see also Kerr, 1992). In contrast, there was no significant effect of age in the event-based prospective memory task. Similar results were obtained in a study by Richardson as reported by Einstein and McDaniel (this volume). These preliminary data are therefore consistent with the prediction that age deficits should be greater for time-based than for event-based prospective memory tasks, because the former require more self-initiated activity than the latter.

The conclusion emerging from these laboratory-controlled studies is that age-related deficits in prospective memory were clearly demonstrated, with the exception of event-based tasks by Einstein and colleagues. An obvious question to ask is what is different about their particular methodology that could account for the discrepancy? There may be several possibilities, but perhaps the most crucial is the fact that they deliberately reduced the cognitive demands of the nonprospective task for the older subjects, at least in their published studies. Thus the difficulty of the short-term memory task was equated across age groups by manipulating the number of items in each word list. Their results are therefore interpreted here as suggesting that the elderly can perform as well as the young in event-based prospective memory tasks, if they have equivalent processing resources available to them.

FURTHER ANALYSIS OF REPEATED PROSPECTIVE MEMORY TASKS

In this section, data from two of the studies, in which subjects were required to repeat the same prospective memory task on several occasions, are considered in more detail. The argument is as follows: Performance on the first occasion is presumably determined by whether or not the intention was sufficiently well-encoded and stored, by whether or not the target time or event is recognized as such (i.e., associated with the original intention), and by whether or not the appropriate action is retrieved and executed. If performance is successful, then an episodic trace of actually carrying out the task is formed in retrospective memory. On the next occasion, performance may still be affected as before by factors at encoding and so on, but there may be an additional influence of this episodic memory. In other words, the trigger for performance this time may be not so much the recall of the intention but more the recall of what was done on the previous occasion.

Consider, for example, the study described earlier in which subjects were repeatedly presented with the same set of famous faces (Maylor, 1993a). The task on each occasion was to name the faces and to mark the trial number if a beard or a pipe appeared. There are several possible strategic responses to the instructions for the prospective memory task that could determine whether or not performance is successful on the first occasion, including subvocal rehearsal of the words *beard* and *pipe*, generation of a visual image of a bearded man smoking a pipe, covert rehearsal of the action to-be-performed, and so on. Assuming a subject succeeds at least once in performing the prospective memory task as instructed, then memory for the action itself (rather than an abstract verbal description of it) can be stored, together with the context of the action. In the present example, the motor act of marking the trial number of the pipe is remembered and also associated with recognizing the face as that

of the ex-Prime Minister, retrieving his name, and so on. Next time, if prospective memory fails to be triggered by the pipe, it could still be triggered by some other aspect of the action's context, such as writing *Harold Wilson*.

These considerations lead to at least three predictions:

1. Retrospective memory should be less strongly associated with whether or not performance is successful on the first occasion than with whether or not performance continues to be successful on subsequent occasions.
2. Because age is known to affect retrospective memory for actions (see Kausler, 1991, for a summary) and context (e.g., McIntyre & Craik, 1987), the same should apply to the effect of aging.
3. There should be other factors, perhaps those associated with encoding, that are more strongly associated with initial performance than with subsequent performance.

In Maylor's (1993a) face-naming study, there were four blocks of trials, with two prospective memory targets (*beard* and *pipe*) per block. Figure 9.1 shows the data broken down by age group and block. Clearly there was no effect of age group in the first block; thereafter, hits increased for the younger group but remained constant for the older group. In further analyses, *forgetting* was

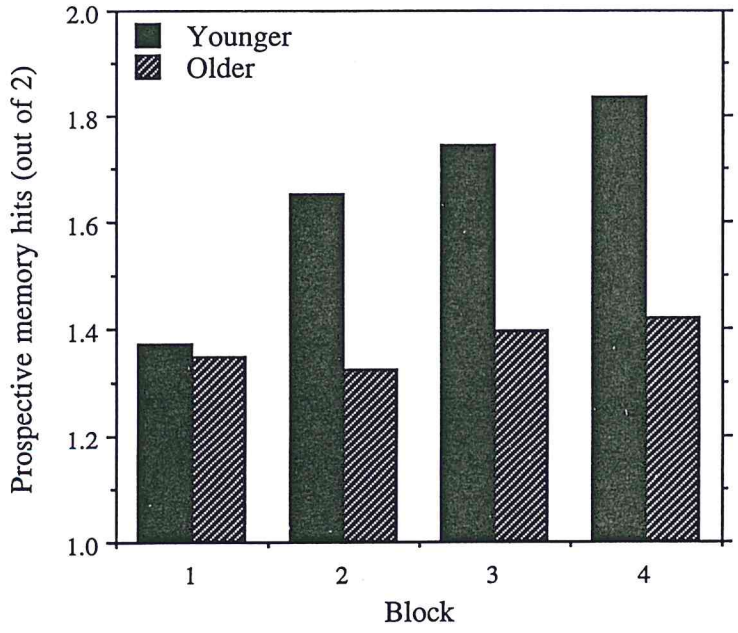

FIG. 9.1. Mean numbers of prospective memory hits as a function of age group and block (data from Maylor, 1993a).

TABLE 9.2
Summary of the Results of Six Analyses of Variance From a Laboratory-Controlled Prospective Memory Task (Maylor, 1993a)

	Initial Performance (0, 1 or 2 hits)	*Subsequent Forgetting (Present or Absent)*
Retrospective memory[a]	No difference between groups	Present worse than absent
Age	No difference between groups	Present older than absent
Coding recall	0 and 1 worse than 2	No difference between groups

[a]Maylor (1993a) combined fluid intelligence, speed, and retrospective memory to produce a general ability factor. The results for retrospective memory were qualitatively identical to those reported for general ability.

Note. The entries shown are the effects of the independent variables (initial performance and subsequent forgetting) on the dependent variables (retrospective memory, age, and coding recall).

defined as success followed by failure on consecutive blocks, and *recovery* was defined as failure followed by success. For example, if a subject responded to the beard in blocks 1, 2, and 4, and to the pipe in blocks 2, 3, and 4, this was scored as one instance of forgetting (beard: block 2 → 3) and two instances of recovery (beard: block 3 → 4; pipe: block 1 → 2). Analysis of the data in terms of such instances of forgetting and recovery indicated that the pattern shown in Fig. 9.1 was attributable to equivalent recovery in the two age groups but greater forgetting in the older group than in the younger group.

Two separate sets of analyses were then performed. In the first set, subjects were categorized on the basis of their *initial performance* (number of hits in the first block: 0, 1, or 2). In the second set, they were categorized in terms of the presence or absence of at least one instance of *subsequent forgetting* (success in one block followed by failure in the next). (A third set of analyses, based on recovery, is not of interest here.) The resulting groups formed the independent variable in analyses of variance, with various measures as the dependent variable including age, retrospective memory (e.g., picture recognition), and coding recall (an unexpected test of memory for the code after completing a letter–letter substitution task). Table 9.2 summarizes the findings. It can be seen that subjects grouped on the basis of their initial performance did not differ significantly in terms of either retrospective memory or age. As predicted, the presence of subsequent forgetting was associated with lower retrospective memory scores and greater age. In contrast, coding recall was associated (positively) with initial performance, but was unrelated to subsequent forgetting.

Coding recall may partly reflect an active strategy of committing informa-

TABLE 9.3
Summary of the Results of a Naturalistic Prospective Memory Task (Reanalysis of Maylor, 1990)

	Initial Performance (Failure or Success)	*Subsequent Forgetting (Present or Absent)*
Proportion of Internal cues	Failure higher than success	No difference between groups
Age	No difference between groups	Internal cues: Present older than absent[a] Conjunction or external cues: Present younger than absent
Coding recall	Failure better than success	Present worse than absent[a]

[a]Marginal effect ($p < .06$)

Note. Subjects were grouped according to initial performance and subsequent forgetting. The entries shown are the differences between these groups in terms of the proportion of subjects using internal cues (χ^2 analyses), age, and coding recall (ANOVAs).

tion to memory rather than passively consulting external sources. It could therefore be related to prospective memory at encoding when the verbal instruction is perhaps converted into a visual image of the target event. This would be important when it is first encountered, but less so on subsequent occasions. To summarize, the evidence so far is consistent with the suggestion that retrospective memory and age should be less strongly associated with initial performance than with subsequent forgetting, and that another variable (possibly more indicative of encoding behavior) should produce the opposite result.

Maylor's (1990) telephone task was then examined in a similar way, that is, in terms of initial performance (subjects who failed vs. subjects who succeeded in telephoning on the first day of the study) and subsequent forgetting (subjects with vs. subjects without at least one instance of forgetting, again defined as success then failure on consecutive days). Table 9.3 summarizes these analyses. The actual results with respect to age and type of cue are presented in Table 9.4. First, it can be seen that subjects who failed initially did not differ in age from those who succeeded initially, regardless of the type of cue used. Second, for subjects using conjunction and external cues, those who subsequently forgot were younger than those who did not forget. In contrast, for subjects using internal cues, those who subsequently forgot tended to be older than those who did not forget. Again, there is the difficulty in explaining why it was the younger subjects using conjunction and external cues who forgot. However, the pattern for those using internal cues is consistent with the predictions regarding age. Third, it is clear from the number of subjects in each cell of Table 9.4 that cue-type influenced initial performance ($\chi^2[1, N = 222] = 18.44$, $p < .001$), but not subsequent forgetting ($\chi^2[1, N = 221] = 1.32$, $p > .10$). In other words, setting up an external or conjunction cue was beneficial to performance on the first day, but was no longer important once a telephone call had been made.

TABLE 9.4
Mean Ages, Standard Deviations, and Numbers of Subjects in Maylor's (1990) Study, Categorized in Terms of Cue (Conjunction and External vs. Internal), Initial Performance (Failure or Success), and Subsequent Forgetting (Present or Absent)

	Initial Performance		
	Failure	*Success*	*Difference*
Conjunction and external cues			
M age	69.7	69.2	$F(1, 163) = 0.03$, $p > .10$
SD	11.9	7.1	
N	8	157	
Internal cues			
M age	72.0	71.2	$F(1, 55) = 0.08$, $p > .10$
SD	10.9	7.7	
N	14	43	
	Subsequent Forgetting		
	Present	*Absent*	*Difference*
Conjunction and external cues			
M age	64.5	70.1	$F(1, 163) = 14.39$, $p < .0005$
SD	6.1	7.2	
N	27	138	
Internal cues[a]			
M age	75.6	70.5	$F(1, 54) = 3.90$, $p = .053$
SD	8.6	8.0	
N	13	43	

[a]1 subject, who telephoned only on the final day of the study, is missing.

Coding recall data were available for only 164 of the 222 subjects. However, the results from 2-way analyses of variance (cue-type being the second independent variable) are intriguing. For initial performance, coding recall was significantly higher for those who failed ($M = 6.9$, $SD = 3.7$, $n = 15$) than for those who succeeded ($M = 4.8$, $SD = 3.8$, $n = 149$)—$F(1, 160) = 5.49$, $p < .05$. This effect did not interact with cue-type ($F < 1.00$). For subsequent performance, coding recall tended to be lower for subjects who forgot ($M = 4.1$, $SD = 3.4$, $n = 31$) than for those who did not forget ($M = 5.2$, $SD = 3.8$, $n = 132$)—$F(1, 159) = 3.63$, $p < .06$. Again, there was no interaction with cue-type—$F(1, 159) = 2.14$, $p > .10$.

Note the contrast between the negative effect of coding recall on initial performance in this naturalistic study (Table 9.3) and the positive effect in the previous laboratory-controlled study (Table 9.2). How can this be explained? It was suggested that coding recall is partly an indication of the extent to which a subject develops an active internal strategy in preference to relying on external sources for information. Within the confines of the laboratory, where subjects are forced to rely on their own memories, an active internal response to the prospective memory instructions (such as imagining what the target might look like) could be expected to improve performance, at least initially. However, deliberately committing the task to memory would not necessarily be the best policy outside the laboratory where relying on the use of external cues such as alarm clocks, memos, and so on, is perhaps more sensible. Although higher coding recall scores were associated with initial failure in the telephone task, they tended to be associated with the absence of subsequent forgetting. Combined with the fact that cue-type significantly affected initial performance but not subsequent forgetting, subjects may have shifted from initially relying on external sources to subsequently relying on their own memories.

Clearly, these explanations are speculative and post-hoc. Nevertheless, the preliminary observations summarized in Tables 9.2 and 9.3 are consistent with the general predictions based on the analysis of possible components involved in repeated prospective memory tasks. It was argued that performance on a particular occasion should be influenced by different factors depending on whether the task is being performed for the first time (in which case, behaviour at encoding may predominate) or has already been performed (in which case, memory for the earlier occasion and its context may play an additional role). Thus two factors, coding recall and cue-type, were found to have stronger effects on initial performance than on subsequent forgetting, whereas two other factors, retrospective memory and age, were found to have stronger effects on subsequent forgetting than on initial performance. These latter results may help to explain why age and retrospective memory produced inconsistent effects in previous studies of prospective memory (see Maylor, 1993b).

CONCLUSIONS

The ability to perform successfully in prospective memory tasks, such as those listed at the beginning of this chapter, is obviously essential for independent living. It therefore is surprising that, until recently, prospective memory was a neglected area of research within cognitive psychology. There are probably both practical and theoretical reasons for this, including the problem of distinguishing between memory failures and lack of compliance, or between prospective and retrospective components of a task, and so on. Indeed, several

studies were excluded from this chapter because they did not correspond to my definition of a prospective memory task.

With regard to age, the elderly would not be expected to perform as well as the young because of their reduced processing resources (e.g., Craik, 1986). In particular, deficits in processes such as self-initiated retrieval, reality monitoring, and output monitoring would be detrimental to performance in prospective memory tasks. However, experience and feedback accumulate with age, providing the opportunity for the elderly to develop compensatory strategies to overcome their cognitive deficits. Preliminary evidence suggests that the use of external memory aids increases with age in some conditions. This could account (at least partly) for the striking absence of age deficits in self-rated ability in everyday prospective memory tasks, and in "naturalistic" prospective memory studies conducted outside the laboratory. As Hunt (1993) commented, "learned habits of personal record keeping and adoption of an orderly life . . . may have overridden changes at the biological and information processing levels" (p. 590).

Consistent with their declining cognitive abilities, the elderly are less able to perform as well as the young under laboratory conditions (where the use of external memory aids is either excluded or controlled by the experimenter). The effect of age is particularly evident in time-based prospective memory tasks in which environmental support is low and self-initiated activity is high. Age deficits are less apparent in event-based tasks (greater environmental support available and less self-initiated activity required), and may be absent altogether if some allowance is made for the elderly's depleted processing resources by reducing the cognitive demands of the background activity accordingly.

Finally, the analysis of data from repeated prospective memory tasks in terms of initial performance, subsequent forgetting, and also subsequent recovery (although not dealt with here) may prove to be a useful approach in the future. The preliminary analyses presented in this chapter suggest that there are factors (including age) that have differential effects on initial and subsequent performance in repeated prospective memory tasks. Both the practical and theoretical significance of this remain to be explored.

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