7

Prospective Memory and Life Span Development

The developmental aspects of prospective memory have been studied for both the early stages of development—with children—and the later stages of development—with older adults. At both ends of the spectrum, a common assumption might be that prospective memory is relatively impaired. The research provides a somewhat different and in some cases surprising counterpoint to this assumption. We first examine the modest literature on children, then turn to the more extensive work with older adults.

Prospective Memory in Children

Even preschool-age children face prospective memory tasks such as remembering "to dress properly to go outside, to bring appropriate objects to games, to deliver messages, to carry out chores on a regular basis" (Meacham, 1982, p. 129). Some researchers have suggested that, more so than remembering in retrospective memory tasks, remembering to perform prospective memory tasks carries social rewards (Meacham,1982; Winograd, 1988). One could argue that these factors might stimulate rather rapid development of prospective memory skills (Kvavilashvili, Kyle, & Messer, in press). One avenue for examining this issue is to assess children's knowledge (metamemory) of prospective memory strategies.

In a seminal study, a survey was taken of children from four different grade levels: kindergarten (4 to 5 years), first grade (6 to 7 years), third grade (8 to 9 years), and fifth grade (10 to 11 years) (Kreutzer, Leonard, & Flavell, 1975). The children were prompted to think of and list strategies they could use to remember to take their skates to school the next morning, and strategies they could use to remember an upcoming event (for example, a friend's birthday). The responses revealed a range of strategies similar to those adults sometimes use (see Chapter 9). As displayed in Figure 7.1, two external strategies were mentioned: putting the skates in some visible location (by the door) and writing a note. The internal strategy of periodic rehearsal of the task was also listed (labeled "Self" in the figure), as was the

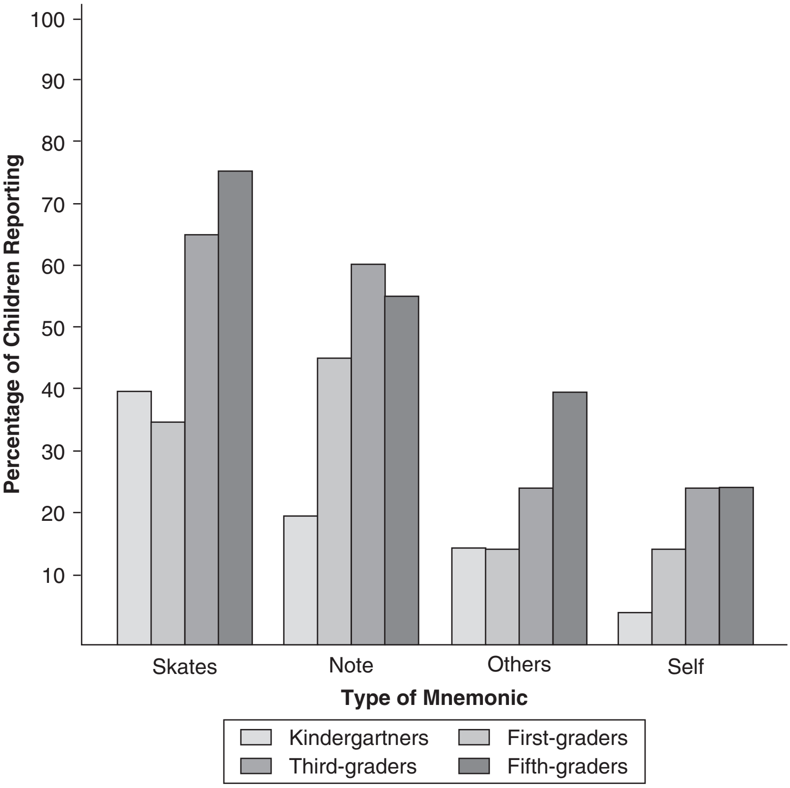

Figure 7.1 Percentage of Children in One Study Who Reported the Use of Different Types of Mnemonics

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strategy of asking others (a parent) to provide a reminder. These types of strategies were listed by every age group, though Figure 7.1 clearly indicates that the older children (third- and fifth-graders) listed more strategies and were more likely to mention each of the strategies than were the kindergarteners. Development of retrospective memory strategies in children displays a roughly similar pattern. By the third through fifth grades, children do recruit encoding strategies for trying to remember target material. By 7 years of age, using rehearsal to remember information emerges with some regularity, and more effective organizational strategies appear at about age 10 (fifth grade) (Kail, 1984). Therefore, these data do not compel us to conclude that prospective memory develops especially early on in children.

A related central question is whether children actually do marshal effective strategies for prospective memory. Time-based prospective memory tasks allow straightforward investigation of this question, because they tend to be dependent on strategic processes (see Chapter 2). Further, the strategic monitoring processes associated with time-based prospective memory (checking a clock) can be readily observed and recorded. In a now classic study, Ceci and Bronfenbrenner (1985) examined time-based prospective memory for 10- and 14-year-old boys and girls who were told to try to remember to take cookies out of the oven in 30 minutes or to remove a battery charger cable in 30 minutes. During the 30-minute interval, the children were encouraged to play a popular video game in another room, and were seated at the game with their backs to a clock. This allowed the researchers to clearly note the instances in which the children checked the clock.

For the most part, the children deployed strategic clock-monitoring strategies, with 10-year-olds showing patterns paralleling those of 14-year-olds. Further, the children showed varied strategies depending on the context in which the prospective memory task was presented. In one situation, the baking and battery-charging tasks were performed in the laboratory. Here, Ceci and Bronfenbrenner (1985) expected the children to be more anxious about performing the prospective memory task on time. To support good performance, many children increased the frequency of their monitoring as the target time approached. Kerns (2000) has reported a similar pattern of strategic monitoring for 7- to 12-year-old children.

In contrast, when the baking and battery-charging tasks were performed in each child’s home with an older sibling conducting the experiment, the children adopted a strategy that maintained prospective memory performance and also freed up maximal time for playing the video game. Both 10- and 14-year-olds showed a U-shaped monitoring function. Monitoring started out at a moderate level, presumably for calibration of an internal clock, then decreased to very low levels until a period immediately preceding the target time. At this point, children substantially increased their rate of monitoring. These patterns indicate that children as young as 10 years of age can recruit strategic monitoring processes to meet their prospective memory objectives.

A handful of children (21 of 98) in Ceci and Bronfenbrenner's 1985 study displayed ineffective monitoring patterns, with frequency of monitoring progressively declining as the target time approached. These children also showed poor prospective memory performance. It is uncertain whether these children could not muster effective strategies or simply chose not to implement a more effective clock-checking strategy. Certainly, for younger children, the personal relevance of the task plays a major role in stimulating recruitment of effective strategies. For instance, when the prospective memory task is to remind a caretaker (typically the child's mother) to buy candy at the store (for the child) tomorrow morning, children (ages 2 to 4) show much higher levels of prospective memory performance (73% success with short delays of several minutes and 53% success with delays on the order of hours) than they do when the task is to remind the caretaker to bring in the washing after the nap (23% success with short delays and 17% success with longer delays) (Somerville, Wellman, & Cultice, 1983). There were remarkably high levels of prospective memory for tasks that were important to the children, even for those as young as 2 years of age (80% for short delays and 50% for longer delays).

Nevertheless, prospective memory dynamics begin to diverge across younger and older children. Several studies with event-based prospective memory tasks illustrate this general claim. One set of experiments found that the manner in which the prospective memory task was encoded differentially affected 7-year-old compared to 10-year-old children (Passolunghi, Brandimonte, & Cornoldi, 1995). The prospective memory task involved pressing a designated key when the word *boat* appeared in a list of words. In one encoding condition, the auditory instructions were supported by the presentation of a picture of a boat (visual encoding). In another encoding condition, auditory instructions were accompanied by practice at pressing the key (motor encoding).

Given the findings reviewed earlier on the relationship between enactment encoding and intention superiority (Freeman & Ellis, 2003), one might expect motor encoding to enhance prospective memory. Indeed, for 10-year-old children, remembering to respond substantially increased from 30% of the time after visual encoding to over 92% of the time with motor encoding. In contrast, for the 7-year-old children, visual encoding was substantially superior to motor encoding (resulting in remembering to respond over 50% of the time as opposed to 5% of the time). The researchers suggested that the 7-year-old children in the motor condition may have found it difficult to form an association between the prospective memory cue and the intended action. It is noteworthy that the 7-year-old children consistently outperformed the 10-year-olds in the visual encoding condition. To maximize prospective memory for children at these ages, communicating the intended activity at an age-appropriate level may be especially important.

Age 7 and Younger

At the outset, we raised the general issue of the extent to which even young children display strategic processes in prospective memory. There are only about half a dozen studies focusing on children younger than 7 years of age. With this limitation and the available findings in mind, we tentatively suggest that relevant strategic control processes for certain aspects of prospective memory performance have not been firmly established for children under 7. One such control process is effectively inhibiting the ongoing activity at the appropriate moment so that the intended action can be executed. In one condition, Kvavilashvili, Messer, and Ebdon (2001) obviated the need to interrupt the ongoing activity by placing the prospective memory target cue at a natural endpoint in the ongoing task. Children had to name stacks of pictures for Morris the Mole, because this mole did not see very well. The target picture for the prospective memory task (hide a particular picture from Morris) was placed either in the middle of each stack (interruption condition) or at the end of each stack (noninterruption condition). In the noninterruption condition, 5-year-olds performed the prospective memory task well (at almost 75%) and nearly at the level demonstrated by 7-year-old children (just over 75%). But when the ongoing activity had to be interrupted so the prospective memory task could be performed, the 5-year-olds' performance fell dramatically (to 25%).

In a study that more directly addressed strategic monitoring processes, Stokes, Pierroutsakos, and Einstein (2005) manipulated whether the prospective memory cue was focal or nonfocal to the ongoing activity (see Chapter 4 for a definition of focal and nonfocal cues). Following the general procedure of Kvavilashvili et al. (2001), 7- and 5-year-old children were given the task of naming a circled picture on a card on which three other pictures were also presented. The prospective memory task was to indicate when a picture of an animal appeared so that the experimenter could hide that card from Geoffrey the Giraffe, who was a bit afraid of other animals. For the children in the focal-cue condition, the target cue was the circled picture, and for the children in the nonfocal-cue condition, the cue was an uncircled picture.

According to the multiprocess theory (see Chapter 4), the nonfocal-cue but not the focal-cue condition should require strategic monitoring. Thus, if 5-year-old children have not developed certain strategic processes, they should show prospective memory declines primarily in the nonfocal-cue condition. Table 7.1 shows the prospective memory performance levels. As you can see, the substantial prospective memory decline for the 5-year-old children (relative to the 7-year-old children) with the nonfocal cue was significantly reduced when the prospective memory cue was focal. These patterns imply that children 5 years of age and younger have not developed strategic monitoring processes or do not have the attentional resources required to deploy these processes during engagement with ongoing activities. In a follow-up experiment performed by Stokes (unpublished), these results were replicated. Further, examinations of the speed of performing the ongoing task (measured only on nontarget trials) with and without a prospective memory task indicated that the older children but the not the younger children in the nonfocal condition slowed down when they were also performing a prospective memory task. This result strongly agrees with the interpretation that the 7-year-old children were strategically monitoring the cards for animals, whereas the 5-year-old children were not. Interestingly, performing a prospective memory task did not slow down ongoing-task responding in the focal condition.

Our analysis of prospective memory performances of younger children has focused on the joint consideration of (a) the degree to which successful prospective remembering requires strategic processes and (b) the degree to which the children have reached a level at which strategic processes (for

Table 7.1 Successful Prospective Memory (PM) Responses in Children in Several Experiments

Experiment	*PM Condition*	*Correct Responses*	
		5-Year-Olds	*7-Year-Olds*
Stokes, Pierroutsakos, & Einstein (2005)	Nonfocal	20%	92%
	Focal	67%	97%
McGann, Defeyter, Ellis, & Reid (2005)			
Experiment 1	Nonsalient	43%	73%
	Salient	61%	71%
Experiment 2	Nonsalient	49%	68%
	Salient	70%	60%

example, monitoring) have developed. In support of this analysis, McGann, Defeyter, Ellis, and Reid (2005, Experiment 1) had children, including 5- and 7-year-olds, name pictures. The prospective memory task was to help Rosie the Rag Doll collect food items for her picnic. Over the course of 80 picture-naming trials, four food items appeared as pictures, and the children had to remember to press a key to select that item for the picnic. The important manipulation was that food pictures were either presented in a salient fashion so that they stood out from the nonfood pictures (they were larger than the nonfood pictures) or were not salient (no size difference). In this experiment, salient but not nonsalient prospective memory targets should minimize the need for strategic monitoring, thus attenuating age differences in prospective memory performance. Confirming this expectation, prospective memory performance of 5-year-olds was significantly poorer than that of 7-year-olds when the target pictures were nonsalient but not when the pictures were salient (see Table 7.1).

A surprise, however, was that a second experiment showed no significant differences between the prospective memory performance of the 5-year-olds and that of the 7-year-olds, even when the targets were nonsalient (see Table 7.1). This result might be understood by noting that the ongoing activity was altered such that in addition to naming the pictures, the children sorted the pictures into categories. Now the prospective memory cue (a food item) was arguably focal to the ongoing activity of considering the category of each picture. Therefore, even for perceptually nonsalient pictures, prospective memory retrieval was not dependent on strategic processes, and 5-year-olds performed relatively well. Though other methodological differences between Experiments 1 and 2 and/or a lack of statistical power in Experiment 2 may have also contributed to the different age-related patterns (see Kvavilashvili et al., in press, for further details), at this point we believe that the multiprocess interpretation offers a fruitful direction for exploring variations in age-related differences in prospective memory in children.

Summary

Prospective memory research with children is only beginning to appear in the literature. The emerging developmental patterns, though admittedly preliminary, are consistent with the multiprocess framework (detailed in Chapter 4). Specifically, this theory acknowledges minimal involvement of strategic processes in some but not other prospective memory tasks and that children develop the capability for such strategic processes at a certain developmental level. Readers interested in a detailed review of this literature can consult Kvavilashvili et al. (in press).

Prospective Memory in Older Adults

Prospective memory has been studied most extensively with regard to its functioning in older adults (typically those over 60 years of age). Craik (1986) stimulated an early and abiding interest in examining prospective memory in older adults with his seminal framework on age-related memory deficits. Craik suggested that memory tasks could be ordered in terms of the amount of self-initiated processes required to retrieve the target information. Generally, the fewer the cues provided by the memory task, the more retrieval is dependent on processes initiated by the individual, such as generating possible cues, generating potential targets, and implementing any other strategies that will help bring the desired information to mind. For instance, as shown in Figure 7.2, recognition is considered to have low self-initiated retrieval demands, because the recognition task provides the target item. In this scheme, prospective memory is thought to have the highest self-initiated retrieval demands because not only is there an absence of cues, but also one has to remember to remember.

According to Craik's framework, because self-initiated retrieval presumably requires extensive processing resources and because processing resources decline with age, age-related deficits in memory should be a function of the amount of self-initiated retrieval required by the memory task. Because prospective memory is assumed to require the most self-initiated retrieval, this compelling theory makes the strong prediction that prospective memory tasks would be especially difficult for older adults. Let's see what the research shows.

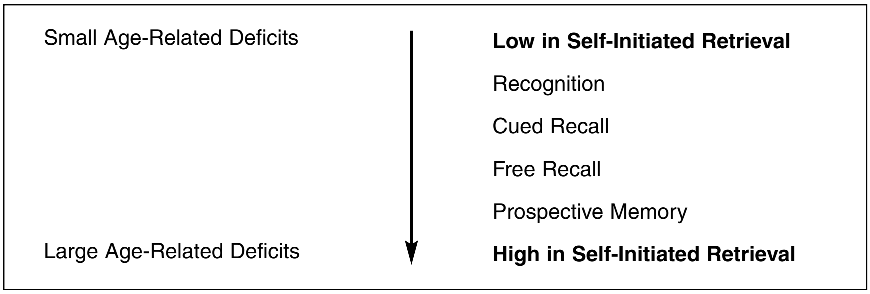

Figure 7.2 Self-Initiated Retrieval Processes

SOURCE: Adapted from Craik (1986).

Semi-Naturalistic Prospective Memory Tasks

One set of studies tested this idea in semi-naturalistic paradigms. Typically, subjects were instructed to telephone the experimenter at specified times over several days or to mail a postcard back to the laboratory on a certain day of the week for several weeks. As revealed in Table 7.2, these studies invariably found no deficit in prospective memory with age, and often reported better prospective memory for older than for younger adults. (See Rendell & Craik, 2000, Experiment 2, for another type of semi-naturalistic paradigm.) To determine the reasons for older adults' good prospective memory performance, some researchers asked subjects if they had used special strategies to help them remember the prospective memory task. Older adults usually indicated that they had implemented external cues, such as marking the scheduled times for calling the experimenter on a calendar (for example, see Moscovitch, 1982). In contrast, younger adults typically reported that they were confident about their ability to remember and thus had no need to implement an external cue. In some research, the experimenters asked older and younger adults not to use external aids, but even in this case, older adults persisted in using external aids and continued to outperform younger adults (Maylor, 1996; Moscovitch, 1982). Thus, in much of the semi-naturalistic research, the relatively good prospective memory performance of older adults likely has been due to their use of an external strategy. In terms of Craik's theory, the older adults were reducing their need for self-initiated retrieval.

In an attempt to circumvent this issue, Rendell and Thompson (1999) implemented complex time-based regimens designed to discourage the use of certain kinds of external cues. Also, Rendell and Craik (2000) explicitly prohibited the use of external aids. Older adults still consistently executed the prospective memory task significantly closer to the target time than did young adults. Nevertheless, it is not certain that older adults were absolutely prevented from using external cues. It is also uncertain that the pacing of ongoing activities was comparable for young and older adults.

To preclude older adults' use of external aids and strategies, many investigators have favored laboratory paradigms of prospective memory. Age effects have been examined with regard to both time-based and event-based prospective memory. The results regarding time-based prospective memory are more straightforward, and we turn to this topic first.

Time-Based Prospective Memory Tasks

As described in Chapter 2, in laboratory time-based tasks, subjects are given an ongoing activity to perform. For the prospective memory task,

Table 7.2 Prospective Memory (PM) Performance in Young and Older Adults in Semi-Naturalistic Experiments

				Memory Aids Used[b]		*Percentage of Correct PM Responses*	
Study	*Experimental Condition or Segment*	*PM Task*	*Memory Aids Prohibited*[a]	*Young*	*Older*	*Young*	*Older*
Devolder, Brigham, & Pressley (1990)	predict[c]	Call 8 times in 4 weeks[e]	no	no information	no information	56%	86%
	postdict[d]		no	no information	no information	57%	81%
Kvavilashvili & Fisher (2007)		Make a phone call at a particular time after 1 week	yes	no (except diary used to record all rehearsals)	no (except diary used to record all rehearsals)	68%	81%
Martin (1986)		Show up for appointments (last 8 years)	no	no information	no information	96%	99%
Patton & Meit (1993) Experiment 1		Return 4 postcards, each on a certain day	no	yes	yes	86%	100%
Patton & Meit (1993) Experiment 3		Return 4 postcards, each on a certain day	no	yes	yes	79%	100%

Study	*Experimental Condition or Segment*	*PM Task*	*Memory Aids Prohibited*[a]	*Memory Aids Used*[b]		*Percentage of Correct PM Responses*	
				Young	*Older*	*Young*	*Older*
Rendell & Craik (2000)[f]	regular[g]	Recite intended action into a recorder at certain points during the day[j]	yes	no	no	68%	83%
	irregular[h]		yes	no	no	51%	72%
	time[i]		yes	no	no	24%	36%
Rendell & Thompson (1993)	4 times	Press a button 4 times a day	no	no information	no information	44%	75%
	1 time	Press a button once a day	no	no information	no information	45%	77%
Rendell & Thompson (1999) Experiment 1[f]	same regular[k]	Press a series of keys on an organizer 4 times a day[j]	only for sequence of numbers entered in organizer	32%	20%	32%	67%
	same irregular[l]		no			40%	68%
	different regular[m]		no			36%	71%
	different irregular[n]		no			41%	69%
Rendell & Thompson (1999) Experiment 2	alarm[o]	Press a series of keys on an organizer 4 times a day[j]	no	yes	yes	60%	86%
	choice[p]		no	yes	yes	42%	78%

(Continued)

Table 7.2 (Continued)

[a] Indicates whether or not subjects were explicitly prohibited from using memory aids.

[b] Indicates whether or not subjects reported using memory aids.

[c] Subjects estimated what their scores on the ongoing retrospective memory task would be before they completed the task.

[d] Subjects estimated what their scores on the ongoing retrospective memory task had been after they completed the task.

[e] A response was considered correct if the participant called within 10 minutes of the appointment.

[f] These experiments included younger-old and older-old groups; older adult prospective memory performances reflect an average of the two groups.

[g] Intended actions were those that would happen the same way every day (e.g., taking medication).

[h] Intended actions were those that would change daily (e.g., calling the doctor at noon).

[i] In this condition, subjects did a time check after each of the irregular activities (e.g., 30 minutes after the first action).

[j] A response was considered correct if the participant performed the task within 5 minutes of the assigned time.

[k] Subjects were to press the button at regular intervals (every 4½ hours, starting at 8:00 A.M.) that were the same each day.

[l] Subjects were to press the button at irregular intervals (e.g., 4¼ hours, 3½ hours, and 4¾ hours) that were the same each day.

[m] Subjects were to press the button at regular intervals that differed each day.

[n] Subjects were to press the button at irregular intervals that differed each day.

[o] An alarm went off whenever the subject was supposed to press the button.

[p] Subjects chose the times for pressing the button to coordinate with regular daily events.

subjects are instructed to execute a particular action (such as press a key on the keyboard [d'Ydewalle et al., 1999]) after a particular amount of time (for example, 3 minutes or 5 minutes) has elapsed. This kind of task is akin to having to remember to take something out of the oven after a particular period of time. Typically, several prospective memory trials are implemented, as the subject is instructed to perform the designated action after a specified elapsed period of time several times over the course of the ongoing task. For instance, for an ongoing task lasting just over 20 minutes, the subject would be instructed to perform the prospective memory action at the 5-minute, 10-minute, 15-minute, and 20-minute marks of the ongoing task.

A key feature of these paradigms is that subjects must perform the prospective memory task without the advantages we sometimes have in everyday time-based tasks, such as using a timer or an alarm. Additionally, no clocks are in direct view and watches are removed from the subjects. Subjects can check a hidden clock, either by turning to view a clock placed behind them or by pressing a key on the keyboard to produce a brief display on the computer monitor. (As an aside, removing watches from the subjects places a prospective memory demand on the experimenter—remembering to return the watches to the subjects upon completion of the experiment. More than once, the experimenter—having missed the target cue—has ended up chasing one of the subjects out of the laboratory with the subject's watch in hand.)

Because no external cues are available to support prospective remembering in the time-based prospective memory paradigms, subjects must initiate retrieval of the intention in the absence of any environmental event signaling that the time is appropriate for performing the task. If subjects adopt a test-wait-test-exit strategy (see Chapter 2), they still must initiate retrieval of the intention to check the clock. Thus, at least in the laboratory, time-based prospective memory is heavily self-initiated, and thus robust age differences should be evident.

To measure accuracy of the prospective memory responses, a favored scoring procedure is to consider a prospective memory response on time if it occurs within a specified time window after the target time. The idea here is that if you remember to take the cookies out of the oven within, say, 15 seconds of the target time, you will be successful—that is, the cookies will not have burned. In an experiment performed by Einstein, McDaniel, Richardson, Guynn, and Cunfer (1995), responses were considered correct if they were within 1 minute of the target time, with the target time occurring every 5 minutes during an ongoing activity. Older adults (ranging in age from 61 to 76) were half as likely as younger adults to remember to perform the prospective memory activity. For middle-aged adults, those from 35 to 49, the news is better: They remembered to perform the prospective memory task at a high level. Using a much narrower response window (7 seconds), Park, Hertzog, Kidder, Morell, and Mayhorn (1997) found similar significant declines in time-based prospective memory in older adults. Researchers who have examined a range of time windows have found no change in this pattern (see Park et al., 1997). Table 7.3 provides a more exhaustive summary of the published results. As you can see, in every case except one (Patton & Meit, 1993), older adults did show a decline in performance relative to younger adults. A meta-analysis of these effects confirms that the size of the age deficit is substantial (Henry, MacLeod, Phillips, & Crawford, 2004).

These results are consistent with the view that age-related declines in resources that support self-initiated retrieval underlie relatively poor time-based prospective memory performance for older adults. Note, however, that other interpretations are possible as well. One hypothesis is that older adults are less accurate in time estimation than are younger adults. The idea here is that older adults retrieve the prospective memory intention and remember to monitor a clock, but fail to do so in a timely fashion because of faulty time estimation. To test this idea, Mantyla and Carelli (2005) had subjects estimate stimulus durations of between 4 and 32 seconds. Time estimation errors increased for longer durations, but older adults were as accurate as middle-aged and younger adults on this task. Moreover, people's time estimation accuracy was at best weakly related to clock-monitoring performance in a time-based prospective memory task. That is, effective monitoring of time for a prospective memory task is not tied to time estimation accuracy, and moreover, time estimation accuracy does not appear to decline with age.

Effective monitoring of time does appear to decline with age, though. As discussed in Chapter 2, clock monitoring in a time-based prospective memory task typically reflects a strategic pattern, becoming significantly more frequent just prior to the target time (see Figure 2.2). It is important to note that this strategic monitoring pattern is not typically found with older adults. Older adults clearly monitor—indeed, they tend to monitor at least as frequently as younger adults in the intervals distal to the target time. But, as Figure 7.3 shows, in the interval just prior to the target time, older adults do not increase their monitoring frequency as do younger adults. It seems likely that the depressed monitoring just prior to the target time is the cause of older adults' less accurate performance on the time-based prospective memory task. What remains unclear is the reason that older adults exhibit less strategic monitoring. It could be that age-related deficits in self-initiated retrieval ability preclude older adults from increasing their monitoring. However, given that older adults monitor as frequently as younger adults at intervals distal to the target time, it may not be that older adults have problems with self-initiated retrieval of the intention to check the clock.

Table 7.3 Prospective Memory (PM) Performance in Laboratory Time-Based Experiments

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Trials*	*PM Window*	*Correct PM Responses*	
							Young	*Older*
d'Ydewalle, Luwel, & Brunfaut (1999)	questions	age, task	Answer trivia questions	Press a key at 4, 9, and 12 minutes	3	1 minute	87%	68%
	faces		Name famous faces	Press a key at 3, 8, and 10 minutes	3		97%	88%
Einstein, McDaniel, Richardson, Guynn, & Cunfer (1995) Experiment 1		age	Learn words presented on screen and recall last 10 words at unpredictable intervals	Press a button every 10 minutes	2	1 minute	83%[a]	50%[a]
							100%[a]	75%[a]
Einstein, McDaniel, Richardson, Guynn, & Cunfer (1995) Experiment 3		age	Answer trivia questions	Press a button every 5 minutes	6	1 minute	65%	32%

(Continued)

Table 7.3 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Trials*	*PM Window*	*Correct PM Responses*	
							Young	*Older*
Martin & Schumann-Hengsteler (2001)	low complexity[b]	age, complexity, age by complexity	Play Mastermind and record protocol	Change protocol sheet every 3 minutes	6	+/– 90 seconds	92%	67%
	medium complexity[c]				6		75%	50%
	high complexity[d]				6		65%	2%
Park, Hertzog, Kidder, Morrell, & Mayhorn (1997) Experiment 2		age	Monitor words and recall last three at unpredictable intervals	Press a button every 1 or 2 minutes	6 or 12[e]	+/– 1 second	81%	40%
						+/– 3 seconds	89%	62%
						+/– 9 seconds	95%	79%
Patton & Meit (1993) Experiment 1		no main effect	Watch a video	Turn video off after 30 minutes	1		26.33[f]	20.35[f]

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[a] This study examined performance on each trial separately.

[b] Easy game of Mastermind.

[c] Moderately difficult game of Mastermind.

[d] Difficult game of Mastermind.

[e] This study only reported means collapsed across these two trial densities.

[f] Given means indicate the amount of time in seconds that passed after the target time before the PM task was executed.

This observation leaves open the possibility that age-related deficits in laboratory time-based prospective memory task performance are related to ineffective monitoring strategies adopted by older adults.

Understanding the factors that influence monitoring behavior may well be a key in explaining the remarkable discrepancy between the robust age deficits seen in laboratory time-based prospective memory tasks and the absence of age deficits seen in semi-naturalistic time-based prospective memory tasks. Earlier we noted that semi-naturalistic studies allow older adults to engineer external reminders for time-based tasks (for instance, a shoe placed by the telephone as a reminder to call the experimenter), thereby obviating the need for extensive self-initiated retrieval or monitoring. Yet some semi-naturalistic studies take care to preclude the use of intentional external reminders, and older adults still perform as well or better than young adults (Rendell & Thompson, 1999; Rendell & Craik, 2000). To reconcile the disparate findings across laboratory and semi-naturalistic paradigms, Kvavilashvili and Fisher (2007) proposed an intriguing alternative to the assumption that time-based prospective memory relies heavily on self-initiated retrieval.

Kvavilashvili and Fisher's (2007) major premise is that outside the laboratory, between the formation of the intention and the time to perform the intention, there are chance encounters with cues that stimulate retrieval of

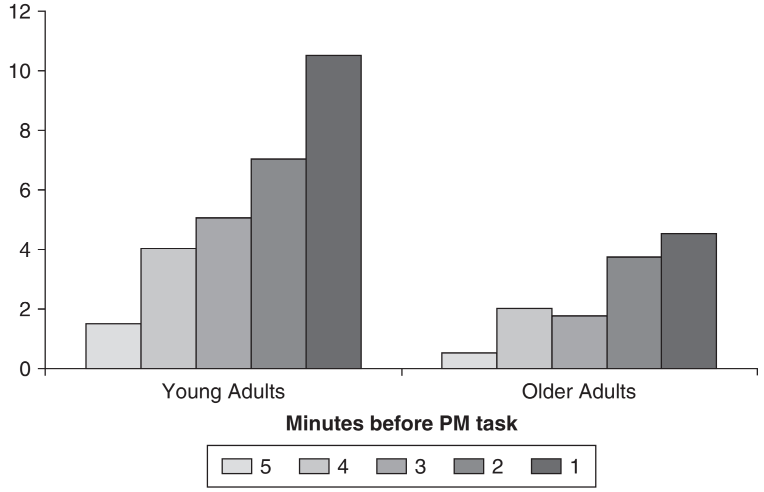

Figure 7.3 Clock Monitoring in Time-Based Prospective Memory in an Experiment Performed by Einstein, McDaniel, Richardson, Guynn, and Cunfer (1995)

the time-based intention. For instance, a week before your mother's birthday, you decide to call her on Monday between 11:00 A.M. and 1:00 P.M. (when she'll be home for lunch). During the week, you might encounter someone talking about a birthday, see a gift being wrapped at a store, or simply look at the telephone. These chance encounters may remind you that you intend to call your mother on her birthday, producing further rehearsal of the intention, which in turn may promote more spontaneous retrieval of the intention with subsequent cues and more frequent checking to see if the appropriate time (or date) is at hand. According to this formulation, in everyday contexts where ongoing activities allow encounters with cues relevant to the intention, even time-based prospective memory hinges on relatively spontaneous retrieval and rehearsal rather than predominantly on self-initiated retrieval (see also Rabbit, 1996). Because spontaneous retrieval appears to be unimpaired in older adults (McDaniel, Einstein, & Rendell, in press), this perspective provides a straightforward explanation of why older adults' time-based prospective memory performance outside the laboratory is not impaired relative to that of young adults.

To obtain evidence for their view, Kvavilashvili and Fisher (2007, Study 2) gave young and older adults a typical semi-naturalistic prospective memory task with a new twist. Subjects were instructed in the laboratory on a Monday that they were to try to remember to call the experimenter the next Sunday at an appointed time. The novel aspect of this study was that during the retention interval, subjects made an entry in a diary whenever the intended action came to mind. The entry included the place where the reminder occurred, the activity in which the subject was engaged, accompanying thoughts, and any evident external cues. The typical pattern for prospective memory performance in a semi-naturalistic setting was obtained: 81% of the older adults remembered to telephone on time, whereas 68% of the young adults telephoned on time.

More critically, for both young and older adults, reminders occurred significantly more frequently in the presence of a chance external cue than they did as a result of an incidental internal thought or a self-initiated plan–related thought. External cues included seeing a telephone, hearing a telephone ring, or even hearing the word *memory* spoken. Another notable finding was that the distribution of remindings over the weeklong interval reflected the familiar J-shaped curve (shown in Figure 7.4) for young and older adults. The frequency of reminders (as noted in the diaries) evidenced an upward scallop as the time for executing the phone call became more imminent. Kvavilashvili and Fisher speculated that, as reminders activate the intention, thereby fostering rehearsal of the prospective memory task, the representation of the intention and the designated time gains higher levels of activation. The higher activation further sensitizes the individual to encounters with cues as the week progresses, producing more spontaneous retrievals of the intention.

Note that in laboratory time-based tasks, the opportunity for chance encounters with environmental cues is minimized by a single, circumscribed ongoing activity. In further research, it will be important to examine whether semi-naturalistic contexts provide environmental support (sufficient chance cues) for a variety of time-based prospective memory tasks or whether the telephone-calling task used by Kvavilashvili and Fisher was especially well suited for this process (because, for example, the external cues—telephones and telephone ringing—are ubiquitous in our society). For instance, semi-naturalistic time-based tasks involving remembering to do something after a relatively brief period of elapsed time may prove more problematic for older adults than for young adults because there is limited opportunity for chance encounters with related cues. An example is remembering to take cookies out of the oven in 12 minutes. During this interval, it seems unlikely that the person's ongoing activity will produce encounters with related cues (especially if he or she leaves the kitchen), and accordingly, older adults may evidence impaired prospective remembering.

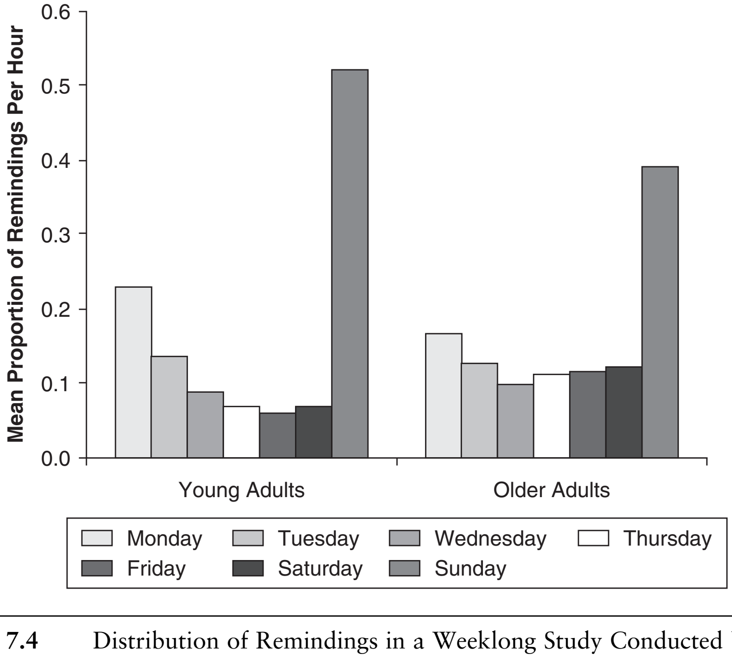

Figure 7.4 Distribution of Remindings in a Weeklong Study Conducted by Kvavilashvili and Fisher (2007)

SOURCE: From Kvaviliashvili, L. (2005, July). *Automatic or Controlled? Rehearsal and Event-Based Prospective Memory Tasks.* 2nd International Prospective Memory Conference. Zurich, Switzerland. Used with permission.

Another possible explanation for the good time-based prospective memory performance evidenced by older adults, however, is that in semi-naturalistic settings older adults have more control over the pace of ongoing activities and therefore have more resources available for internally initiated reminders or monitoring (see discussion of an experiment performed by McDaniel et al. [in press] later in this chapter). More work is needed to follow up these possible explanations, but for now they offer some possibilities for reconciling the opposing age-related patterns in laboratory versus semi-naturalistic time-based prospective memory tasks.

Event-Based Prospective Memory Tasks

The age-related patterns in event-based prospective memory mirror those in the time-based prospective memory literature: Taken as a whole, laboratory event-based tasks but not semi-naturalistic event-based tasks find substantial declines in prospective memory performance in older adults relative to young adults (Henry et al., 2004). But an additional intriguing puzzle emerges for event-based tasks. Table 7.4 summarizes over 80 event-based laboratory conditions contrasting young adults' and older adults' performances. Take a moment to examine the pattern of results to see whether the experiments reveal significant age-related differences.

What you undoubtedly noticed is that a number of experiments have found significant declines for older adults relative to younger adults, reinforcing the conclusion held by some researchers that "prospective memory failure generally increases with age" (Craik, 2003, p. 13). Yet you probably also noticed that some experiments have found equivalent or not significantly different levels of performance for older and younger adults. These findings have prompted the alternative conclusion that "prospective memory seems to be an exciting exception to typical age-related decrements in memory" (Einstein & McDaniel, 1990, p. 724). How can we reconcile these conclusions and the opposing findings from the laboratory-based paradigms from which these conclusions arise?

In recent years, researchers have animatedly discussed this issue among themselves, and a number of ideas have been offered. One idea is that the experiments finding no age differences have sampled more highly functioning older adults than have experiments finding age differences. Consistent with this idea, Cherry and LeCompte (1999) found that older adults with relatively high working-memory capacity exhibited prospective memory performance at levels equal to those of younger adults, whereas older adults with low working-memory capacity showed significantly worse prospective memory than did the younger adults. Another provocative idea rests on the

(Text continues on page 157)

Table 7.4 Prospective Memory (PM) Performance in Younger and Older Adults in Event-Based Laboratory Experiments

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Cherry & LeCompte (1999)	low ability[a]	low/high ability	Recall words from a list	Press button when target word appears	focal	6	65%	40%
	high ability[b]				focal	6	68%	69%
Cherry et al. (2001) Experiment 1	specific	age, specificity	Recall words from a list	Press button when target word appears	focal	3	90%	50%
	generic			Press button when target category appears	nonfocal	3	54%	29%
Cherry et al. (2001) Experiment 2	specific	specificity	Recall words from a list	Press button when target word appears	focal	3	53%	62%
	generic			Press button when target category appears	nonfocal	3	43%	27%
Cherry et al. (2001) Experiment 3	typical specific[c]	age, specificity	Recall words from a list	Press button when target word appears	focal	3	86%	61%
	typical generic[d]			Press button when target category appears	nonfocal	3	67%	44%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
	atypical specific[e]			Press button when target word appears	focal	3	78%	75%
	atypical generic[f]			Press button when target category appears	nonfocal	3	44%	28%
Cohen, West, & Craik (2001) Experiment 1	related[g]	extent of relatedness, age by extent of relatedness	After studying picture-word pairs, give word when shown picture	State intended action (could not actually be performed in the laboratory)	focal	24	92%	78%
	unrelated[h]				focal	24	73%	52%
Cohen, West, & Craik (2001) Experiment 2	related pair[i]	format, extent of relatedness, age, format by age	After studying picture-word pairs, give word when shown picture	State intended actions paired with either picture-word pairs or just words	focal	24	96%	85%
	related word[j]				focal	24	74%	54%
	unrelated pair[k]				focal	24	91%	83%
	unrelated word[l]				focal	24	73%	34%

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
d'Ydewalle, Luwel, & Brunfaut (1999)	questions	age, task	Answer trivia questions	Circle item number if question is about a certain topic	focal	3	81%	42%
	faces		Name famous faces	Circle item number if face belongs to a man wearing a bow tie	nonfocal	3	92%	73%
Einstein & McDaniel (1990) Experiment 1	external aid[m]	external aid	Recall words from a list	Press button when target word appears	focal	3	83%	69%
	no external aid[n]			Press button when target word appears	focal	3	47%	47%
Einstein & McDaniel (1990) Experiment 2	familiar words	familiarity	Recall words from a list	Press button when target word appears	focal	3	28%	36%
	unfamiliar words				focal	3	83%	94%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Einstein, Holland, McDaniel, & Guynn (1992) Experiment 1	short delay,^{o} one target word	number of target items, age, age by number	Recall words from a list	Press button when target word appears	focal	3	58%	53%
	short delay,^{o} four target words			Press button when any of four target words appears	focal	3	58%^{p}	19%^{p}
	long delay,^{o} one target word			Press button when target word appears	focal	3	42%	61%
	long delay,^{o} four target words			Press button when any of four target words appears	focal	3	47%^{p}	11%^{p}
Einstein, Holland, McDaniel, & Guynn (1992) Experiment 2		age	Recall words from a list	Press button when any of four target words appears	focal	3	53%^{p}	14%^{p}

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Einstein, McDaniel, Richardson, Guynn, & Cunfer (1995) Experiment 2	specific	specificity	Learn words presented on screen and recall last 10 words at unpredictable intervals	Press button when target word appears	focal	8	85%	83%
	general			Press button when target category appears	nonfocal	8	56%	47%
Einstein, McDaniel, Richardson, Guynn, & Cunfer (1995) Experiment 3		no age main effect	Answer trivia questions	Press button when target word appears	focal	6	93%	86%
Einstein, Smith, McDaniel, & Shaw (1997) Experiment 1	high demand	age, demand	Rate words and detect specific digits among other digits	Press button when target word (a word which has appeared in yellow previously) reappears	focal	3	58%^{p}	25%^{p}
	low demand		Rate words		focal	3	71%	53%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Einstein, Smith, McDaniel, & Shaw (1997) Experiment 2	high R/low E[q]	age, demand at encoding, demand at retrieval	Rate words only (low demand) or rate words and also detect specific digits among other digits (high demand)	Press button when target word (a word which has appeared in yellow previously) reappears	focal	3	64%[p]	38%[p]
	low R/high E[q]				focal	3	47%[p]	54%[p]
	high R/high E[q]				focal	3	55%[p]	17%[p]
	low R/low E[q]				focal	3	66%	58%
Kidder, Park, Hertzog, & Morrell (1997)	2 words[r]/ 1 target background	age, number of words (demands of ongoing task), age by number of words[s]	Recall words from a list	Press button when target background appears	nonfocal	6	98%	98%
	2 words[r]/ 3 target backgrounds			Press button when any of three target backgrounds appears	nonfocal	6	97%	85%
	3 words[r]/ 1 target background			Press button when target background appears	nonfocal	6	82%	69%
	3 words[r]/ 3 target backgrounds			Press button when any of three target backgrounds appears	nonfocal	6	90%	63%

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Mantyla (1993)	typical,[t] primed[u]	age, typicality, priming, age by typicality by priming	Perform cued recall using subject-generated associates as cues	Draw X on any page containing word(s) from one of four categories	nonfocal	8	85%[p]	75%[p]
	atypical,[t] not primed[u]				nonfocal	8	80%[p]	50%[p]
	atypical,[t] primed[u]				nonfocal	8	80%[p]	30%[p]
	atypical,[t] not primed[u]				nonfocal	8	47%[p]	25%[p]
Mantyla (1994)	typical[t]	age, typicality, age by typicality	Perform cued recall using subject-generated associates as cues	Draw X on any page containing word(s) from one of four categories	nonfocal	16	79%[p]	65%[p]
	atypical[t]				nonfocal	16	65%[p]	26%[p]
Marsh, Hicks, & Cook (in press) Experiment 1		no age main effect	Decide which category each given word belongs to	Press button when target word appears	nonfocal	8	62%	62%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Marsh, Hicks, & Cook (in press) Experiment 2		no age main effect	Decide which category each given word belongs to	Press button when target word appears	nonfocal	8	55%	63%
Maylor (1993)	Block 1	age, block, age by block	Name faces	Circle slide number if face is wearing glasses; cross out slide if face is smoking	nonfocal	2	80%	67%
	Block 2				nonfocal	2	83%	66%
	Block 3				nonfocal	2	88%	69%
	Block 4				nonfocal	2	93%	70%
Maylor (1996)	Block 1	age	Name faces	Circle slide number if face is wearing glasses; cross out slide if face is smoking	nonfocal	2	57%	26%
	Block 2				nonfocal	2	65%	25%
	Block 3				nonfocal	2	67%	27%
	Block 4				nonfocal	2	60%	28%

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Maylor (1998)	Block 1	age, block	Name faces	Circle slide number if face is wearing glasses; cross out slide if face is smoking	nonfocal	2	68%	30%
	Block 2				nonfocal	2	75%	25%
	Block 3				nonfocal	2	80%	28%
	Block 4				nonfocal	2	88%	32%
McDaniel, Einstein, & Rendell (in press) Experiment 1	focal	focality	Give occupation of person whose face is pictured	Circle slide number if face belongs to a politician	focal	8	88%	84%
	nonfocal			Circle slide number if face is wearing glasses	nonfocal	8	45%	40%
McDaniel, Einstein, & Rendell (in press) Experiment 2	focal	focality	Decide which category each given word belongs to	Press button when target word appears	focal	4	92%	90%
	nonfocal			Press button when target syllable appears	nonfocal	4	64%	52%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
Park, Hertzog, Kidder, Morrell, & Mayhorn (1997)	6 trials	age	Monitor words presented on changing backgrounds and recall last three words at unpredictable intervals	Press button when target background appears	nonfocal	6	94%	71%
	12 trials				nonfocal	12	92%	87%
Rendell, McDaniel, Forbes, & Einstein (in press) Experiment 1	focal	age, focality, age by focality	Name famous faces	Circle slide number if face belongs to a person named John	focal	8	90%	78%
	nonfocal			Circle slide number if face is wearing glasses	nonfocal	8	87%	55%
Rendell, McDaniel, Forbes, & Einstein (in press) Experiment 2	standard task	age by task	Name famous faces	Circle slide number if face is wearing glasses	nonfocal	8	78%	40%
	simple task		Guess ages of faces		nonfocal	8	73%	70%

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
	slow task		Name famous faces (pictures stay on screen longer)		nonfocal	8	64%	70%
Tombaugh, Grandmaison, & Schmidt (1995)		age	Work on LAMB tests	When a designated word or phrase has been encountered, say it out loud	focal	6	87%	60%
Vogels, Dekker, Brouwer, & de Jong (2002)	letters block 1	block	Read aloud letters appearing on one side of screen	Remember to use +/– (which appears occasionally) to determine which side to read	indeterminate	12	81%^{p}	81%^{p}
	letters block 2						91%^{p}	88%^{p}
	letters block 3						94%^{p}	97%^{p}
	word	age	Press specific button depending on category of each given word pair	Press button if words are of same letter case or appear in same color	nonfocal	20	94%	68%

(Continued)

Table 7.4 (Continued)

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
	picture	age	Press specific button depending on category of each given picture	Press button when target object appears	indeterminate	35	84%^{p}	69%^{p}
	letter strings, feedback for prospective memory responses	no age main effect	Press button when certain letters appear	Press button if any letter appears three times in a row	indeterminate	8	88%^{p}	87%^{p}
	letter strings, no feedback for prospective memory responses	no age main effect			indeterminate	8	84%^{p}	87%^{p}

Study	*Experimental Condition or Segment*	*Significant Main Effect and/or Interaction*	*Ongoing Task*	*PM Task*	*PM Task Type*	*PM Trials*	*Correct PM Responses*	
							Young	*Older*
West & Craik (1999)		age	Press specific button depending on category of each given word pair	Press button if words are of same letter case or appear in same color	nonfocal	40	95%	79%
West, Herndon, & Crewdson (2001)		age	Press a button if word pairs are related; press a different button if word pairs are unrelated	Press button if both words are capitalized	nonfocal	40	95%	83%

(Continued)

Table 7.4 (Continued)

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[a] Subjects had low educational levels and verbal ability.

[b] Subjects had high educational levels and verbal ability.

[c] Target cue was a well-known word.

[d] Target cue was any word in a given category, but only the third-most-common exemplar from the category was presented.

[e] Target cue was a less frequently used word.

[f] Target cue was any word in a given category, but only the fifteenth-most-common exemplar from the category was presented.

[g] Target action was related to the picture cue.

[h] Target action was unrelated to the picture cue.

[i] Target cue was a picture-word pair related to the target action.

[j] Target cue was a word related to the target action.

[k] Target cue was a picture-word pair unrelated to the target action.

[l] Target cue was a word unrelated to the target action.

[m] Subjects were allowed to create their own reminders for the prospective memory task.

[n] Subjects were not allowed any external reminders for the prospective memory task.

[o] *Delay* indicates the interval between the instructions and the beginning of the prospective memory task.

[p] Data were not included in the focal versus nonfocal analyses (see Chapter 7).

[q] *R* indicates demand at retrieval; *E* indicates demand at encoding.

[r] Subjects were to recall the indicated number of last words presented.

[s] This interaction just failed to meet standard levels of significance ($p = .06$).

[t] *Typical* indicates that the target was a typical exemplar of a given category; *atypical* indicates that the target was a less typical exemplar of a given category.

[u] *Primed* indicates that the category serving as the prospective memory target had been used by subjects, prior to the ongoing activity, in an exemplar-generation task

observation that, when tested at their optimal time of day but not at their nonoptimal time of day, older adults often perform memory tasks as well as young adults (Intons-Peterson, Rocchi, West, McLellan, & Hackney, 1998; May, Hasher, & Stoltzfus, 1993). There is some evidence that prospective memory performance varies across the day (Leirer, Tanke, & Morrow, 1994; Wilkins & Baddeley, 1978). Perhaps experiments finding no age differences in prospective memory performance have tended to test older adults at their optimal time of day (mornings), whereas experiments finding age differences have tested them at their nonoptimal times (Maylor, 2005). These ideas merit consideration, but three explanations for the disparate age-related patterns seem most compelling:

Prospective memory difficulty and age differences. One explanation is based on the long-standing idea that age differences in cognitive performance are a function of the difficulty of the cognitive task. For present purposes, the idea is that age differences in event-based prospective memory become more prominent as the prospective memory task becomes more difficult. A more specific variant of this idea is that easier prospective memory tasks are associated with ceiling effects, which precludes the emergence of age differences (Uttl, 2005). A way to evaluate the difficulty of tasks and the plausibility of the ceiling-effect explanations is to correlate the age difference in prospective memory performance with the level of performance of the older adults across experiments. A significant negative correlation would be consistent with these explanations. Using a set of 133 experimental conditions, Uttl reported a correlation of –0.64. We computed the correlation using the set of experiments shown in Table 7.4, and also obtained a significant negative correlation (–0.67). These relatively high correlations lend currency to the interpretation that diverging age differences in event-based prospective memory are related to the difficulty of the prospective memory task. Easier tasks may either not be subject to age differences or simply not reveal age differences because of ceiling effects.

Yet the correlations may not provide a complete explanation of the varied age-related patterns. Inspect Table 7.4 again, and you will see there were several experiments in which subjects remembered to make the prospective memory response just over 50% of the time, yet age differences were not found (Einstein, Holland, McDaniel, & Guynn, 1992; Einstein et al., 1995, Experiment 2). Even when prospective memory performance dropped below 50%, there were instances when older adults perform as well as younger adults (Einstein & McDaniel, 1990, Experiments 1 and 2). In these experiments, performance is not at ceiling, nor is the prospective memory task particularly easy (as determined empirically by levels of performance). These findings stimulate another explanation for varied age effects in event-based prospective memory, an explanation based on the multiprocess theory and findings presented in Chapter 4.

The multiprocess theory and age differences. Recall that according to the multiprocess theory, prospective memory retrieval can be accomplished by resource-demanding self-initiated processes (for example, monitoring) or by relatively spontaneous retrieval processes that demand few resources. According to this view, age differences are expected in performance of event-based tasks in which resource-demanding self-initiated processes are engaged. Age differences are not expected when spontaneous retrieval is prominent in supporting prospective remembering.

Certainly there are a number of factors that influence whether event-based prospective memory will require self-initiated processes (monitoring) versus more spontaneous or reflexive retrieval processes. Characteristics of the target event itself are undoubtedly important. For instance, as the target event becomes more frequent, retrieval may become more reflexive. In line with this idea, Vogels, Dekker, Brouwer, and de Jong (2002) reported no age differences in an experiment with frequently occurring target events, but they did report age differences in an experiment in which the target event was infrequent. Another apparently important characteristic of target events is the number of them. For instance, as noted above, Einstein et al. (1992) found no age differences despite relatively low prospective memory performance (53% to 61%); in these conditions, the intended action was to be performed upon the occurrence of one particular target word. In the other conditions, the intended action was to be performed upon the occurrence of any one of four words, and here substantial age differences appeared.

A more stringent evaluation of the fruitfulness of the multiprocess explanation is based on its prediction that the relationship of the target event to the ongoing task is a prominent factor in determining age effects in event-based prospective memory (McDaniel & Einstein, 2000). As described in Chapter 4, the target event can be focal to the processing engaged by the ongoing task. That is, the anticipated features of the target event are the very features that are processed because of the ongoing activity. An example of a situation involving a focal cue would be one where you encounter and pause to converse with the friend to whom you intended to give a message (see Table 4.1 for other examples). Here, the friend's physical features, name, and so on are likely activated when you intend to give her a message, and when you encounter her later on, these features are likely activated as part of the encounter. With focal cues, prospective memory retrieval is posited to be spontaneous (Einstein et al., 2005; see also Chapter 4), and thus age differences are not expected.

In contrast, processing of the target event may be nonfocal to the processing required by the ongoing task. In this case, the features of the target event are not activated by the ongoing activity. An example of a nonfocal cue would be a grocery store (at which you intended to buy bread) located a bit off the road when you are traveling in rush hour traffic. With nonfocal target cues, resource-demanding processes such as monitoring are assumed to be required, and for these cues, age differences are expected. Another way to phrase these ideas is within the transfer-appropriate processing terminology from retrospective memory research (for example, Morris, Bransford, & Franks, 1977; Roediger, Weldon, & Challis, 1989). Within this framework, age differences in prospective memory are attenuated as the degree of overlap increases between the type of information processing required by the ongoing task and the processing needed to identify the critical features of the prospective memory target cue (Maylor, Darby, Logie, Della Sala, & Smith, 2002).

To help evaluate the multiprocess explanation, Table 7.4 provides for each experiment a description of the ongoing task, the prospective memory target event, and our determination of whether the target event is focal or nonfocal to the ongoing task. Because cognitive theories are incomplete regarding how items are processed for certain tasks, for a few experiments we were not confident in making a designation. Those experiments are given the designation *Indeterminate.* Consistent with the multiprocess analysis, the magnitude of age-related differences is linked to whether the target event is focal or nonfocal to the ongoing activity. The average age-related difference in prospective remembering was nearly twice as large when cues were nonfocal (23%) as it was when cues were focal (12%)—a statistically significant difference. A similar analysis by Henry et al. (2004) classified the event-based laboratory prospective memory studies into those that seemed to impose higher levels of controlled strategic demand and those that were supported by more spontaneous processes. Henry et al. found that the prospective memory tasks they associated with higher strategic demand showed large age-related decline, whereas the tasks thought to be supported by more spontaneous processes showed minimal age-related decline.

Could it be that focal prospective memory tasks simply produced higher levels of performance than did the nonfocal tasks? If so, the patterns just discussed might still be interpreted within the difficulty explanation presented above. This possibility is ruled out by inspecting the performance dynamics of the focal and nonfocal experiments in Table 7.4. The average prospective memory performances for older adults across focal and nonfocal tasks were nearly identical (65% for focal tasks and 59% for nonfocal tasks). Further, the ranges of performance were virtually the same (36% to 94% for focal tasks and 27% to 98% for nonfocal tasks). In sum, the older adults' performances show a remarkably similar topography of difficulty across experiments with focal and nonfocal cues, yet the age-related differences are reduced when the cues are focal.

In a direct experimental test of the multiprocess view, Rendell, McDaniel, Forbes, and Einstein (in press, Experiment 1) manipulated whether the target event was focal or nonfocal. The ongoing task required subjects to identify the names of a set of famous faces and to write the name of each face on a separate page (which was marked with the appropriate slide number) in a booklet. In the focal-cue condition, younger and older adults were instructed to remember to circle the number of any slide featuring a person with the first name John. In the nonfocal-cue condition, the younger and older adults were instructed to remember to circle the slide number whenever a face wearing glasses appeared. The same faces served as target cues in both conditions. The prospective memory responses are displayed in Figure 7.5, and they mimic the cross-experimental comparisons described above. Age-related differences with the focal "John" cue were slight (though significant) and significantly reduced relative to those with the nonfocal glasses cue.

Resource demands emerge as age-related costs to the ongoing activity. A third explanation for the absence of age-related effects in some event-based prospective memory experiments rests on the observation that older adults might maintain prospective memory by sacrificing performance on the ongoing activity (cf. Smith & Bayen, 2006). In some experiments, older adults perform as well as younger adults on both the prospective memory task (when cues are focal) and the ongoing task, but these patterns may not be conclusive because the ongoing activity was made somewhat easier for the older adults than it was for the younger adults (for example, see Einstein & McDaniel, 1990; Einstein et al., 1995). The rationale for this methodology is that if older adults have declining cognitive resources, these resources would be disproportionately utilized for the ongoing activity, leaving fewer resources for the older adults than for the younger adults for the prospective memory activity. But perhaps the adjustment for the ongoing activity in these experiments more than compensated for older adults' declining resources. Because of these arguments, most existing data do not satisfactorily address this third explanation of the divergent age-related findings.

To more convincingly evaluate this third explanation, McDaniel et al. (in press) measured the baseline performance of the ongoing activity for the younger and older subjects when there were no prospective memory demands. They used a category decision activity that was sensitive to response speed and in which accuracy was high. Of central interest was whether the older adults' response speed would suffer relative to that of the younger adults when the prospective memory task was embedded in the ongoing activity. Performance was examined both when the cue was focal (a particular target word) and when it was nonfocal (a particular syllable contained in the words presented for the category decision). As it turned out, prospective memory performance was equivalent for older adults relative to younger adults in both the focal- and nonfocal-cue conditions. Did older adults sacrifice their speed of performing the ongoing activity to meet the resource demands of the prospective memory task?

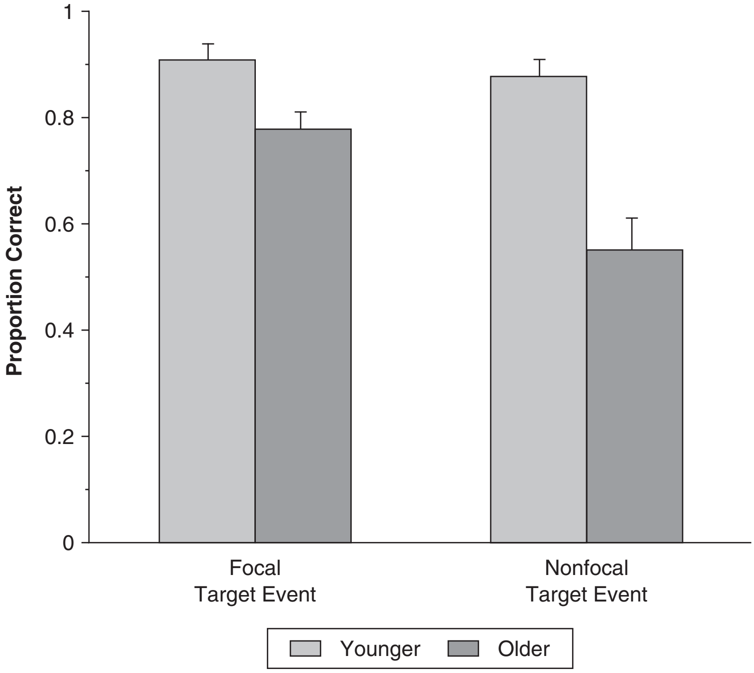

Figure 7.5 Prospective Memory Responses in an Experiment Performed by Rendell, McDaniel, Forbes, and Einstein (in press)

SOURCE: From Rendell, P., McDaniel, M., Forbes, and Einstein (in press). Age-related effects in prospective memory are modulated by ongoing task complexity and relation to target cue. *Aging, Neuropsychology, and Cognition.*

In the focal-cue condition, neither the younger nor the older adults showed significant increases in response times for the category decisions when the prospective memory task was added. On the other hand, in the nonfocal-cue condition, both age groups showed significant slowdowns. Of central importance, the older adults showed more exaggerated slowdown than did the younger adults, suggesting that with nonfocal cues the older adults were disproportionately sacrificing ongoing-task performance to maintain prospective memory at levels equivalent to those achieved by the young adults. Taken in concert, these patterns are entirely in line with the multiprocess analysis. Event-based prospective memory seems to demand minimal resources for retrieval when the target event is focal to the ongoing activity (see also Chapter 4), and accordingly, age-related differences are minimal. In contrast, when the target event is nonfocal, retrieval is relatively resource demanding, and age-related differences emerge either in prospective memory performance or in performance of the ongoing activity, or possibly both.

Although we argue here that the data support the multiprocess theory, you might be troubled by the results summarized earlier in Table 7.4 and the Rendell et al. (in press) finding (see Figure 7.5) that on average there is still at least a modest age difference in the experiments that used a focal cue. If prospective memory retrieval on an event-based task with focal targets is completely the result of spontaneous processes, there should be no age differences. One reasonable explanation of the age differences starts with the view that spontaneous retrieval is a probabilistic process in that when a target item is focally perceived, it will sometimes, but not always, lead to retrieval of the intended action. Therefore, some young-adult subjects may augment this process with a monitoring process, which should improve prospective memory.

A second but not exclusive explanation is that the spontaneous retrieval process may indeed be completely spared in older adults and that the age-related decrement may reflect postretrieval difficulties experienced by older adults. Specifically, because the pacing of the ongoing task is usually fixed and equal for younger and older adults, this task may be functionally more demanding for older adults. Therefore, even though the intended actions may be spontaneously retrieved when the target item is processed, high ongoing-task demands could interfere with selecting and acting upon the intention while it is still active in working memory. Further research is needed to evaluate these possible explanations.

Do It or Lose It: When Responding Is Delayed After Prospective Memory Retrieval

Consider the story that has been circulating on the Internet about the typical day of an older adult:

> This is how it goes: I decide to wash the car; I start toward the garage and notice the mail on the table. OK, I'm going to wash the car. But first, I'm going to go through the mail. I lay the keys down on the desk, discard the junk mail, and I notice the trash can is full. OK, I will just put the bills on the desk and take the trash can out, but since I'm going to be near the mailbox anyway, I'll pay the bills first. Now where is my checkbook? Oops, there's only one check left. My extra checks are in my desk. Oh, there is the Coke that I was drinking. I am going to look for those checks. But first I need to put my Coke further away from the computer—oh, maybe I'll pop it into the fridge to keep it cold for a while. I head toward the kitchen and my flowers catch my eye; they need some water. I set the Coke on the counter and uh-oh! There are my glasses. I was looking for them all morning! I better put them away first. End of day: The car isn't washed, the bills aren't paid, the Coke is sitting on the kitchen counter, the flowers are half watered, and the checkbook still only has one check in it.

This humorous story underscores that immediate performance of an intention is not always carried out in everyday situations, perhaps especially for older adults. Yet standard prospective memory laboratory tasks generally allow performance of the intended action immediately upon cue presentation. In other words, subjects are instructed to press the designated response key as soon as the target item occurs. In contrast, in everyday prospective memory situations, performance of a retrieved intended action is often briefly delayed. For example, upon seeing your neighbor, you remember that you need to give that neighbor a message. But the neighbor is in the middle of a conversation with another person, and politeness dictates that you delay delivering the message until there is a pause in the conversation. Or, when you are in your bedroom you retrieve the intention to take your medication, but you must delay taking the medication until you walk to the kitchen to get the medicine bottle.

How does age affect performance in these delayed-execute situations? The above vignette captures the idea that as a person ages, he or she may become more distractible or less able to inhibit irrelevant or competing information (Hasher & Zacks, 1988). Also, there is theoretical and empirical work suggesting that keeping current concerns activated is a core function of working memory (Engle, Tuholski, Laughlin, & Conway, 1999), and working-memory resources have been shown to decline with age (Park et al., 2002; Salthouse, 1991). All of these considerations suggest that brief delays may be very problematic for older adults. On the other hand, the delays are often very brief, a matter of seconds, and such brief delays may not be very challenging for younger or older adults. How do older adults fare when the execution of a retrieved intended action must be briefly delayed?

To answer this question, Einstein, McDaniel, Manzi, Cochran, and Baker (2000) developed a delayed-execute laboratory paradigm that is schematized in Figure 7.6. Subjects read a series of short, three-sentence paragraphs. Following each paragraph were a series of tasks. First, several synonym items were presented, followed by several trivia questions. After the trivia questions, a comprehension question about the paragraph just read was presented. For the prospective memory task, subjects were instructed to press a designated key (the F1 key) whenever they encountered a particular target word in the paragraphs. The target word was always presented in capital letters so that it was a very salient cue. In an immediate-execute condition (in which the action was to be performed immediately upon presentation of the target word), performance was nearly perfect for both young and older adults. Thus, as intended, the salient cue produced virtually perfect retrieval.

The critical conditions were those in which subjects were instructed to delay executing the intended action until they encountered the first trivia question. By manipulation of the number of synonym questions presented, the delay between presentation of the cue and the trivia questions was

- Cover Task: Story Comprehension
  - Read three sentences about an event
  - Perform a synonym task
  - Answer two unrelated trivia questions
  - Answer multiple-choice comprehension question
- Prospective Memory Task
  - Immediate: Whenever you see *TECHNIQUE* or *SYSTEM,* press the F1 key
  - Delayed: Whenever you see *TECHNIQUE* or *SYSTEM,* press the F1 key **but not until you begin answering the trivia questions (delay varies from 5 to 40 seconds)**

Figure 7.6 A Delayed-Execute Laboratory Paradigm

SOURCE: From Einstein, McDaniel, Manzi, Cochran, and Baker (2000).

varied. In a series of experiments, Einstein, McDaniel, and their colleagues (Einstein et al., 2000; McDaniel, Einstein, Stout, & Morgan, 2003) showed that older adults display robust and dramatic declines in performance on this task. With delays as brief as 5 seconds (the time it takes to answer one intervening synonym question), older adults remembered to execute the action less than half the time, a substantial drop relative to their immediate-execute performance levels. Younger adults did not show a substantial decline; even with 15-second delays (answering three synonym questions), their performance was correct more than 80% of the time.

Remarkably, the low level of performance for older adults occurred even when the 5-second delay was not filled with any distracter activity (McDaniel et al., 2003) (see Figure 7.7). Again, this low level of performance for older adults was in sharp contrast to younger adults' performance. Younger adults responded nearly 90% of the time after the 5-second unfilled delay. The implication from these findings is that brief delays preceding the opportunity for execution pose serious problems for older adults, apparently causing more difficulty than initial retrieval of the prospective memory intention (especially for focal target events).

At this point, we do not have a clear understanding of why older adults have problems maintaining intentions for 5 to 30 seconds. One possibility is that older adults are less aware of the fleeting nature of passively stored information (a metamemory problem). Consistent with this possibility, the study performed by McDaniel et al. (2003) showed that older adults who were instructed to rehearse the intended activity over the brief delay improved their prospective memory performance (see Figure 7.7). However, these older adults still did not achieve the performance levels displayed by younger adults who had not been so instructed. Perhaps reduction in working-memory resources with age produces difficulty in maintaining the activation of retrieved

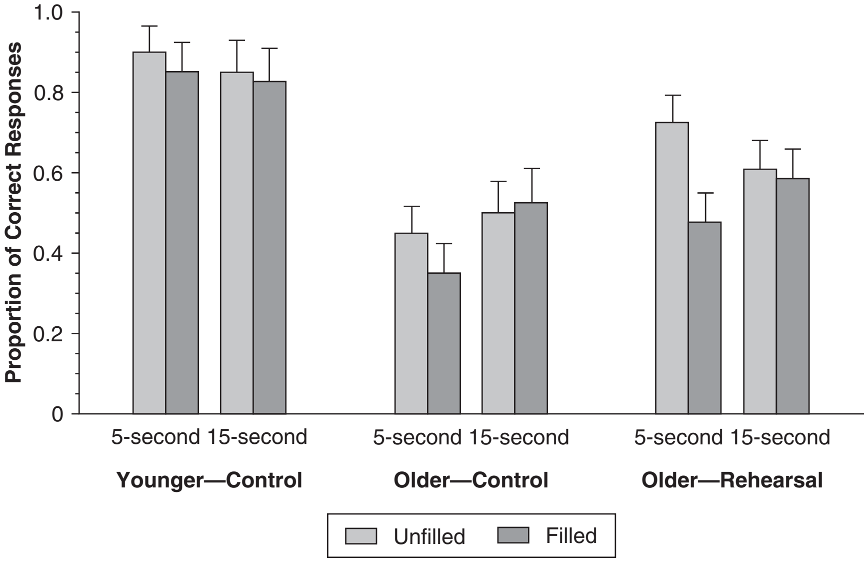

Figure 7.7 Proportion of Correct Responses in an Experiment Performed by McDaniel, Einstein, Stout, and Morgan (2003)

intentions. Compromised working-memory ability could create difficulties in maintaining rehearsal while performing other activities. But this may not be the whole story either, because with unfilled 5-second delays older adults still displayed a dramatic decline in performance relative to younger adults. Perhaps reduced inhibition, even during unfilled delays, allows unrelated thoughts to distract older adults (see Yoon, May, & Hasher, 2005). Still another idea is that in the delayed-execute situations, older adults have difficulty reformulating their plans once the intention cannot be carried out at that moment. For instance, if while in the bathroom a person forms the intention to take his vitamins, but then he is interrupted by a brief phone call that he must answer in the kitchen, he may not be able to reformulate the plan so that once he gets off the phone he will return to the bathroom to take his vitamins. Regardless of the factors responsible for older adults' prospective memory declines, in delayed-execute situations you might advise your grandparent (as well as yourself) to "do it or lose it" upon retrieving an intention.

Habitual Prospective Memory Tasks

A type of task that has received little attention in the experimental literature but seems to be prevalent in daily activity is the habitual prospective memory task. In habitual prospective memory tasks, the intended activity is performed on a regular or systematic basis. Older adults have a number of important habitual prospective memory tasks, perhaps the most prominent being adherence to a medication regimen. On a regular basis, older adults also may have to remember to monitor their physical status (if they are diabetic, for instance) and also remember more mundane tasks such as paying bills. As the task becomes habitual, the possibility of forgetting it may be minimized; however, a new challenge of remembering whether you actually performed the activity on a particular day may become more pronounced. For example, you likely remember that you need to take your multiple vitamin in the morning, but as you leave the house you may be confused about whether you really took it while you were in the bathroom that morning.

One experiment with younger and older adults was conducted using a laboratory paradigm that attempted to approximate a habitual prospective memory situation. In this experiment, participants performed eleven 3-minute tasks. To keep subjects especially busy, there was also a secondary task of detecting odd digits in an ongoing audio stream. The prospective memory action was to press a designated key about 30 seconds into each task (Einstein, McDaniel, Smith, & Shaw, 1998). After each trial (task), to promote more habitual performance of the prospective memory task, subjects were asked whether they had remembered to perform the prospective task. The prospective memory task became more habitual over the course of the experiment, as evidenced by high levels of performance in both younger and older adults after the initial trials. However, as the trials progressed, a new kind of error emerged for older adults. As the prospective memory task became more habitual, older adults demonstrated increasing repetition errors, whereas younger adults demonstrated very low levels of repetition errors (see Figure 7.8). That is, older adults could not remember whether or not they had performed the activity, and consequently often repeated the activity.

It should be noted that older adults' repetition errors were substantially reduced in a condition in which the secondary digit detection task was not included. From this initial experiment, we can provisionally conclude that under very demanding ongoing activity in which older adults' resources are occupied, output monitoring of habitual prospective memory actions may be compromised (see Marsh, Hicks, Cook, & Mayhorn, in press, for additional evidence on older adults' output monitoring in prospective memory). For tasks such as medication taking, it can be critical to avoid repetition (overmedication) or omission (undermedication). Using external cues (for example, pillboxes) to monitor daily execution of these tasks seems to be a prudent step.

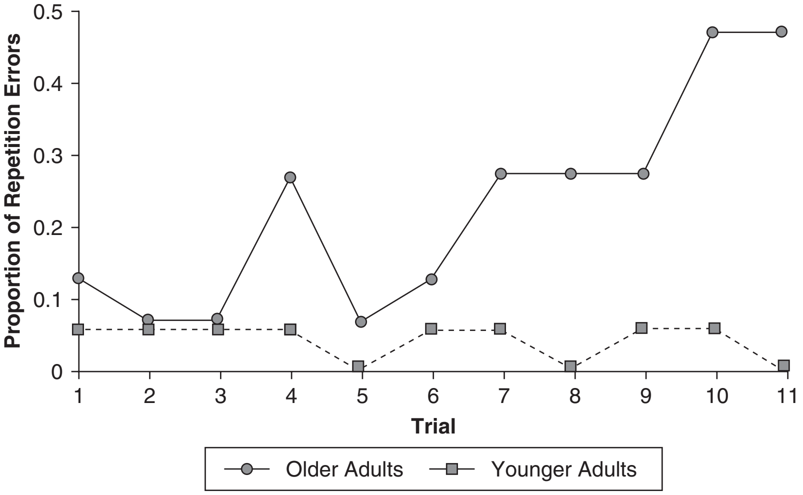

Figure 7.8 Repetition Errors in Prospective Memory Performance When Subjects' Attention to the Ongoing Task Was Divided in an Experiment Performed by Einstein, McDaniel, Smith, and Shaw (1998)

Prospective Memory Performance as a Possible Index of Risk for Dementia

Prospective memory's relationship to dementia is of interest for several reasons. First, prospective memory difficulties may be especially worrisome for adults with Alzheimer's disease, and pose a frustrating challenge for their caretakers (see, for example, Camp, Foss, Stevens, & O'Hanlon, 1996). In Chapter 9, we will discuss some practical techniques for improving prospective memory (see also Chapter 5). Second, prospective memory may be especially sensitive to the mildest forms of dementia, and prospective memory performance may even provide an early warning signal of the onset of Alzheimer's disease in older adults. It is with this second tantalizing possibility that we conclude this chapter.

A variant (allele) of the apolipoprotein E (apo E) gene is associated with Alzheimer's dementia (AD). The presence of just one e4 allele of the apo E gene confers an estimated fourfold risk of developing AD, as well as a risk of developing it at an earlier age (see Small, Rosnick, Fratiglioni, & Bäckman, 2004). One issue of interest in recent years is the extent to which exaggerated memory decline might be evidenced in older apo E e4 carriers who as yet do not display AD. Existing work on memory impairment in nondemented apo E e4 carriers has found mixed results, with general trends suggesting limited e4-related impairments in episodic memory performance (small effect sizes) on standard episodic memory tasks like recall and recognition (Small et al., 2004). Would the pattern change if prospective memory performance were assessed?

Driscoll, McDaniel, and Guynn (2005) tested older adults, some of whom were apo E e4 carriers and some of whom were not, on a standard laboratory event-based prospective memory task. The ongoing task was to rate characteristics of words on one of four dimensions (concreteness, pleasantness, meaningfulness, and vividness). The prospective memory task was to remember to write down a specified word if a particular target word appeared. To minimize retrospective memory demands so that possible retrospective memory impairments would not cloud interpretation of the results, in the critical conditions the response word was highly associated with the target word. For instance, the intended responses for the targets *SPAGHETTI* and *STEEPLE* were *sauce* and *church,* respectively. Postexperimental testing verified that 100% of the e4 carriers (as well as the noncarriers) remembered the intended response for the target word.

Like the normally aging adults in the experiments reviewed earlier in this chapter, the noncarriers displayed good prospective memory performance, correctly responding on 85% of the three trials. In sharp contrast, the apo E e4 carriers remembered to respond on only 25% of the trials. Further, 70% of the carriers failed to respond on any of the prospective memory trials, whereas just 12% of the noncarriers failed to respond on any of the trials.

Were the carriers already in the early stages of Alzheimer's disease? If so, the prospective memory decline was the only behavioral marker that Driscoll et al. (2005) observed that showed a significant difference between the two groups of older adults. The groups did not significantly differ in performance on various cognitive tests that can show decline with AD: the modified mini-mental state exam, recall, Color Trails A and B, and clock drawing. The provocative possibility is that a simple laboratory prospective memory task could become an important diagnostic marker for early detection of AD.

Research by Duchek, Balota, and Cortese (2006) converges with this interpretation. They found a precipitous decline in performance on an event-based prospective memory task (different from the one used by Driscoll et al. [2005]) in older adults diagnosed with early-stage AD relative to normally aging older adults. Moreover, prospective memory performance explained a significant amount of variance in categorizing older adults as either nondiseased or affected by AD, and was a single potent predictor of the disease. Thus, prospective memory could be a unique and valuable cognitive marker fostering earlier detection and treatment of pathological cognitive decline in older adults. Certainly, the results obtained in Driscoll et al.'s and Duchek et al.'s (2006) experiments suggest exciting directions for future research.

Summary and Observations

Some of the earliest theoretical work in prospective memory suggested robust age-related decline in prospective memory based on the assumption that prospective memory retrieval depends heavily on self-initiated retrieval (Craik, 1986). A relatively active research literature on this topic has emerged since the appearance of this important theoretical assertion. Surprisingly, the empirical results are mixed, fueling much debate concerning the inevitability of age-related decline in prospective memory. Some of the mixed findings seem understandable if one notes that prospective memory tasks can vary in their demands. At least in the laboratory, time-based prospective memory tasks appear to rely heavily on self-initiated processes (see Hicks, Marsh, & Cook, 2005, for a different view). Here there are consistent age-related declines. In contrast, some event-based prospective memory tasks appear to support relatively spontaneous retrieval, and age-related differences do not necessarily emerge under these conditions. Much exciting theoretical debate is emerging as researchers attempt to explain these results.

Given the laboratory findings, perhaps more puzzling is the absence or even reversal of age-related deficits in prospective memory in semi-naturalistic studies. Even when experiments are designed to produce close parallels between laboratory and natural settings, the age-related declines found in the laboratory setting are eliminated in natural settings (Rendell & Craik, 2000). We anticipate that richer and more nuanced conceptual frameworks will develop as researchers continue to pursue understanding of prospective memory and aging.

The concerted interest in prospective memory and aging has stimulated consideration of age-related effects on prospective memory processes in addition to retrieval of the intention. New laboratory paradigms have been developed to assess performance of a retrieved intended action when its execution must be very briefly delayed. Age-related declines appear to be substantial when a retrieved intention must be briefly maintained before execution (McDaniel et al., 2003). Additional issues come to the fore in habitual prospective memory tasks, tasks that are centrally important to older adults (for example, medication taking). Habitual prospective memory introduces demands for accurate output monitoring. In the laboratory, under distracting conditions, older adults appear to misremember having performed a habitual task and therefore may repeat the activity (Einstein, Smith, McDaniel, & Shaw, 1997). These initial findings suggest that investigation of older adults' prospective memory in everyday contexts might fruitfully address situations that require delayed execution of retrieved intentions and output monitoring for habitual prospective memory tasks. An experience one of our colleagues had with his older relative illustrates the potentially powerful influence of output monitoring illusions on prospective memory behaviors. The relative strongly claimed she had taken her daily medication even when she was shown the pill remaining in the pillbox. Thus, though external memory aids are available to facilitate adherence to a medication regimen, age-related changes in memory processes may not be entirely neutralized. Also, preliminary work hints that prospective memory declines could serve to signal aspects of pathological aging. Many of these themes are sure to receive increased attention in the next generation of prospective memory and aging work.

We close with two general thoughts. First, as should be clear from the research described in this chapter, the question of whether age (at either the younger or the older end of the spectrum) affects prospective memory is too simplistic. Given that different processes are likely to be more or less important in the wide variety of prospective memory tasks, we believe it is more fruitful to uncover those processes that are and that are not affected by age and then to understand those prospective memory situations that are and that are not especially difficult for very young and older individuals.

Second, we believe it is important to come to grips with the methodological difficulty of studying developmental changes in prospective memory. Given that variables such as the perceived importance of the prospective memory task have been shown to affect prospective memory, it is important to equate these over age groups. What is seen as an interesting and important task for a 5-year-old may not be so for a 7-year-old. Also, in the aging literature, researchers tend to use a fixed presentation rate. Given the well-documented cognitive slowing that occurs with age (see, for example, Salthouse, 1991), the ongoing task may be functionally more demanding for older adults (see Einstein et al., 1997, for a discussion of this issue). In light of these concerns, we recommend getting as much information as possible from subjects about their views of the prospective memory task (for example, the perceived importance of the task). We also recommend that researchers use a self-paced procedure for the ongoing task and measure the speed of performing the ongoing task both with and without the presence of a prospective memory task. This will enable younger and older subjects to proceed at their own pace, and allow the researchers to determine the extent to which either group is trading performance on the ongoing task for higher prospective memory performance (or vice versa). Of course, other factors merit consideration as well, such as the time of day that is optimal for older versus younger adults.