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Prospective and Retrospective Memory in Adulthood

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Prospective memory (ProM) is a distinctive aspect of memory that forms the logical, natural complement of retrospective memory (RetM). ProM is required for carrying out planned activities, such as removing the pot before it boils over, getting groceries en route from work to home, and taking medication nightly at bedtime. However, despite the fact that it is intimately involved in many everyday activities and the fact that its breakdown seems as debilitating as impairments in RetM, ProM has received little attention by mainstream memory researchers, and the topic is frequently not even mentioned in introductory cognitive-psychology texts. We believe that this neglect of ProM has several causes, prominent among them are the absence in the literature of clear definitions of memory's prospective function and the lack of convincing empirical support for the claim that ProM is a distinct form of memory.

With the overall goal to increase the visibility of ProM, we begin this chapter by identifying and defining the uniquely prospective function of memory. This function appears to encompass a domain as wide as that of RetM. Therefore, we argue, ProM research should proceed with a divide-and-conquer strategy similar to that used for RetM research, that is, by identifying distinct subdomains (like episodic and semantic memory) and by pursuing research questions and theoretical accounts that focus on them. For the reasons that made it useful and even necessary to adopt clear subdomain labels and definitions for RetM, we believe that it will be equally useful and necessary in the future for ProM researchers to identify precisely which subdomain is targeted by each investigation.

In this chapter we focus on that subdomain of ProM that seems most directly analogous to James's (1890) memory proper, today more generally known as explicit episodic memory. We will identify this subdomain of ProM, herein called ProM proper (see Graf & Uttl, 2001), specify exactly how it differs from explicit episodic RetM, and show how it can be operationalized and measured. In addition, we use this chapter to introduce a new methodology for measuring ProM proper. A major advantage of this new methodology is that it yields a continuous index of performance, in contrast to existing methods that produce primarily success/failure data. We report new research that employed this methodology to demonstrate that various experimental manipulations and subject variables have different effects on ProM proper and on explicit episodic RetM performance. The finding of such performance dissociations supports the claim that ProM proper is a distinct form of memory.

A final objective of this chapter is to report new research on the hypothesis that ProM task performance is more sensitive to age-related changes than RetM task performance. This hypothesis builds, first, on the widespread assumption that aging is associated with a decline in the attention resources required for performing a wide range of cognitive tasks (Hasher & Zacks, 1979; Salthouse, 1980, 1985) and, second, on the notion that performance of ProM tasks is more dependent on attention resources than performance on RetM tasks (Craik, 1986). According to Craik, performance on all memory tests is determined by a combination of processes that are either driven or guided by the environment or initiated and controlled by the subject. He proposed that subject-initiated processing is more resource-demanding than environmentally guided processing, and because ProM tests provide less environmental cues for supporting performance than other memory tests, age-related performance differences are larger on ProM than RetM tests.

Memory's Prospective Function

ProM has been described in many ways, including as intention memory (Goschke & Kuhl, 1996; Kvavilashvili & Ellis, 1996; Loftus, 1971), memory for future actions (Einstein & McDaniel, 1996; Mäntylä, 1996), and remembering that something has to be done (Dobbs & Rule, 1987; Maylor, 1996b). As in these examples, the prospective function of memory is defined by the to-be-remembered content. But a content-based definition is difficult to sustain because it raises obvious questions, such as these: How is memory for plans and intentions different from memory for anything else (i.e., memory for words, memory for music, memory for emotions)? Does a content-specific domain of episodic memory require a name of its own? In separate commentaries that appeared in the first book entirely devoted to ProM (Brandimonte, Einstein & McDaniel, 1996), Crowder (1996) and Roediger (1996) answered the latter question with an emphatic no, and we agree with this position.

To ferret out memory's uniquely prospective function, we examined the word "prospective," what it means to be a prospector, and the unique operational requirements of prospective memory tasks.

Prospectors are specialists, trained to see beyond the obvious (i.e., they see not just what is, but also what could be), their core task is to examine the environment for telltale signs of mineral deposits. Typically, the job of unearthing or recovering such deposits is left to the next set of specialists, miners. By analogy, we regard RetM, like the miner, as being concerned with specialized recovery operations, whereas unique to ProM is the capacity to see beyond the obvious, to recognize telltale signs (see Craik, 1986; Ellis, 1996; Einstein & McDaniel, 1990, 1996). Concretely, if the plan is to buy groceries en route home from work, ProM is required for recognizing the supermarket as relevant to this plan, even when attention is focused elsewhere (e.g., on driving or talking on the phone). If the plan is recollected in the presence of an appropriate cue, RetM is engaged to recollect the items on the grocery list (i.e., for recovery operations). On this understanding, the cues given for a memory test function like the telltale signs sought out by prospectors.[1] RetM begins with cues, with recognized telltale signs, and it uses these as guides for recovering prior episodes, events, and experiences (i.e., hidden knowledge deposits). By contrast, the prospective function of memory is required for situations where telltale signs have to be recognized before recovery operations can be initiated.

These characterizations of ProM and RetM tasks lend themselves to a task analysis. Any memory task may be defined as a request or a comparable situation (defined by the experimenter, the subject, ongoing activities, or the environment) that occurs in a particular context and that calls for, elicits, or recruits a particular type of responding. Consistent with this definition, any memory task is objectively describable in terms of cues, instructions, a context (e.g., spatial, emotional), and a response type (see Graf & Birt, 1996). Under some circumstances, a difference in a single property is sufficient for distinguishing between two types of memory tasks. In many previous investigations of implicit and explicit memory, for example, the memory tests differed only in terms of the instructions given to subjects. That is, both tests used the exact same cues, required the same response type, and were given in the same context (e.g., Graf & Mandler, 1984; Schacter & Graf, 1986). Similarly, we can conceive of ProM and RetM tasks that make use of the same cues and context. The context might be a laboratory room, and a cue for remembering might be the experimenter's giving the subject a printed form showing the initial letters of previously studied words. When cues and context are held constant in this manner, this serves to isolate the crucial differences between ProM and RetM tasks, in this case, the exact instructions given to subjects. For the RetM task, the instructions, delivered together with the test form, might direct subjects to write previously studied words on the test form. For the ProM task, the instructions, which would have been given earlier in the experiment, might be "After you receive the recall form later on, please request a red pen from me and use it to write your name on the test form."

Table 1 summarizes the core similarities and differences between ProM and two familiar RetM tasks—implicit and explicit. We make the assumption that the cues, the context, and the response type are held constant. If so, what differs between the tasks is, first, whether at the time of testing subjects are alerted to the cues and directed to work with them in a target/task-relevant manner, and second, whether subjects are specifically instructed to use the cues in a manner that is relevant to the prior study or planning phase. For all RetM tasks, subjects are aware of or are made aware of the cues at the time of testing, and they are given specific instructions on how to work with them. As the table shows, the critical difference between explicit and implicit tests is that for the former, subjects are specifically instructed to use the cues in a study/trial-relevant manner. That is, they are instructed to use the cues as aids for recollecting previously studied words. For implicit memory tests, subjects also are instructed on how to use the cues (e.g., subjects may be told to complete

Table 1
Properties of tests for explicit retrospective, implicit retrospective, and prospective memory

Type of memory test	Cues provided on test	At test, Ss are alerted to cues and instructed to work with them in a task-relevant manner	At test, Ss are alerted to the study/planning-phase relevance of cues
Retrospective			
Explicit	Yes	Yes	Yes
Implicit	Yes	Yes	No
Prospective	Yes	No	No

the cues with any words that come to mind), but the instructions do not draw attention to specific prior learning events and experiences (Graf & Schacter, 1985). By contrast, for ProM tasks, subjects may or may not be aware of the cues (the cues may be central or incidental to an ongoing task); what is critical is that at the time of testing, subjects are not instructed to work with the cues in a ProM-task-relevant manner. When driving by the supermarket, nothing alerts us to pay attention to this cue, and no one instructs us that this cue is relevant to a previously formed plan (e.g., to get the groceries en route from work to home). Instead, in ProM tasks the cues appear as a natural part of other tasks or situations; they are embedded in other ongoing activities. *What is unique about ProM tasks is that they require identifying or recognizing cues as telltale signs of previously formed plans and intentions when the cues occur as part of ongoing thoughts, actions, or situations* (Craik, 1986; Einstein & McDaniel, 1996; Graf & Uttl, 2001; Kidder, Park, Hertzog & Morrell, 1997; Kvavilashvili, 1987; Maylor, 1993; Mäntylä, 1996; Park & Kidder, 1996).

The uniquely prospective function of memory must not be confused with what is indexed by performance on commonly used ProM tasks, such as time-based versus event-based tasks (Einstein & McDaniel, 1990; Harris, 1983), or habitual versus episodic tasks (Einstein, McDaniel, Smith & Shaw, 1998). Performance on such tasks is not a "process pure" barometer of recognizing cues as telltale signs. This is highlighted by what can happen when the task is, for example, to get groceries en route from work to home. We can fail this task either because we did not recollect the intention (to get groceries) when driving by the supermarket or because we did not remember the items on the grocery list. It is widely acknowledged that only the first of these components—recollecting the intention—is clearly prospective (Dobbs & Rule, 1987; Einstein & McDaniel, 1996; Graf & Uttl, 2001); the latter seems part of retrospective memory and is not different from recollecting (or failing to recollect) a list of words upon request.

We have developed a new methodology that yields a separate index of each of these components. This methodology is described later in this chapter, together with new investigations of the relation between performance on ProM and explicit episodic RetM tasks.

Subdomains of ProM

An intuitive analysis reveals that different ProM activities are associated with different conscious experiences. For example, waiting for the pot to boil is a short-term task; it is likely to be kept active in working memory and to dominate conscious awareness. By contrast, if we plan in the morning to get groceries en route from work later in the day, this involves a different type of conscious experience. This plan is not likely to remain active and dominant in working memory; it is out of conscious awareness for most of the retention interval (i.e., the period between making the plan and executing it). Instead, the retention interval is filled with other activities, the ProM-task-relevant cue (e.g., the supermarket) appears incidentally as a natural part of these other activities (e.g., driving home from work), and what is of interest is whether the cue succeeds in bringing the previously formed plan back into conscious awareness (Einstein & McDaniel, 1996; Graf & Uttl, 2001; Kvavilashvili, 1998; Mäntylä, 1996; Meier & Graf, 2000).

The different conscious experiences associated with these different prospective activities seem analogous to the experiences that characterize performance on primary- and secondary-memory tasks, and thus it seems reasonable to proceed in the spirit of William James's work. James stipulated that "memory proper" requires "the knowledge of an event, or fact, of which meanwhile we have not been thinking, with the additional consciousness that we have thought or experienced it before" (1890, p. 684). By analogy, we propose to define *ProM proper as requiring that we are aware of a plan, of which meanwhile we have not been thinking, with the additional consciousness that we remember making the plan earlier.* By this definition, ProM proper does not encompass the prospective equivalent of primary memory, that is, when a plan or intention remains active in working memory throughout the retention interval. The latter situation is more typical of vigilance or monitoring tasks, and thus such labels seem more appropriate for the ProM equivalent of primary memory (cf. Baddeley & Wilkins, 1984; Craik & Kerr, 1996; Einstein & McDaniel, 1996; Meacham & Leiman, 1982).[2]

We regard vigilance and ProM proper as part of a continuum of possible prospective-memory activities. At one end of this continuum, the prospective task dominates working memory and conscious awareness during the retention interval. At the other end, the ProM-proper end, the plan is out of working memory during the retention interval and conscious awareness is focused on competing activities. We hypothesize that what varies along the continuum is the proportion of available processing resources allocated to the prospective task during the retention interval. For vigilance, all or most of the available resources are allocated to the prospective task, whereas for ProM proper, all or most of the available resources are allocated to competing activities. Other tasks, such as waiting for the arrival of a limousine or for the cupcakes to finish baking may fall between these extremes (see Ceci & Bronfenbrenner, 1985; Dobbs & Reeves, 1996; Harris & Wilkins, 1982). Such tasks may recruit a more equal allocation of resources to prospective and other activities.

The domain of ProM proper seems further circumscribed by the distinction between episodic and habitual tasks (Harris, 1983; Meacham, 1982), which appears analogous to the distinction between episodic and semantic memory tasks. Buying groceries en route from work is an episodic task, like an episodic-memory task, in the sense that the plan arose out of a single event and is to be executed only once. By contrast, taking medication and brushing one's teeth at bedtime are habitual tasks; they are similar to semantic-memory activities that have been shaped by many previous repetitions. Episodic and habitual tasks are radically different from each other: they arise out of different needs, they are associated with different conscious experiences, and they are marked by different histories (i.e., number of occasions for thinking about and practicing them). For these reasons, by analogy with Tulving's (1972) distinction between episodic and semantic memory, we use the label ProM proper only in reference to episodic or one-off tasks.

Our focus in this chapter is on ProM proper, specifically, on responding to cues as telltale signs of previously formed intentions. ProM proper seems to be the direct complement of explicit episodic RetM. For this reason, an investigation of ProM proper is most relevant to theoretical assumptions about age-related changes in prospective and retrospective memory (see Craik, 1986).

Assessing ProM Proper

ProM researchers have exercised considerable ingenuity in developing tasks for assessing various aspects of prospective memory (e.g., Einstein & McDaniel, 1990, 1996; Harris, 1983; Harris & Wilkins, 1982; Kvavilashvili & Ellis, 1996), but none of them have been designed specifically to focus on ProM proper. Our goal was to develop such a task. Furthermore, we wanted this task to be more sensitive to gradations in performance than the success/failure scores provided by existing tasks.

Our starting point for developing a new task was an investigation by Dobbs and Rule (1987). Their subjects were required to complete a questionnaire at home, and the ProM task was to write the time and date in the upper right corner of the form. Dobbs and Rule scored performance in two ways. By a strict criterion, both the time and the date had to be written in the correct location, and by a lenient criterion, performance was counted as successful if either the time or the date were in the correct location. According to Dobbs and Rule, the "lenient criterion provides some measure (albeit not perfect) of remembering to do something while placing minimum requirements on remembering the content of the task" (1987, p. 216). Dobbs and Rule found that the strict scores showed only a marginal influence due to age, but the lenient scores showed a significant, substantial age-related performance decline.

To our knowledge, Dobbs and Rule's (1987) study was the first investigation that attempted to estimate ProM proper in this manner, and by their own words, their lenient scores are far from being a perfect measure. Nevertheless, their approach underscores that ProM proper leaves a distinct signature on responding, and the methodological challenge is to magnify this signature and assess it independently of the RetM component. Toward this objective, we conducted an investigation that involved a series of attention, perception, and memory tasks (Uttl, Graf, Miller & Tuokko, 2001). The participants were 133 community-dwelling healthy adults between 65 and 95 years of age. To assess ProM proper, for one task, the Name task, subjects were told "In the course of the experiment, when I [the experimenter] say, 'This is the end of this task. I would like you to ask for a pen and a piece of paper, and then I would like you to write your name on the paper'." Following these instructions, subjects performed various activities, at the end of one of which the experimenter said, "This is the end of this task." In order to indicate that they recognized this cue as a telltale sign, subjects responded to it with comments like, "We need to stop here for another task," "Oh, there is something I have to do now," by explaining that they had to ask for something, or by asking for the pen and/or the paper. By this method, we elicited responses to the cue that are indicative of ProM proper. By contrast, explicit-episodic-RetM performance was indexed by whether or not subjects asked for the objects (e.g., the pen and piece of paper) and by whether or not they carried out the assigned task (i.e., write their name on the paper).

A subset of the results from our investigation appears in table 2. The top of the table shows the mean ProM proper scores for the name task, the ProM task described in the preceding paragraph. The means show a significant age-related decline in performance. The means for explicit episodic RetM on this task are not shown, because performance was at the ceiling, which indicates that most participants who remembered that they needed to perform a task were successful in remembering what objects they had to request (i.e., a pen and a piece of paper) and

Table 2
Mean levels of performance on one test of ProM proper and on two tests of explicit episodic RetM

Memory task	Subject age groups (in years) 65–69	70–74	75–79	80–95
Name[a]				
M	0.84	0.76	0.45	0.43
SD	0.37	0.43	0.50	0.51
Buschke 1–3[b]				
M	10.02	9.34	9.33	8.78
SD	1.00	1.21	1.46	1.37
RAVLT A1–5[c]				
M	9.82	9.19	8.99	8.46
SD	1.46	1.84	2.66	2.04

a. A test for assessing ProM proper: the ability to recognize cues as telltale signs of previously formed plans.
b. Buschke Selective Reminding Test (see Spreen & Strauss, 1991); average recall for trials 1 to 3.
c. Rey Auditory Verbal Learning Test (see Spreen & Strauss, 1991); average recall for trials 1 to 5 on List A.

what they had to do with these objects (i.e., write their name on the paper).

Table 2 includes the mean scores from two commonly used standardized tests of explicit episodic RetM that were included in our test battery: the Buschke Selective Reminding Test (BSRT) and the Rey Auditory Verbal Learning Test (RAVLT). Both of these tests were administered according to published instructions (Spreen & Strauss, 1991). The BSRT measures free recall of 12 unrelated concrete words across three trials, and one part of the RAVLT tracks learning of 15 unrelated words across five trials. Shown in table 2 are the performance levels achieved on the BSRT and on the RAVLT. Both sets of means show a noticeable age-related decline in performance.

Our investigation was intended to explore the relationship between age-related performance declines in ProM proper and explicit episodic RetM. In contrast to the expectation derived from Craik's (1986) view that aging has a more profound effect on ProM proper than on explicit episodic RetM, the means in table 2 point to declines of similar magnitudes (i.e., about 1 SD). Nevertheless, it appears that these declines are mediated by different mechanisms, as suggested by the outcomes of follow-up correlation analyses. The results showed a moderately strong correlation of $r = .70$ between performance on the two RetM tests, whereas the correlations between performance on these tests and performance on the name test (our index of ProM proper) were substantially smaller ($r = .18$ and .24 with the BSRT and the RAVLT, respectively).

The investigation by Uttl et al. (2001) convinced us that it is possible to assess ProM proper directly, reliably, and independently of explicit episodic RetM. The limits of this method became equally obvious, however, by our explorations of the correlations among tasks. Like all existing tasks, the method used by Uttl et al. provides only a success/failure index of ProM proper. This type of index is not sensitive to subtle influences on performance and is ill suited, for example, for systematic investigations of the factors (e.g., speed of processing) that mediate age-related declines in memory performance. For these reasons, we embarked on the development a new method that provides a continuous index of ProM proper.

The inspiration for the new method was the claim made earlier in this chapter, that the distinguishing feature of the prospective functions of memory is the requirement to identify cues as telltale signs when these occur as a natural part of other thoughts, actions, or situations. From this claim, it follows that to execute a previously formed plan, a first step is to stop or pause the ongoing activity, and so the action of stopping or pausing in response to a cue provides an index of ProM proper (Dobbs & Rule, 1987; Einstein & McDaniel, 1996; Graf & Uttl, 2001). This index would be a continuous variable if a cue were presented for an extended period of time, and if we tracked the time required to identify it as a telltale sign. A similar dependent variable would result if the same cue were presented repeatedly and if we counted the number of presentations required to identify it as a telltale sign. Stopping in response to a cue seems independent of the retrospective component of the task: it does not guarantee that we remember what needs to be done, just as stopping a colleague in the hallway does not guarantee that we remember a message we intended to convey.

For the research reported in the next section of this chapter, we required subjects to respond to a visual cue presented several times, with each successive version larger than the preceding display. The dependent variable was the number of displays, directly correlated with the size of the display, required until subjects recognized it as a sign for executing a previously formed intention, in this case, recalling a list of words memorized earlier in the experiment. The specific objectives of our work were, first, to examine whether or not performance on our new test of ProM proper would dissociate from performance on a standard test of explicit episodic RetM and, second, to investigate whether or not performance on these two test types is affected differently by age-related changes in cognition.

Dissociating ProM Proper from Explicit Episodic RetM

General method

We conducted two experiments with each using the same general method for assessing ProM proper and explicit, episodic RetM. Each experiment required subjects to complete a series of attention, perception, and memory tasks, including two ProM tasks that were designed to be analogous to remembering to get groceries en route home from work. We required subjects to learn a list of common concrete words, like a shopping list, and to recollect this list later in the experiment while they were engaged in an unrelated activity (i.e., an ongoing task like driving home from work). To ensure learning, the word list was presented for two study-test trials, with each trial structured according to the procedure used for the RAVLT. At the time of learning, subjects were instructed that their task was to recall the list later in the experiment whenever they saw the recall cue, which was a picture of a common object (e.g., a helicopter). The specific instructions were, "If at any time during this experiment you see a picture of a helicopter [or one of the other cues], stop whatever you are doing and recall the list you have just learned." These instructions were repeated until subjects were able to report what was required of them. Subjects were reminded that the instructions would not be repeated, that it was their responsibility to recall the list at the appropriate time.

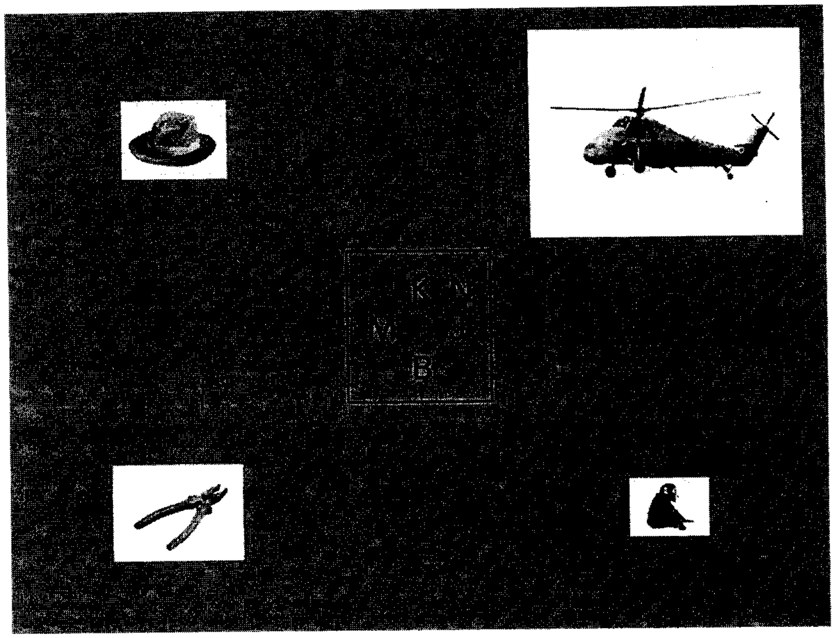

Figure 1
An example of the materials displayed for the card-sorting task and for assessing prospective memory.

ProM was tested later in the experiment, while subjects were engaged in a simple decision-making task. This task was modeled on Rabbitt's (1965) card-sorting task. We prepared two sets of 54 computer displays, each of which looked like a 7 × 7 cm playing card (see figure 1 for an example). Each card was divided into nine equal squares. For half of the cards in each set, one square had printed on it the target letter A, and the other cards had printed on them the target letter B. The target letters A and B were in capitals, printed in 28-point Helvetica font. Across the cards, they occupied each of the nine possible squares equally often. For one third of the cards from each set, the remaining squares were left blank. For another third of the cards, a random four additional squares were occupied by irrelevant or filler letters that were selected randomly and without replacement from the rest of the alphabet. And for the remaining cards, all eight additional squares were occupied with other letters from the alphabet. All letters from the alphabet (other than A and B) were used about equally often as fillers; they were assigned randomly to each square and were printed in the same manner as the targets. The 54 cards from each set were displayed randomly, one at a time, and subjects were required to sort them into two groups by separating cards marked with A from cards marked with B. The specific instructions were, "Press the left-arrow key if there is an A on the card, and press the right-arrow key if there is a B on the card." The critical dependent variable was the time required to sort each card, as well as the number of errors made in sorting the cards under each condition (i.e., cards with 0, 4, and 8 irrelevant letters).

The decision-making task had three blocks, each with 108 (i.e., 2 sets of 54) trials. For block 1, subjects were presented with cards, and they made AB decisions as described in the preceding paragraph. For block 2, each card was displayed together with four distracting pictures, arranged as shown in figure 1. The pictures were color photos of 128 common objects. Each display included 4 different objects, selected randomly from the pool of all available objects. As shown in figure 1, the photo displays differed in size; some were as small as 98 × 72 pixels, whereas others were as large as 336 × 252 pixels. Subjects were instructed to concentrate on making AB decisions and were informed that "this phase of the experiment assesses your ability to keep focused on the decision task despite the pictures." For block 3, the same method for constructing displays was used, except that this time one of the pictures was the ProM cue. This cue was shown for the first time on about the thirtieth trial of block 3, and thereafter on about every fourth trail (the actual number was a random choice between 3, 4, and 5 trials). On its first presentation, the ProM cue measured 98 × 72 pixels (i.e., the smallest picture in figure 1). It grew in width and height on every succeeding display in equal steps until it reached a maximum size of 336 × 252 pixels (i.e., the largest picture in figure 1) after 16 presentations.[3] For each presentation, the ProM cue appeared in a randomly chosen quadrant of the display. Consistent with the instructions given earlier in the test session, upon recognizing the ProM cue, subjects were expected to halt making decisions and to recall the word list learned earlier. The dependent variable for ProM proper was the cue size when it was detected.

Cue type and retention interval influences

The first experiment examined whether or not ProM proper and explicit episodic RetM are affected differently by a manipulation of the ProM cue type and by a manipulation of the length of the retention interval. The subjects were 72 undergraduate students who participated in return for course credit. They completed a battery of attention, perception, and memory tests, including two instances of the decision-making task described in the preceding paragraphs. The latter were separated from each other by at least 15 minutes spent on completing other battery items. The ProM task was to "recollect the list of words you are about to learn if you see a picture of a helicopter [i.e., one of the ProM cues] at any time during the experiment."

For each instance of the ProM task, the participants learned a different list of 18 common words, and ProM was cued either with a color picture or with a black and white picture. This manipulation of cue types was counterbalanced across subjects. For the retention manipulation, the ProM-instruction and list-learning phase occurred either immediately prior to administering block 1 of the card-sorting task or about 10 minutes earlier in the test session. In the latter condition, subjects completed two additional test-battery items after learning the to-be-remembered list and only then proceeded to block 1 of the card-sorting task. By this manipulation, the retention interval from list learning to the first display of the ProM cue averaged about 6 minutes in the immediate condition and about 20 minutes in the delayed condition. For subjects who interrupted the card-sorting task when they detected the ProM cue, they recollected the word list and then continued on with the card-sorting task. For subjects who did not notice the cue, they were asked to recall the word list immediately after completing the card-sorting task.

The critical findings for RetM and ProM test performance are shown respectively in figures 2 and 3. Figure 2 shows that the ProM cue-type manipulation had no effect on free-recall-test performance ($F(1, 66) = 0.10$, $MSE = 6.45$), and that free recall performance was not affected by the delay manipulation ($F(1, 66) = 0.71$, $MSE = 6.61$). Additional analyses examined recall performance after the first and second list-learning trials; they showed the expected increase from trial 1 ($M = 10.40$, $SD = 1.77$) to trial 2 ($M = 13.06$, $SD = 1.55$): $F(1, 66) = 216.92$, $MSE = 1.10$.

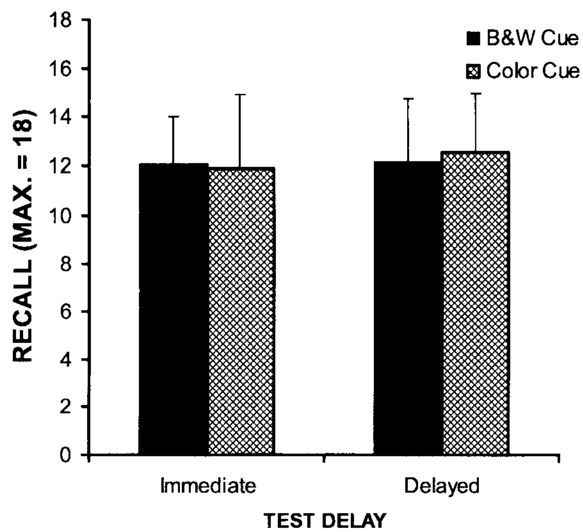

Figure 2
Average free recall of words as a function of ProM cue type and retention interval. (Error bars are standard deviations.)

Recall performance was higher immediately after the second learning trial than when it followed ProM cue detection ($F(1,66) = 25.37$, MSE $= 1.06$). This general pattern of findings is consistent with previous evidence showing a rapid loss of information immediately after learning, followed by relatively stable performance across small differences (6 versus 20 minutes) in retention intervals.

Figure 3 shows ProM test performance. The top panel shows the proportion of participants who detected the ProM cue, and the bottom panel shows the level or size of the cue at the time it was detected. Although they draw attention to different aspects of performance, both panels show the same pattern of effects: a higher level of performance in the immediate condition than in the delayed condition, and when the ProM cue was in color rather than in black and white. The top panel reveals a performance-ceiling effect in the immediate testing condition, and for this reason, we focused statistical analyses on the data in the bottom panel of figure 3. For these analyses, subjects who failed to detect the ProM cue received a score of 18, that is, a value of one higher than

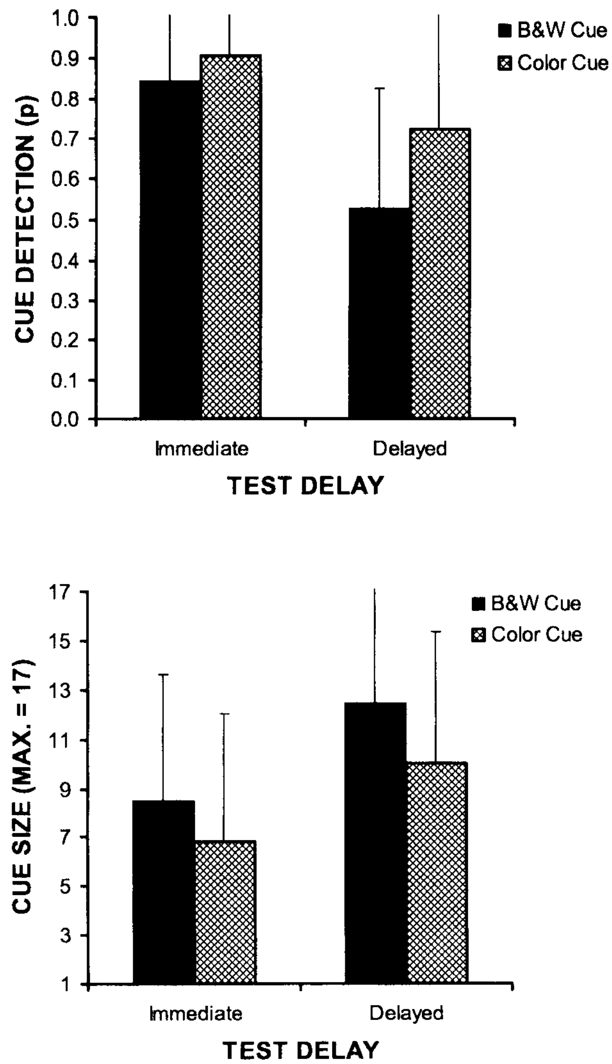

Figure 3
Average ProM test performance as a function of ProM cue type and retention interval. (Bars are standard deviations.) The top panel shows the proportion of participants who detected the ProM cue; the bottom panel shows the size of the ProM cue when it was detected.

the maximum cue size displayed in the experiment. The results showed that participants were able to detect the ProM cue on the basis of a smaller display when it was in color than black and white ($F(1, 66) = 6.58$, MSE $= 21.69$), and when it occurred after a short retention interval rather than after a longer retention interval ($F(1, 66) = 13.97$, MSE $= 31.57$). No other effects were significant.

The combined findings from this experiment are encouraging for theoretical and methodological reasons. The finding that two variables—cue type and retention interval—have different effects on ProM proper and on explicit episodic RetM implies mediation by different perceptual and/or cognitive processes. It is too early to speculate about the nature of these processes, however, until the generality of our findings is more firmly established. We anticipate that future research will show both similarities and differences between ProM proper and explicit episodic RetM. It seems likely, for example, that a longer-retention-interval manipulation would affect both forms of memory in similar ways. Other variables, that are known to influence explicit episodic RetM such as the nature of the to-be-remembered materials (e.g., related versus unrelated lists of words) or the type of learning phase activity (e.g., levels of processing manipulations), may have no effect on ProM proper. Future research will explore these possibilities.

The main goal of our experiment was methodological: concerned with providing evidence that our new method for assessing ProM proper works, that it is able to reveal performance dissociations between ProM proper and explicit episodic RetM. This goal has been achieved.

Age-related changes in ProM proper and in explicit episodic RetM

The main goal of this experiment was to test the hypothesis that ProM is more sensitive to aging than RetM, more specifically, to examine whether age-related changes in cognition have a larger effect on ProM proper than on explicit episodic RetM. We used the same basic method as for the experiment reported above. Each participant was tested in two sessions scheduled at least 24-hours apart. The retention-interval manipulation was not used. Instead, we manipulated the nature of the to-be-remembered materials by requiring subjects to learn a list of 15 unrelated common words for one session, and a list of 15 related common words (3 words each from 5 different categories, such as fruit or furniture) for the other session. The assignment of materials was counterbalanced.

The subjects were 111 community-living older adults who participated in the Victoria Longitudinal Study (VLS). (For a detailed description of this project and of the subjects, see Hultsch, Hertzog, Dixon & Small, 1998.) They were between 67 and 93 years of age, highly educated, and generally in good health. Brief descriptive data on the subjects are provided in table 3. As indicated by the table, the subjects were arranged into two groups, one consisting of young-old adults (67–74) and the other of old-old adults (75–93).

Table 3
Descriptive data on participants

	Age group (years)		Age effects[a]	
	67–74	75–93	r^2	$F(1, 109)$
N	60	51		
Sex				
Men	21	21		
Women	39	30		
Education				
M	14.3	13.9	.007	0.77
SD	3.16	3.14		
ETS vocabulary				
M	43.0	44.5	< .001	0.06
SD	5.47	5.94		
WAIS-R Digit Symbol[b]				
M	43.2	39.5	.092	10.98*
SD	7.34	9.56		
Optimal overall health rating[c]				
M	1.75	1.59	.010	1.04
SD	0.70	0.67		

a. Age effects were computed by regression analysis.
b. WAIS-R Digit Symbol scores (Wechsler, 1981).
c. Participants used a 5-point scale to rate their health relative to "perfect health" (0 = very good to 4 = very poor).
* $p < .05$.

On the RetM test, the materials manipulation had the expected effect. Overall free recall was higher on the related list (M = 10.32, SD = 2.19) than on the unrelated list (M = 7.30, SD = 2.35): $F(1, 108) = 224.29$, MSE = 2.62. The recall-test means also show a higher level of performance for the young-old adults than for the old-old adults ($r^2 = .076$, $F(1, 109) = 8.93$, MSE = 51.24). Additional analyses that examined recall performance after the first and second list-learning trials showed the expected increase from trial 1 (M = 8.08, SD = 2.01) to trial 2 (M = 9.61, SD = 2.27): $F(1, 110) = 146.72$, MSE = 0.89. Recall that performance was higher immediately after the second learning trial than when it followed ProM cue detection (M = 8.64, SD = 2.48): $F(1, 110) = 69.88$, MSE = 0.74.

Figure 4 shows ProM test performance. The top panel shows the proportion of participants who detected the ProM cue, and the bottom panel shows the level or size of the cue at the time it was detected. Although they draw attention to different aspects of performance, both panels show the same pattern of effects: higher performance by the young-old group than the old-old group. There was no influence due to the materials manipulation. These observations were supported by the outcome of statistical analyses, which revealed a significant age effect on the cue detection data in the top panel ($r^2 = .068$, $F(1, 109) = 8.01$, MSE = 1, 12) and on the cue size data in the bottom panel ($r^2 = .078$, $F(1, 109) = 9.28$, MSE = 257.05). No other effects were significant.

We used hierarchical regression analyses to examine more directly the hypothesis that age-related changes in cognition have a larger effect on ProM proper than on explicit episodic RetM. In contrast to this expectation, the results showed comparable effects, revealing significant r^2 values of .078 and .066 for ProM and RetM, respectively.

In a final analysis, we explored the relationship between ProM proper and explicit episodic RetM, as well as the relationship between these and performance on the card-sorting task. Card sorting is a highly resource-demanding task. For this analysis, we used a separate index of sorting cards without distractors (CS-ND) versus sorting cards in the presence of distractors (CS-D). The results are summarized in table 4. The table corroborates the outcome of the regression analysis by showing similar

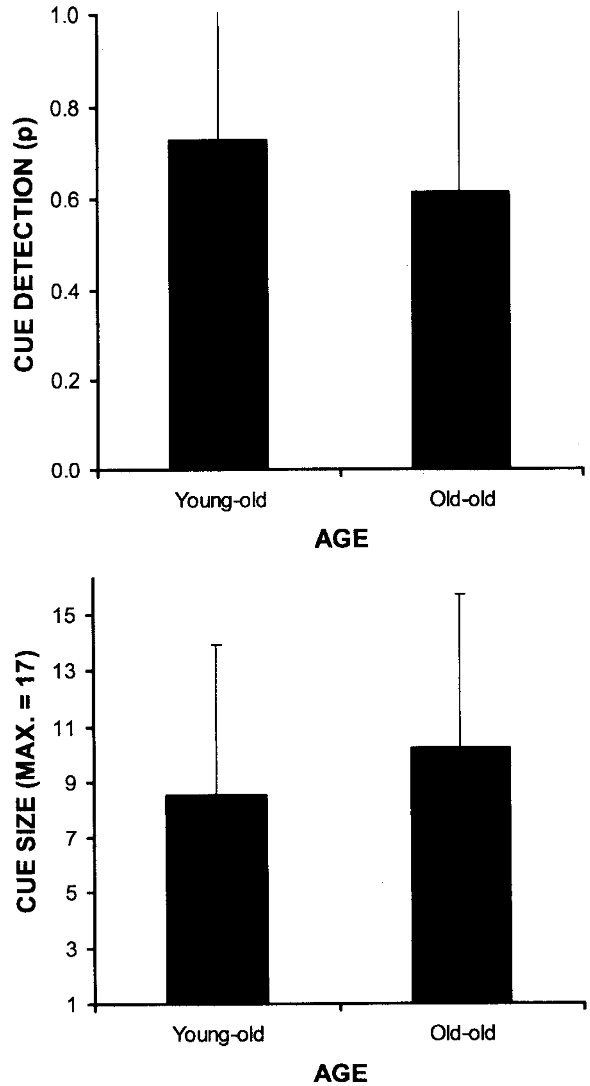

Figure 4
Average ProM test performance as a function of age group. (Bars are standard deviations.) The top panel shows the proportion of participants who detected the ProM cue; the bottom panel shows the size of the ProM cue when it was detected.

Table 4
The pattern of intercorrelations of age, RetM, ProM, and card sorting under different conditions

	Age	RetM	ProM	CS-ND	CS-D
Age		−0.26	0.28	0.35	0.23
RetM	−0.26		−0.21	−0.33	−0.27
ProM	0.28	−0.21		0.32	−0.24
CS-ND	0.35	−0.33	0.32		0.66
CS-D	0.23	−0.27	−0.24	0.66	

correlation for ProM and RetM with age. (The different signs of the coefficients reflect the manner in which ProM and RetM performance were scored.) Also noteworthy in table 4 is the low correlation between ProM proper and explicit episodic RetM.

These findings complement those of the preceding experiment by showing a different kind of performance dissociation between explicit episodic RetM and ProM proper. In the preceding experiment, the retention-interval manipulation influenced ProM-proper test performance but not RetM test performance. By contrast, the materials manipulation used for the present experiment affected RetM test performance but not ProM-proper test performance. The results from the present experiment also showed that another factor, age group, had a comparable influence on both test types. This combination of findings illustrates the complex relationship between ProM proper and explicit episodic RetM.

The correlation data from the second experiment do not support the view that aging has a more profound effect on ProM-proper test performance than on explicit-episodic-RetM test performance (see Craik, 1986). The results revealed similar age-related performance declines in ProM proper and explicit episodic RetM. The results also showed that a widely used index of processing resources—card-sorting task performance—was only weakly and similarly correlated with ProM and RetM test performance. This finding replicates and extends the results reported by Uttl et al. (2001), and together with the outcome from the present experiment, they undermine the proposal that ProM test performance is more dependent on attention resources than RetM test performance.

Notes

1. Like all analogies, the analogy between prospectors and ProM is not perfect. A prospector is likely to use a conscious strategy to search the environment for telltale signs. By contrast, an important and defining feature of some ProM tasks (e.g., getting groceries en route from work to home) is that the search for task-relevant cues (e.g., the supermarket) is not guided by a strategy that is maintained in conscious awareness. For such tasks, the cues appear as part of ongoing thoughts, actions, or situations (e.g., driving home), when attention is focused elsewhere (e.g., on driving or listening to the radio).

2. The critical difference between monitoring and ProM proper is not defined by the time interval between instructions and the ProM cue. Monitoring tasks are those where an intention is maintained in consciousness until it needs to be executed. In contrast, for ProM proper, intentions are not maintained in consciousness through the retention interval while performing an ongoing task (see James, 1890). A clear operational distinction between monitoring and ProM proper may be difficult to achieve in each case. However, ProM researchers might go forward, as did RetM researchers in the 1960s (when they struggled to find clear operational distinctions between short- and long-term memory), by avoiding boundary cases and instead focus research on clear examples of monitoring and ProM proper.

3. The pixel size of the pictures used as ProM cues and as distractors varied slightly among the experiments; the experiments also differed slightly in terms of the number of ProM cue-size increments that were used. (Precise method details are reported in Uttl, Graf & Dixon, in preparation, and in Graf & Uttl, in preparation.)

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