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Prospective Memory Across the Lifespan

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The past few years have seen an increasing interest in prospective memory, or ProM (see Brandimonte, Einstein, & McDaniel, 1996), which can be defined as remembering at some point in the future that something has to be done, without any prompting in the form of explicit instructions to recall. This contrasts with retrospective memory (RetM) which refers to remembering information from the past. It should be noted at the outset that all ProM tasks have a RetM component so that a “pure” ProM task probably does not exist. For example, if the task is to remember to give a message to someone when you next see them, you may fail because you forget the content of the message which would be a RetM failure. In general, studies of ProM have deliberately attempted to make the RetM component as undemanding as possible to ensure that performance is more determined by ProM than by RetM (e.g., Maylor, 1998).

A ProM task can be divided into at least four phases (cf. Ellis, 1996): (1) the formation or encoding of an intention, (2) the retention interval, (3) the execution of an intention, and (4) the evaluation of the outcome. In this chapter, experiments will be presented that were designed particularly to examine the second, third, and fourth of these phases.

It is clear that living independently in the community requires the successful functioning of both ProM and RetM. There has been a vast literature concerned with RetM and with its development in childhood (e.g., Schneider & Pressley, 1997) and its decline in old age (e.g., Hultsch, Hertzog, Dixon, & Small, 1998) and dementia (e.g., Morris, 1996). But only recently have researchers turned their attention to investigating ProM across the lifespan, and most of this

work has been concerned with normal aging (see Maylor, 1993b, 1996b, for reviews).

A Theoretical Framework. In 1986, Craik proposed what has become an influential framework for understanding age differences in memory tasks. Performance is determined by an interaction between two factors: (1) external factors such as cues and context (or more generally, environmental support), and (2) the type of mental operation required. The claim is that self-initiated mental activities (such as retrieval) become more difficult with increasing age. However, age-related deficits are reduced in situations in which environmental support is high. In the resulting hierarchy of memory tasks, “remembering to remember” (now ProM) is at the top of the hierarchy as having low environmental support, requiring a high degree of self-initiated activity, and consequently being the most impaired by old age. Next in the hierarchy come more traditional tests of RetM (free recall, cued recall, then recognition) which usually involve the presentation of information that the subject is later asked to recall or recognize in response to some prompt from the experimenter. Finally, at the bottom of the hierarchy, priming involves the greatest environmental support, requires the least self-initiated activity, and is therefore least impaired by age.

Craik’s (1986) hierarchy was largely drawn up on an intuitive basis – at the time, there was very little evidence on aging and ProM. But the clear prediction was that age-related memory impairments should be greater in ProM tasks than in RetM tasks. This is because prospective remembering, by definition, places a heavy demand on self-initiated retrieval processes in the absence of any

prompt or cue from the environment. In fact, two more recent claims have been made about ProM, the first claim being less consistent with Craik's predictions than the second. The first was made by Einstein and McDaniel (1990) which is that ProM is unusually spared in normal aging, that is, ProM appears to be an exception to typically-found age-related decrements in memory. The second claim, by Huppert and Beardsall (1993), is that ProM tasks are particularly sensitive to the early stages of dementia; in other words, ProM is disproportionately impaired in abnormal aging. If these two claims are confirmed, then they would obviously have enormous implications, particularly with regard to the diagnosis of dementia, but also for the debate on whether there is continuity or discontinuity between normal aging and dementia.

ProM and Normal Aging. What is the evidence from studies of ProM and normal aging? First, if we consider so-called naturalistic studies in which volunteers are asked to make a series of telephone calls or mail postcards from home, the results seem to show preserved ProM (see Maylor, 1993b, 1996b, for summaries), contrary to Craik's (1986) predictions. Many older people can perform at least as well as younger people in such ProM tasks, but they may achieve their success by using efficient cues (e.g., Maylor, 1990). These may be suitable for tasks such as important occasional appointments. However, many everyday ProM tasks probably have to be tackled without the use of alarm clocks, calendars, and so on, for obvious practical reasons. Thus, the finding that older people do not perform so well if they do not use cues (Maylor, 1990) may be quite important.

At least one problem with naturalistic studies is that there is little control over the other activities that volunteers have to carry out. We therefore have to turn to laboratory-controlled experiments to determine whether or not ProM is affected by normal aging. In 1990, Einstein and McDaniel introduced a novel paradigm for investigating ProM in the laboratory. Participants were presented with lists of words that they had to recall (short-term RetM task). Some time before the task began, they were instructed to press a key whenever a specified word (ProM target event) appeared in the list. No significant difference was found between the performance of young and older adults in terms of the number of responses to the ProM target events. This was obviously a very surprising result with important implications for both the aging and memory

literatures, which led Crowder (1996) to suggest that “here was one form of memory that seemed to obey different laws” (p. 145). In other words, the result provided important evidence for a dissociation between RetM and ProM because old age significantly affected one but not the other.

Einstein et al. (1995) have since replicated the result and also have extended it by examining age differences in both event- and time-based ProM tasks (e.g., compare taking medicine after every meal vs. every four hours, respectively). The event-based ProM task was as before, namely, to press a key whenever a particular word was presented. In the time-based ProM task, participants were required to press a key every ten minutes. The clock was not visible while performing the background task; participants were required either to turn around to see the clock or to press a function key to reveal a clock on screen. The results again revealed no age-related impairment in the event-based ProM task but there was an age deficit in the time-based ProM task (see also Park et al., 1997). These findings were interpreted within Craik’s (1986) framework by suggesting that age-related impairment is not apparent in the event-based task because the target event itself provided a strong external cue to support performance; self-initiated retrieval was therefore unnecessary. In contrast, in the time-based task, participants had to take active steps to monitor the clock; environmental support was low and self-initiated retrieval was high.

However, this cannot be the whole story because there are other studies in the literature which have found age-related decrements in event-based ProM performance (e.g., Cherry & LeCompte, 1999; Einstein, Smith, McDaniel, & Shaw,

1997; Kidder, Park, Hertzog, & Morrell, 1997; Mäntylä, 1994; Maylor, 1993a, 1996a, 1998; West & Craik, 1999). For example, Maylor (1998) asked participants to name 120 famous people (RetM background task), and also to circle the trial number if the person was wearing glasses (event-based ProM task; $n = 8$ targets). There were three groups of participants: young, middle-aged, and old, with mean ages of 20, 59, and 76 years, respectively. As expected from studies of aging and proper name retrieval (e.g., Maylor, 1997), the young and middle-aged were significantly more successful at naming the famous people than the old (53%, 54%, and 32% correct, respectively). ProM performance declined significantly from the young (77%) to the middle-aged (62%) to the old (26%). Note that when participants were questioned carefully at the end of the experiment, almost all of them were able to repeat the task instructions correctly. In other words, they all knew (and remembered) what they were required to do, but they simply forgot to do it at the appropriate time.

How, then, can we account for these different patterns of results? There may be several possibilities or issues that need to be addressed, but there is space here to mention only two. The first issue is that of the difficulty of the background task. Einstein and McDaniel (1990) in fact deliberately reduced the cognitive demands of the background task for their older participants by presenting them with shorter word lists to remember (see also Cherry & LeCompte, 1999). In contrast, Maylor (1993a, 1996a, 1998) used a background task of naming that is known to be particularly difficult in old age (cf. Maylor, 1997). This raises the question of the relationship between the ProM task and the

background task in which it is embedded (see Maylor, 1998). Second, there is perhaps another difference between studies that could be crucial in accounting for mixed results, namely, that procedures vary in terms of the relationship between stimulus processing required to perform the background task and stimulus processing required to perform the ProM task. This has been termed the task-appropriate processing hypothesis (Maylor, 1996a). Thus, in Einstein and McDaniel's study, the background and ProM tasks required the same type or level of stimulus processing in order both to remember the word for the short-term memory task and to recognize it as the ProM target. In contrast, in Maylor's studies (see also Mäntylä, 1994), a shift was required in the level of stimulus analysis from the background naming task ("semantic" level) to the ProM task ("structural" level) in order both to name the person and to recognize the photograph as the ProM target (identified by a physical feature). Thus, Einstein and McDaniel may have failed to observe age differences, not because their ProM task was event-based (note that all of the tasks just described were event-based), but because there was considerable overlap between the stimulus processing necessary (although not sufficient) to perform each task.

A Test of the Task-Appropriate Processing Hypothesis. We designed an experiment to test these possibilities (Darby and Maylor, 1998). On each trial, participants were presented with a target word followed by six alternative responses (e.g., UNCTUOUS -- anxious, ingratiating, undertone, unaware, maroon, uncover). The background task was either semantic (write down the word closest in meaning to the target word) or structural (write down the word

that follows the target word in alphabetical order). The ProM task was similarly either semantic (circle the trial number if the name of a color appears) or structural (circle the trial number if a word with a double letter appears). Each participant was assigned to one of four conditions according to the background task-ProM task combination: (1) Semantic-Semantic, (2) Semantic-Structural, (3) Structural-Semantic, and (4) Structural-Structural. There were two main questions of interest. First, we expected older participants to find the semantic background task easier than would the younger participants because of their superior crystallized intelligence (e.g., Schaie, 1996). This would allow a comparison between ProM performance across age groups in the context of a background task on which older participants were not impaired. Second, on the basis of the task-appropriate processing hypothesis, we predicted that age differences in ProM would be greater in conditions 2 and 3 (where a shift in the level of stimulus analysis was required to perform both the background and ProM tasks) than in conditions 1 and 4 (where no shift was required). There were 65 trials (10 s per trial). ProM targets appeared on trials 28 (maroon), 45 (green), and 62 (yellow).

There were two groups of participants. Younger participants ($n = 79$) were aged between 18 and 24 years (M age = 19) and were psychology undergraduates whose participation in the study was a course requirement. Older participants ($n = 76$) were aged between 63 and 84 years (M age = 72) and were selected from a panel of community-dwelling volunteers aged over 50.

The results for the background task are shown in Figure 1a for each of the four background-ProM task conditions. It can be seen that the older participants performed considerably better than the younger participants in identifying synonyms (semantic background task; conditions 1 and 2), whereas the younger participants performed slightly better than the older participants in selecting the next word in alphabetical order (structural background task; conditions 3 and 4). There appeared to be little influence of the nature of the ProM task on background task performance in either age group. An analysis of variance (ANOVA) was conducted on these background task data with age group (younger vs. older), background task (semantic vs. structural), and ProM task (semantic vs. structural) as between-participant variables. There were significant effects of age group, $F(1, 147) = 5.42, p < .05$, and background task, $F(1, 147) = 141.40, p < .0001$. The interaction between age group and background task was also significant, $F(1, 147) = 51.12, p < .0001$. There were no other significant effects (all remaining p values $> .10$). In summary, we succeeded in our aim of selecting background tasks that differed in their relative difficulty across age groups, thereby providing an interesting case for the comparison of age differences in ProM performance.

Figure 1b shows the results for the ProM task for each of the four background-ProM task conditions. It is clear that, regardless of the background task, the younger participants were more successful in responding to the ProM targets than the older participants. ProM performance was higher for the semantic task (color targets) than for the structural task (double letter targets),

despite the fact that the ProM targets were physically identical in the two tasks. More importantly, consistent with our predictions, the age difference in ProM appeared to be greater when a shift was required between the levels of stimulus analysis required by the background and ProM tasks (conditions 2 and 3) than when no shift was required (conditions 1 and 4). These effects were confirmed by an ANOVA with the same variables as before. There were significant effects of age group, $F(1, 147) = 37.55$, $p < .0001$, and ProM task, $F(1, 147) = 24.82$, $p < .0001$. The only other significant effect was the crucial three-way interaction between age group, background task, and ProM task, $F(1, 147) = 4.79$, $p < .05$. Thus, the age difference in ProM was 38% when a shift was required but only 18% when no shift was required.

To determine the extent to which the effects of age on ProM could be attributable to RetM failures in the older participants, the ProM data were reanalyzed after having excluded participants who were unable to select the correct ProM task instructions in a recognition test at the end of the experiment. This led to the loss of 1 younger participant and 8 older participants. The ANOVA on ProM performance was very similar to before except that the three-way interaction was now only marginally-significant, $F(1, 138) = 3.75$, $p = .055$, with mean age differences in the shift and no shift conditions of 36% and 17%, respectively.

To conclude, it is clear that ProM is not always spared in normal aging and that deficits can be observed even when (1) the background task is relatively easier for older participants, and (2) failures of RetM in retaining the task

instructions are taken into account. In addition, there is evidence to support the task-appropriate processing hypothesis (Maylor, 1996a) such that age deficits are greater when a shift is required between the type of stimulus processing required by the background task and stimulus processing required by the ProM task. An interesting possibility for future research is that this task-shifting deficit may be particularly related to the loss of frontal functioning in old age (see West, 1996, on the frontal hypothesis of aging, and McDaniel et al., 1999, on its relationship to ProM). In summary, the results from these and other studies converge on the conclusion that age deficits do vary across different ProM tasks. As with RetM, age deficits appear to be greatest when task demands are high (task-shifting being perhaps just one example of how tasks differ). In terms of Craik's (1986) framework, it is probably not the case that all ProM tasks are low in environmental support and high in self-initiated activity.

ProM and Dementia. Returning to our two original claims, if ProM is not always unaffected by normal aging, then this rather weakens the case for poor ProM as an early indicator of dementia. But what about the claim that ProM may be disproportionately impaired by abnormal aging? There are certainly some anecdotal reports that when people consult their doctors because they are worried about possible symptoms of dementia in one of their relatives, it is often ProM problems that they complain particularly about (e.g., McKittrick, Camp, & Black, 1992). However, to date, there have been very few experimental studies of ProM in dementia. One potential problem was briefly mentioned earlier, namely, that it is difficult to separate prospective from retrospective failures. So in a

ProM task, you have to remember that something has to be done (ProM component), but also what has to be done, and when and where (RetM component). Usually retention of the RetM component is near-perfect in studies with normal participants since the content is deliberately kept as simple as possible (such as marking the trial number if someone is wearing glasses). Unfortunately, remembering the task requirements may not be such a trivial task for patient populations. People with dementia may therefore perform poorly in a ProM task, not necessarily because of impaired ProM, but because of impaired RetM (see Maylor, 1995, for further discussion).

In a project based at the University of Aberdeen, we have taken two approaches to the study of ProM in dementia. The first was a questionnaire study to obtain reports of the frequency of ProM and RetM failures and associated frustration in patients with Alzheimer's disease (AD), their carers, and both younger and older controls (Smith, Della Sala, Logie, & Maylor, in press). Contrary to the anecdotal evidence, ProM failures were no more frequent than RetM failures in AD patients (from carers' ratings); however, AD patients were rated near ceiling for both, so this absence of a difference may be difficult to interpret. Significantly more ProM than RetM failures were reported in the remaining groups, and this effect was identical for younger and older controls. Patients' ProM and RetM failures were reported by carers as being equally frustrating to AD patients, whereas ProM failures of AD patients were reported as more frustrating for carers than their RetM failures. Thus, although ProM failures were rated as no more frequent than RetM failures in AD patients (i.e.,

both generally occurred very often), they may have greater impact on the lives of carers in terms of the resulting levels of frustration and therefore may be more likely to be reported as early indicants of the disease.

Our second approach to the study of ProM in dementia was to conduct laboratory-controlled experiments to compare ProM and RetM performance of AD patients with that of age-matched controls and young controls (Maylor, Smith, Della Sala, & Logie, in preparation). To illustrate with one example, the background task was to view a 17-min film of scenes in and around Aberdeen. Participants were advised to watch the film carefully because there would be a recognition memory test at the end of the film. Each participant was assigned to one of two ProM conditions. In the event-based condition, participants were asked to say “animal” whenever they saw an animal in the film. A cow, a horse, a dog, a pig, and a sheep appeared on the screen for 3 s at approximately 3, 6, 9, 12, and 15 min. In the time-based condition, participants were asked to stop a clock every three minutes throughout the film by pressing the spacebar of a computer keyboard (which reset the clock to zero). A large clockface was displayed on a computer screen placed to the right of participants so that they were required to turn their heads to check the time.

There were three groups of participants: young, old, and AD patients. The AD patients were closely matched in age to the old participants. Several measures of RetM were obtained, including digit span, sentence span, and free recall. In addition, the recognition memory test at the end of the film, in which 12 scenes from the film were presented together with 12 new scenes for old/new

judgements, provided a further measure of RetM. The young and old groups did not differ significantly in terms of digit span, sentence span, and recognition. However, the young group achieved higher scores on the free recall test than the old group. As expected, the AD patients performed significantly worse than the old group on all four measures of RetM.

Before summarizing the results for the ProM tasks, it is important to note that all participants were able to recall accurately the ProM instructions when questioned at the end of the experiment, although some AD patients required occasional prompting. In other words, ProM failures cannot be attributed to RetM failures in retaining the task instructions (see earlier discussion). ProM performance was scored as follows. For the event-based task, a response within 4 s of the animal's onset was counted as a ProM success. For the time-based task, stopping the clock between 2 s before and 2 s after the clock reached 3 min was counted as a ProM success. Young participants were significantly more successful than old participants, who themselves significantly outperformed the AD patients. Although the age decline between young and old was greater in the time-based task than in the event-based task (cf. Einstein et al., 1995; Park et al., 1997), this comparison was compromised by ceiling effects for the young group on this particular measure of performance. Comparing the old group with the AD patients, the deficit was very similar across the two tasks. It might have been expected that the task more adversely affected by normal aging (i.e., time-based) would also be more adversely affected by abnormal aging. However, it should be acknowledged that larger age deficits in time- than event-based tasks are not

always found (see, for example, d'Ydewalle, Luwel, & Brunfaut, 1999), and that it is probably the case that both event- and time-based ProM tasks can vary (e.g., in terms of the degree of self-initiated activity required) such that some event-based tasks can be more demanding than some time-based tasks.

Perhaps of more interest here is the comparison between the effects of both normal and abnormal aging on ProM vs. RetM. First, for normal aging (young vs. old), this experiment revealed significant ProM deficits in both event- and time-based tasks in the context of significant decline in free recall, but no decline in measures of span or recognition. Thus, we again have evidence that ProM is not unusually spared in normal aging. Second, for abnormal aging (old vs. AD patients), there were significant deficits for both event- and time-based ProM tasks, but also for measures of RetM. To compare the effects of dementia on ProM and RetM directly, we calculated standardized scores for the AD patients and their age-matched controls. The differences between the two groups were very similar across the five memory measures, with no evidence of greater impairment for ProM than for RetM.

The conclusion from our experimental work on ProM and dementia is that there is no evidence that ProM is particularly impaired by AD in comparison with RetM. This would appear to conflict with Huppert and Beardsall's (1993) conclusion that ProM tasks are particularly sensitive to the early stages of dementia. However, it should be noted that Maylor et al.'s (in preparation) AD patients were not necessarily in the early stages of dementia. It therefore remains possible that ProM failures may be earlier indicators of dementia than RetM

failures, as argued by Huppert and Beardsall on the basis that ProM tasks may require the use of more brain areas than RetM tasks (see also Glisky, 1996).

The Retention Interval I: Clock-Checking and Self-Rated Thoughts. The discussion so far has largely concerned the third phase of ProM tasks (i.e., intention execution), where we have seen clear deficits due to both normal aging and dementia. We turn now to consider the second phase, namely, the retention interval. The question of interest here is what is the status of the intention or ProM task during the period when the task cannot be carried out? And are there age and dementia differences here too? We have investigated behavior during the retention interval in a number of ways. First, we have followed others in examining clock-checking behavior in time-based ProM tasks. For example, in the time-based condition of Maylor et al.'s (in preparation) study described earlier, we recorded the number of times participants checked the clock during each 30-s period leading up to (1) successful ProM responses, and (2) unsuccessful ProM responses. For checks on the clock prior to successful ProM responses, considerably more checks were made in the final 30-s period than in the previous periods, as expected. In addition, clock-checking differed significantly across the three groups such that young participants checked the clock less often than the old participants, who in turn checked the clock less often than the AD patients. These results with respect to normal aging would appear to be inconsistent with those of both Einstein et al. (1995) and Park et al. (1997) who observed less clock-checking in their older than in their younger age groups. However, these previous studies did not distinguish between clock-

checking prior to ProM success and clock-checking prior to ProM failure. Note that older adults are more likely than younger adults to forget the ProM task and therefore fail to check the clock. Our results suggest that successful ProM performance is preceded by different overt behaviors in both normal aging and dementia.

A second method of investigating the retention interval was adopted by Maylor (1998). Participants were asked at the end of an event-based ProM experiment to rate how often they had thought about the ProM component during the task. Regression analyses relating such self-rated thoughts to ProM performance showed that even when participants reported the same level of thoughts about the ProM task, the older participants were still less successful in responding to ProM targets. Alternatively, for the same level of ProM performance, older participants reported thinking more about the ProM task than younger participants.

The Retention Interval II: The Intention-Superiority Effect. For obvious reasons, it is probably not sufficient to rely entirely on self-ratings obtained retrospectively. Instead, a more direct method of investigating the status of ProM tasks during the retention interval is provided by Goschke and Kuhl (1993). Students were asked to memorize descriptions of different activities such as setting the dinner table or clearing a messy desk. They were then informed as to which of these scripts they were to execute (rather than simply observe) later. In a subsequent speeded recognition test for the words in the instructions, participants were faster to respond to words from the to-be-executed script than

to words from the to-be-observed script. Goschke and Kuhl's (1993) results from four experiments suggested that representations of intentions are characterized by a "heightened level of subthreshold activation in long-term memory" (p. 1211). They demonstrated that this "intention-superiority effect" was neither the result of selective encoding nor differential rehearsal but instead reflected the "intrinsic property of representations of intentions to decay more slowly than representations of nonintended activities" (p. 1223).

We have recently attempted to extend the intention-superiority effect in a number of ways (see Maylor, Darby, & Della Sala, 1999). First, we were interested in whether the effect applied to participants' own intentions as opposed to experimenter-imposed intentions. Second, we wondered whether the effect would occur for long-term intentions, that is, tasks to be carried out hours or days rather than minutes in the future. Third, we were obviously interested in possible differences between age groups in the intention-superiority effect. We have employed a speeded fluency task to compare the production of tasks that have to be carried out in the future with the production of tasks that have already been carried out in the past. Thus, participants were asked to recall as many instances as possible from a specified category in four minutes. There were two categories, with order counterbalanced across participants: (1) Jobs, appointments or things you did last week (RetM), and (2) Jobs, appointments, or things you intend to do next week (ProM). Participants were instructed to summarize each memory in one or two words.

Young participants recalled slightly more ProMs than RetMs, thereby demonstrating a long-term intention-superiority effect for participants' own intentions. This is a particularly striking result for at least two reasons. First, the memory representations of events that have taken place are surely richer (e.g., they contain more sensory detail) than those of events that have yet to take place. Second, we do not plan everything we do a week in advance; thus, there are potentially many more memories available from the past than from the future. Despite these two considerations, the young participants displayed an intention-superiority effect. In contrast, middle-aged participants recalled similar numbers of RetMs and ProMs, whereas both older participants and AD patients actually recalled fewer ProMs than RetMs (an intention-inferiority effect). This pattern of results suggests that there are age differences in the relative status of intentions during the retention interval phase of ProM tasks.

Marsh, Hicks and Bryan (1999) have recently shown that two effects may contribute to the intention-superiority effect, namely, the facilitation of ProMs and the inhibition of RetMs. The intention-inferiority effect observed in our older adults and AD patients could therefore be due to reduced facilitation of ProMs, reduced inhibition of RetMs, or indeed both. It is not possible to decide between these alternatives from the present data. However, it can be noted that there is some support from other paradigms for reduced inhibitory processing in normal aging (e.g., McDowd, Oseas-Kreger, & Filion, 1995).

Although a direct link between the intention-superiority effect and ProM performance remains to be established, it seems reasonable to assume that

successful prospective remembering depends at least partly on the level of resting activation of the intended action. Since the representations of intentions in older adults and in AD patients are less characterized by some form of privileged status in long-term memory than in young adults, it is suggested that this may at least contribute to observed deficits in prospective remembering in normal aging and dementia.

ProM and Development. Clearly, ProM declines with normal aging and dementia. But how does ProM develop at the other end of the lifespan? So far there have been almost as few studies of ProM in children as there are studies of ProM in dementia. The existing handful of studies have used very different methodologies and have produced inconsistent results. Some have found little or no ProM improvement (e.g., Somerville, Wellman, & Cultice, 1983) and therefore have argued that ProM develops at a much earlier age than RetM. However, others have found significant improvement (e.g., Passolunghi, Brandimonte, & Cornoldi, 1985), in some cases attributable to greater use of effective external cues (Beal, 1985). Here, we briefly present two of our own attempts to look at the development of ProM.

First, we were interested in the extent to which any improvement in ProM with increasing age was related to changes in RetM. Children ($n = 200$) were asked to name teachers from their photographs (background task) and to indicate if the teacher was wearing glasses or if there was a plant in the picture (ProM task). The RetM task was immediate free recall of ten everyday objects.

There were significant improvements from 6-11 years for both ProM and RetM, and these improvements were very similar in terms of standardized scores (-0.55 to +0.72 for ProM, and -0.97 to 0.65 for RetM, from 6-11 years). The ProM data were further analyzed in terms of successful responses to each ProM target (glasses vs. plant). Improvement with increasing age was more striking for the plant than for the glasses such that the younger children were much less successful in responding to the plant than to the glasses. This was despite the fact that the plant was visually more prominent in the photographs than the glasses (e.g., in terms of size). A possible explanation is that young children may have particular difficulty when the ProM target event is not within the focus of attention for the background task (i.e., identifying and naming the person in the photograph). This would be consistent with the task-appropriate processing hypothesis discussed earlier with respect to aging. In other words, young children may be less likely to switch attention on every trial from stimulus processing required to perform the background task and stimulus processing required to respond to the ProM target.

A second experiment was based on a recent study by Einstein, McDaniel, Smith, and Shaw (1998) designed as a laboratory analogue of an habitual ProM task, that is, where the same ProM task has to be done on a regular basis, like remembering to feed the goldfish once a day. In habitual ProM tasks, we are particularly interested in the fourth phase of the task, that of evaluating the outcome. One possibility is that young children might fail to perform the task (i.e., an omission error) because they mistake thinking about feeding the goldfish

with actually feeding the goldfish (i.e., an output or reality monitoring error). Or children might think that they have performed the task because they are mistakenly recalling their memory of feeding the goldfish yesterday (i.e., a temporal discrimination error). A related problem with habitual ProM tasks is repetition errors. Thus, children might feed the goldfish twice because they forgot that they had already fed them, or they might remember that they fed the goldfish but attribute the memory to yesterday rather than to today.

We asked 90 children aged 5-11 years to play a game in which points were scored by manoeuvring a steel ball around an obstacle course. Each game lasted 90 s, and children were asked to play the game 10 times. The ProM task was to turn a counter over once on each trial; however, they were not allowed to turn the counter over during the first 20 s. A timer moved from Start to Stop over the course of each game. During the first 20 s, the timer pointed to a red zone; from 20-90 s, the timer pointed to a green zone. Participants were instructed to turn the counter over only when the timer reached the green zone. After each trial, participants were asked if they had remembered to turn the counter over on that trial.

Omission errors in the ProM task (i.e., failing to turn over the counter) were most frequent in the youngest children. There were few repetition errors (i.e., turning the counter over more than once), with no significant effect of age. We were particularly interested in the two types of outcome evaluation errors: (i) the number of times children claimed to have turned over the counter but in fact had not, conditionalized on ProM failures, and (ii) the number of times they

claimed not to have turned over the counter when in fact they had, conditionalized on ProM successes. For the first type of error, there was a significant increase with age. This can be explained as follows: Children may fail to perform the ProM task but may think that they have because they are mistakenly recalling their ProM response from a previous trial (temporal discrimination error). This is more likely to occur in older children because a previous trial is more likely to be a ProM success than it is for younger children. The second type of error is particularly interesting because it could lead eventually to repetition errors. Most of these errors occurred in the last few trials, consistent with Einstein et al.'s (1998) conclusion that as a ProM task becomes habitual, it is more difficult to remember whether or not the ProM task has been performed. This second error type significantly decreased with age. There are two possible interpretations of this result: First, if younger children are more prone to temporal discrimination errors, they would be more likely to attribute their memory of performing the task on the current trial to the previous trial. Second, younger children may be more prone to output monitoring failures; in other words, they may simply forget that they performed the task, perhaps because it has become automatic. Further empirical work is required to distinguish between these two possibilities (cf. Einstein et al., 1998).

Conclusions. ProM research is still in its infancy, particularly with respect to changes in ProM across the lifespan. Nevertheless, although there have been some mixed results, it is clear that ProM does develop in childhood, and decline in old age, with further decline in dementia. Both in development and in normal

aging, it seems that ProM is more affected when the attentional demands of the task are high. For example, age effects are greater when attention-switching is required between the background task and ProM task demands (task-appropriate processing hypothesis; Maylor, 1996a).

There is currently no evidence that ProM is more affected by dementia than RetM, at least in moderately-demented patients. Careful longitudinal research is still required to provide an appropriate test of Huppert and Beardsall's (1993) suggestion that ProM failures may be earlier indicators of dementia than RetM failures. Whether or not ProM failures turn out to be more prevalent than RetM failures in the early stages of dementia, it is clear that patients' ProM failures are more frustrating to carers than their RetM failures. This finding may provide an explanation for the anecdotal evidence that relatives of patients note problems with ProM in particular when initially consulting their doctors.

During the retention interval between the formation and execution of an intention, ProM tasks are less represented in long-term memory by a heightened level of activation (relative to RetM tasks) in old age and dementia than in young adults, which could account for at least some of the deficits observed. However, the reason for this (e.g., reduced facilitation of ProMs, reduced inhibition of RetMs, or indeed both) is not yet clear. When ProM is successful in old age and dementia, it is achieved at the expense of greater effort during the retention interval, for example, in terms of more checks on the clock in a time-based task, or more thoughts about the task in an event-based task.

A final issue is whether there is anything special about ProM or whether we can simply predict ProM changes across the lifespan on the basis of what we know about RetM changes. Initial studies suggested that ProM was exceptionally spared in old age, but subsequent studies have shown age deficits in ProM performance that are largely consistent with Craik's (1986) framework. Thus, deficits are greater when self-initiated activity is high and environmental support is low, both for ProM and RetM (although care must be taken to avoid circularity here). It certainly seems the case that findings from the RetM literature can help in understanding ProM data. For example, the development of temporal memory may be able to account for some of the outcome evaluation errors observed in the study of habitual ProM.

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Figure Caption

Figure 1. Data from a study by Darby and Maylor (1998). The four conditions represent the combination of background task (semantic or structural) and ProM task (semantic or structural). (a) Background task performance. For the Sem-Sem and Sem-Struc conditions, the background task was to select the word closest in meaning to the target word, whereas in the Struc-Sem and Struc-Struc conditions, the background task was to select the word that followed the target word in alphabetical order. (b) ProM task performance. For the Sem-Sem and Struc-Sem conditions, the ProM task was to respond to colors, whereas in the Sem-Struc and Struc-Struc conditions, the background task was to respond to words with double letters. ProM targets = maroon, green, and yellow in both tasks. Error bars represent 1 SE.

