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Virtual Week and Actual Week: Age-related Differences in Prospective Memory

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SUMMARY

Several previous studies have shown that whereas young adults perform better than older adults on prospective memory (PM) tasks in the laboratory, this superiority is often reversed in real-life PM tasks. The present studies investigated this paradox by creating a laboratory task in the form of a board game (Virtual Week) that mimicked many features of daily living. It was hypothesized that older adults might use strategies derived from their more structured lives to outperform young adults on the board game. However, contrary to our prediction, it was found that younger adults were superior. In Experiment 2 we had participants perform very similar PM tasks in real life (Actual Week), and found that now the older adults were generally superior to their younger counterparts. Possible reasons are discussed for this striking age-related difference between laboratory-based and naturalistic PM tasks. Copyright © 2000 John Wiley & Sons, Ltd.

The present report is concerned with age-related differences in prospective memory (PM) performance, and how these differences are modified by the setting in which testing takes place. Schonfield (1982) drew researchers' attention to possible declines in PM with increasing age from young to older adulthood. In particular he suggested that older people have difficulty 'remembering to remember' and cited some earlier work of his own (reported by Welford, 1958) in support of this suggestion. Interestingly, in the same volume, Moscovitch (1982) reported an informal study in which participants of various ages were asked to phone the laboratory from home at various designated times; in this case the older adults outperformed their younger counterparts — a result directly opposing Schonfield's suggestion. However, it seemed that the older participants in Moscovitch's study performed well largely through their greater use of external aids and reminders. Subsequent research has generally shown that older adults do perform less well than younger adults in laboratory tests of PM, but the few studies carried out in naturalistic settings have tended to find an age-related *improvement* in PM performance. The studies described in the present article explored this possible difference between PM in the laboratory and in real life.

Adult age differences in laboratory-based PM tasks are reasonably well documented at the present time. Initial reports suggested that age-related differences were slight (e.g. Einstein and McDaniel, 1990), but subsequent studies have usually found that performance declines with increasing age. Craik (1983, 1986) suggested that older adults have difficulty with cognitive tasks that require a lot of self-initiated mental activity, and in line

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with this suggestion Einstein, McDaniel and their colleagues made the useful distinction between time-based and event-based PM tasks. Event-based tasks are those cued by some external happening, whereas in time-based tasks the PM action must be carried out at a certain time, in the absence of external reminders. The argument is that time-based tasks require more self-initiated activity than do event-based tasks, and the finding is that the former show greater age-related decrements than the latter (Einstein *et al.*, 1995; McDaniel and Einstein, 1992). However a recent study by d'Ydewalle *et al.* (1999) did not find a greater age deterioration with time-based compared to event-based PM. Other results include the findings that increased task complexity and an increase in the number of PM targets exacerbates the age decrement (Einstein *et al.*, 1992; Mäntylä, 1994; Park *et al.*, 1997) and that the age decrement is also amplified as the retrospective memory component of the PM task increases in difficulty (Einstein and McDaniel, 1996).

Tests of age differences in PM performance under real-life conditions are clearly more difficult to control, and here the results are more variable. One study found no age differences (West, 1988) but this phone-in task did not require participants to respond at a specific time. Most other studies have found superior performance by older adults (e.g. Devolder *et al.*, 1990; Moscovitch, 1982; Rendell and Thomson, 1993, 1999). Those naturalistic PM studies that have compared young–old participants (in their 60s and early 70s) with old–old participants (in their later 70s and 80s) have typically found little or no age-related difference (Leirer *et al.*, 1988; Maylor, 1990; Park *et al.*, 1992; Rendell and Thomson, 1999).

Rendell and Thomson (1999) tested the same 380 participants on a naturalistic PM task and on two laboratory PM tasks embedded within a retrospective memory task session. The naturalistic PM task required participants to log the time with a portable electronic organizer at four times a day over seven days. The older adults were consistently more accurate than the young adults; they were on-time for about 70% and 40% of the set times respectively. In addition, there was no difference between the young–old and old–old age groups. This age-related pattern was consistent across six different regimens that varied the regularity of time schedules and the opportunity to use external aids and conjunction cues — that is, linking the prospective action to some routine event such as a meal or checking for mail (Maylor, 1990). The participants showed the typical age-related decline on word list recall and recognition tasks. In contrast to the naturalistic PM task, there was an age-related decline on the two laboratory PM tasks embedded within the word memory task session. These involved stopping a stop-clock at seven minutes after the start of the session and noting the time the questionnaire was finished. Older adults, superior on the naturalistic task, were inferior to young adults on the laboratory PM tasks. Old–old and young–old did not differ on the naturalistic PM task but old–old were inferior on the laboratory PM tasks.

No clear explanation for the paradoxical findings has emerged, but there are several possible reasons for the difference in age-related trends between laboratory-based and naturalistic PM tasks. The possible reasons include motivation, use of external aids, lifestyle, and task differences. Rabbitt (1996) discusses other reasons, especially for time-based tasks, for example the strong links between time and activity in real life. Motivational differences may favour older participants; with older people possibly approaching the task quite seriously, whereas younger participants possibly treating the task more routinely (Rendell and Thomson, 1999). Moscovitch (1982) reported that his older participants made heavy use of external aids, and this report is in line with the observation of older adults that they now make lists and leave notes for themselves,

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whereas when they were younger they 'just remembered'. However, most of the participants in Rendell and Thomson's studies (1993, 1999) did not use external aids, according to their self-reports, yet still performed the PM tasks at a higher level. Laboratory-based and naturalistic tasks also tend to differ in several ways; whereas real-life tasks are often simple (phone the lab), regular (at the same time each day), and explicit, laboratory PM tasks are typically more complex, less regular, and are often presented as secondary or incidental to some ongoing task.

A further difference concerns the predictability of PM target appearance in the background of ongoing activity. In real life one can anticipate (through knowledge of routine activities) when, or under what circumstances a target might appear (cf. Ellis, 1996). In laboratory tasks, particularly event-based, one has no idea because of the artificial nature of the ongoing activity. Even a time-based task is less predictable in the lab because of possible dissociations between time perception and activity (cf. Rabbitt, 1996).

Finally, it seems possible that the older participants in PM tasks lead more structured and regulated lives than the younger participants, who are often college students. In carrying out previous experiments (Rendell and Thomson, 1993, 1999) one of the present authors found that the older adults appeared to have a more routine pattern of daily activities and to lead more predictable lives. Organizing appointments with the older adults, even weeks ahead, required some negotiation to find a time in their schedules; interestingly, they often knew what they would be doing at various times of day several weeks into the future. In contrast, the younger adults seemed to lead more spontaneous and variable lives. These observations led to the conjecture that if we could capture the salient features of a real-life day in some laboratory task, the older adults might show the same superiority that they typically exhibit in naturalistic PM tasks. Accordingly we set out to devise a board game, 'Virtual Week', that would simulate the times and events that occur naturally in real life. Our prediction was that an age-related increase in PM performance would be found in this laboratory task.

EXPERIMENT 1 VIRTUAL WEEK

Virtual Week was developed as a laboratory PM task that would more closely represent PM tasks in everyday life and provide an opportunity to investigate the different sorts of PM tasks in daily life. The aim of this research was to explore the paradoxical age trends on laboratory and naturalistic PM tasks. In addition, there was the secondary aim to develop a procedure that was an explicit test of PM and a procedure that was purpose-built to assess performance on PM tasks. Previous laboratory studies have tended to add on PM tasks to those already developed to test retrospective memory. In contrast, Virtual Week aimed to have PM tasks that were plausible, had multiple responses, and had the flexibility to include different kinds of tasks, such as regular (routine, recurring tasks) and irregular (one-off, non-recurring tasks), and event-based versus time-based tasks.

Virtual Week is a board game. This was chosen as it seemed to be an engrossing format with which both younger and older adults would be comfortable. Participants move around the board with the role of a dice. The times of the day people are typically awake are marked on the board. The game requires participants to circuit the board seven times in a simulation of a week in their life with each circuit representing a day. As they move around the board, participants make choices about daily activities and are required to remember to carry out lifelike activities (PM tasks). Participants pick up 10 event cards each virtual day.

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The event cards give three options about ordinary daily activities relevant to the virtual time of day and determine the roll of dice that is required before moving on. Reading aloud the event cards, making decisions about daily activities, rolling dice and moving the game token, provide the backdrop to the PM tasks. This backdrop was designed to capture the structure in a typical day of routine activities. The event-card activities combine to present a day of activities that is coherent, structured and plausible. Three meals at similar times each day provided some of the structure and regularity of the virtual days.

Similarly, the PM tasks proper in Virtual Week are also plausible daily activities. Participants do not physically undertake the tasks; instead they simply tell the researcher about them at the set time for time-based tasks, or in relation to a set event in the game for event-based tasks. A time-based task, such as a request to phone the plumber at 4 p.m., requires participants to tell the researcher they need to phone the plumber when they pass the square labelled 4 p.m. An event-based task, such as a request to pick up dry-cleaning when next out shopping, requires the participant to tell the researcher they need to pick up dry-cleaning when reading an event card later in the virtual day that describes the activity of going shopping. The PM tasks are spread out during each virtual day. In addition, the tasks were designed so that it is reasonable and possible for participants to carry them out at the set time or when the event occurred. It was ensured that the event-card activities were consistent with but not dependent on carrying out any of the tasks. This avoided the event-card descriptions providing additional cues for the PM tasks.

There are 10 PM tasks during each virtual day. Of these tasks, four are classified as *regular*, four are classified as *irregular*, and two are classified as *time-check*. The regular and the time-check PM tasks simulate the taking of medication. The regular tasks comprise two event-based tasks requiring antibiotics to be taken with breakfast and dinner, and two time-based tasks requiring asthma medication to be taken at 11 a.m. and 9 p.m. In the time-check task, a stop-clock is started at the beginning of each circuit of the board and participants are required to do a lung test on two occasions, at 2 minutes 30 seconds, and at 4 minutes 15 seconds. These times are quite separate from the virtual times marked on the board. The critical features of the regular and time-check tasks are that they are the same each day and participants are informed about them before starting the game.

The irregular PM tasks simulate the kinds of occasional tasks that occur as one undertakes normal daily activities. The irregular tasks include phoning a plumber, putting gas in the car and returning a library book. The critical features of irregular PM tasks are that they are all different tasks and that participants are informed about them during the game; either at the start of the day or during the day on which they must be carried out. As with the regular tasks, the irregular tasks are both time-based and event-based. Each virtual day one event-based and one time-based task is given both at the start of a day and during a day.

The time-check task was included as it involved 'breaking set' from the board game activity. It seemed possible that older participants would use the structure of their real lives to support performance on board game activities, but might then be relatively penalised when it was necessary to switch out of that set to monitor real time on the stop-clock. It was expected that all participants would do better on the recurring regular tasks than on the irregular tasks; older participants might have trouble with the irregular tasks, given that each task comprised both a triggering event or time and a specific action that would tax retrospective memory (Einstein *et al.*, 1992). The distinction between time-based and event-based tasks is somewhat artificial here, as each depended on passing a specific time square on the board or on encountering a specific event. Nevertheless, there is a

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distinction; event-based tasks were triggered by some information on an Event Card (e.g. 'Your friend Kate telephones you' or 'You visit your swimming pool/sports club') whereas time-based tasks must be triggered by passing a particular time on the board (e.g. 10 a.m. or 4 p.m.) that is otherwise passed with no comment.

The overall speculative prediction was that, unlike previous laboratory-based PM tasks, older participants could use their experience with their own more structured lives to outperform younger adults. We expected to replicate older adults' superiority over young adults found on real-life PM tasks. Virtual Week is more than a simulation of plausible PM tasks as these tasks are embedded in a simulation of daily activities with a very structured pattern. In real-life PM tasks, the pattern of daily activities provides both the backdrop and a possible framework to assist the carrying out of PM tasks (cf. Ellis, 1996).

Method

Participants

A total of 60 adults participated in the experiment: 20 young, 20 young–old and 20 old–old. Table 1 summarizes the characteristics of the three age groups. The age groups did not significantly differ in mean years of education completed, $F(2, 57) = 3.08$, $MSE = 3.57$, $p > 0.05$. There were significant age differences on the Mill Hill Vocabulary test, a synonym recognition test, $F(2, 57) = 12.92$, $MSE = 6.00$, $p < 0.001$. The young scored lower on the Mill Hill Vocabulary test than both the young–old and the old–old, but the young–old and old–old did not differ. The young adults were second- and third-year undergraduate psychology students, and they received course credit and $5.00 for their participation. The older adults were recruited from the greater Toronto metropolitan area and received compensation to cover travel costs. Participants rated their health from 1 (*excellent*) to 5 (*poor*) on the day of test and over the previous few months. The age groups

Table 1. Characteristics of participants (Virtual Week)

	Young	Young–old	Old–old
Sex			
Men	4	4	4
Women	16	16	16
Age (in years)			
Range	19–24	61–73	75–84
M	21.30	67.83	78.84
Education (in years)			
M	15.10	16.55	15.55
SD	0.64	2.35	2.19
Mill Hill test score			
M	14.05	17.60	17.30
SD	2.87	2.09	2.32
Self-rated health[a]			
Day of test			
M	2.00	1.50	1.80
SD	0.79	0.61	0.62
Over last 2 or 3 months			
M	2.20	1.65	1.85
SD	0.77	0.75	0.67
Number taking medication	1	14	13

[a]Self-rated health responses varied from 1 (*excellent*) to 5 (*poor*).

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did not differ in the mean self-ratings of current health $F(2, 57) = 2.76$, $MSE = 0.46$, $p > 0.05$, and health over the previous few months $F(2, 57) = 2.92$, $MSE = 0.53$, $p > 0.05$). All participants rated their health on the day of test and over the previous few months as excellent, very good or good. A substantial number of the older adult participants were taking medication at the time of testing but only one young participant was taking medication at the time.

Materials

The board game Virtual Week (Figure 1) was developed for this study. The board (31 cm by 36 cm) contained 122 squares representing times from 7 a.m. to just after 10 p.m. Participants moved a token round the board in accordance with the number shown by each roll of a simulated dice on a computer screen. After each roll a random number from 1 to 6 was displayed. At the beginning of each circuit participants were required to throw a six before moving off (to simulate waking up) and they also picked up a start card which indicated the day of the week and outlined two PM tasks (irregular tasks) for that day. At the end of each circuit, participants stopped at the start square even when the number rolled on the dice was higher than needed to reach the start square.

As shown in Figure 1 there were 10 event squares evenly spaced around the board. Whenever participants landed on or passed an event square they were required to pick up

Figure 1. The Virtual Week board (actual size was 31 cm by 36 cm)

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an event card which included a brief description of a daily activity and three options related to that activity. As examples, the event card could be 'Monday Breakfast' with the activity of reading the paper and the options 'For breakfast, do you have: cereal, waffles, or bacon and eggs?' or 'Phone call'; your friend Kate suggests seeing a movie and the options 'comedy, romance, or drama'. After choosing one option, the participant turned over the card which then revealed the necessary dice throw for the selected option; for example 'throw an even number', 'throw any number' or 'throw a three' before moving on. The point of these options was simply to keep participants busy and to discourage them from continuing to rehearse the PM tasks for that day. The activities on the event cards were designed to be relevant to the virtual time of day and they were chosen to be both ordinary and plausible daily activities for participants. Embarrassing events were avoided. In addition, the 10 event cards for each virtual day were designed to provide a logical sequence of daily tasks. There was some repetition of the events from day to day but generally each virtual day had a different set of events. The meals were at the same time each virtual day. The same event squares each day corresponded to the event cards describing breakfast, lunch and dinner. Piloting of the game indicated that the different age groups involved in the study found the activities entirely plausible, including those activities associated with attending university. In addition to meals, activities included phone calls, visit from neighbour, shopping, going to library, watching television, session at university, house cleaning, baby-sitting, going out in car, seeing a movie, going to a swimming pool/sports club and visit by repairman.

Procedures

Participants were tested individually in a session lasting up to two hours (between 75 to 120 minutes). After arriving for their appointment at the laboratory, participants were given a brief overview of the purpose of the study and informed consent was obtained. Participants then completed a brief biographical questionnaire and the Mill Hill Vocabulary test. Following these background tasks, the board game was introduced. In the introduction, participants were explicitly informed about the purpose of Virtual Week. They were told that the game would assess the kinds of choices they make in completing daily activities and how they go about remembering to do things. The details of the game were then explained. With regard to the PM tasks, participants were told that there would be some tasks they would be asked to do later, and that they should inform the researcher about such tasks when passing the set time square or when they encountered the specified event. They were encouraged to inform the researcher even if late. Participants then completed a practice circuit, during which the researcher explained the procedures and responded to any questions. The practice day had four irregular tasks, but not the regular or time-check tasks; these latter tasks were explained after the practice day and before starting the first day of Virtual Week. Before commencing the game, participants were required to recite verbatim the regular and time-check PM tasks details, twice. Participants were warned that it would be a busy week! During the game, the participant sat at a desk and played the game alone with the researcher sitting quietly behind and to one side. The participants became engaged in a kind of a running commentary of each virtual day (or a continuous conversation with themselves) as they read aloud from the event and start cards. Their comments indicated they were strongly identifying with the event-card activities and the PM tasks and that participants had embraced the game.

Ten PM tasks were given on each virtual day. Four were the same 'regular' tasks that were performed each day; they simulated taking medications, two were time-based

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(11 a.m. and 9 p.m.) and two were event-based (breakfast and dinner). Two further tasks were also performed each day; these were the 'time-check' tasks in which the participant informed the researcher when the stop-clock (which was in full view) showed 2 minutes 30 seconds and 4 minutes 15 seconds. The remaining four PM tasks were 'irregular'— that is, different on each day. Two of these tasks were presented at the start of each circuit, and two were presented on event cards picked up during the circuit; in both cases, one of the two tasks was time-based and one was event-based.

Results and discussion

Participants generally took between 5 and 10 minutes to complete each circuit of the board. The younger adults took less time than the older adults, and all participants got faster as they played the game. The mean times (minutes:seconds) for the first and last day were: young 6:46, 5:20; young–old, 8:13, 6:31; old–old, 9:34, 7:32. The results also showed that age-related differences in performance on Virtual Week did not vary systematically over the seven successive circuits of the board. Participants' PM responses were judged to be correct if they were made before the next dice roll following the target time or event, and if the gist of the message was reported accurately. In the case of the time-check task, correct responses were those made within 10 seconds of the target time. Figure 2 shows the overall performance levels of the three age groups on the three types of task. The figure shows that the age-related decline was small on regular tasks, but substantial on both the time-check and irregular tasks. These impressions were borne out by a 3×3 analysis of variance (ANOVA) involving the between-subjects variable of age group and the within-subject variable of PM task. Both main effects were statistically reliable; for age group, $F(2, 57) = 47.96$, $MSE = 0.03$, $p < 0.001$, and for PM task, $F(2, 114) = 135.48$, $MSE = 0.02$, $p < 0.001$. Additionally, the interaction between age group and task was significant, $F(4, 114) = 7.94$, $MSE = 0.02$, $p < 0.001$.

Analysis of the significant interaction between age and PM task revealed a significant effect of PM task within age group: ($F(2, 114) = 12.93$, 56.75 and 81.68, $MSE = 0.02$, all $ps < 0.001$, for young–adults, young–old and old–old respectively. For each age group,

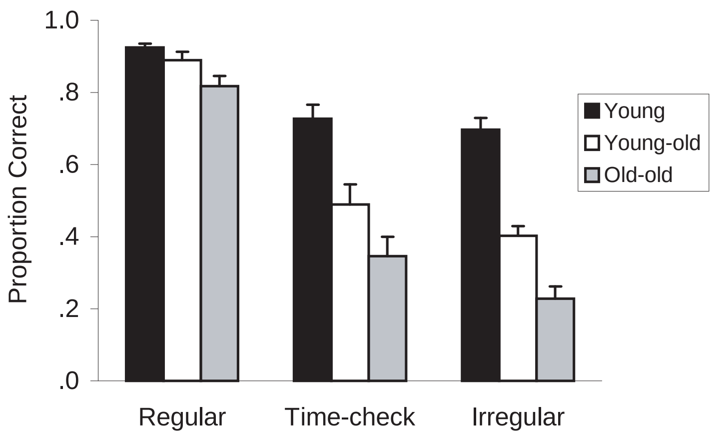

Figure 2. Mean proportions of correct responses on Virtual Week by each age group for the three types of PM task. Bars represent one standard error of the mean

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Tukey *post-hoc* tests revealed that the proportion correct on the regular tasks was significantly higher than both the time-check task and the irregular tasks. There was no significant difference between the time-check tasks and the irregular tasks except for the old–old who performed significantly worse on the irregular than on the time-check tasks. Further analysis revealed that age was a significant effect within each category of PM task: $F(2, 57) = 5.92$, 14.85 and 56.34, $MSE = 0.01$, 0.05 and 0.02, $p\text{s} < 0.01$, for regular, time-check and irregular tasks respectively. Tukey *post-hoc* tests revealed that the young performed significantly better than the old–old on all three PM tasks. The young performed significantly better than the young–old on the time-check and the irregular tasks but on the regular tasks the young and the young–old did not differ significantly. The young–old and old–old did not differ significantly on the regular and time-check tasks but the young–old performed significantly better than the old–old on the irregular tasks.

The four regular tasks were made up of two time-based tasks (11 a.m. and 9 p.m.) and two event-based tasks (breakfast and dinner). Further analyses revealed that the number of correct responses to dinner (72%) was less than the numbers to breakfast (93%), 11 a.m. or 9 p.m. (93% and 92% respectively). There were no interactions with age, however. Further analysis of the time-check task showed no significant differences between the two target times. A $3 \times 2 \times 2$ ANOVA was conducted on the proportions of correct responses for the irregular tasks. The first factor was age and the other two factors were when informed (on the start card or during the day) and type of target (time-based or event-based). This analysis revealed significant effects of age, $F(2, 57) = 56.34$, $MSE = 0.08$, $p < 0.001$, of when participants were informed, $F(1, 57) = 12.62$, $MSE = 0.04$, $p < 0.001$, and of the interaction between when informed and type of target, $F(1, 57) = 6.87$, $MSE = 0.02$, $p < 0.05$. Age did not interact significantly with either when informed or type of target. The main effect of when informed reflects the finding that being given the instruction on the start card resulted in better performance than being given the instruction on an event card during a circuit (49% versus 40% respectively). The interaction between time of information and type of task reflects the fact that for event-based tasks the time of information made a difference (54% for start card versus 39% for during the day), whereas for time-based tasks there was no such difference (44% versus 40% respectively). In summary, there was a substantial age-related decline on all four types of irregular tasks, but age did not interact with other variables; in particular it is noteworthy that age did not interact with the factor of time-based versus event-based tasks.

There was considerable variation in the overall performance on the irregular tasks, ranging from 22% to 83% correct. Given that all participants completed the same version of Virtual Week it is not possible to pinpoint the exact characteristics of poorly and successfully performed tasks although some informal observations can be made. One factor might be the number of further events intervening between the presentation of a task and its target time or event, but this does not appear to be a strong factor since the mean number of intervening events for the six worst-performed tasks is actually less (4.8) than the mean number for the six best-performed tasks (5.2). However, there was a trend for the best-performed tasks to require the participant to remember to do something for a hypothetical friend or family member (e.g. 'take niece to softball at 10 a.m.', 'take photos to family lunch', 'phone brother who is overseas at 10 p.m.'). In turn, this suggests that participants *were* treating the board game somewhat like their real lives and were thus possibly applying strategies from everyday life in their performance.

Table 2 shows the proportions of correct responses and various types of error for the different groups and tasks. For the regular tasks, virtually all the errors were failures to

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Table 2. Proportions of correct responses and different types of error for three age groups (Virtual Week)

PM task	Regular			Time-check			Irregular		
Age group:	Y	Y–O	O–O	Y	Y–O	O–O	Y	Y–O	O–O
On-time[a]									
Correct	0.93	0.89	0.82	0.72	0.47	0.34	0.70	0.41	0.22
Wrong[b]	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.17	0.20
Late	0.03	0.05	0.04	0.23	0.30	0.27	0.03	0.02	0.01
Miss[c]	0.04	0.06	0.13	0.05	0.23	0.39	0.19	0.41	0.56

[a]Time-check on-time was within 10 seconds. For other tasks on-time was before next roll of dice.
[b]Includes trials in which participants indicated that they knew they should do something, but had forgotten content.
[c]This category includes occasional responses to wrong target.

respond; there were few wrong or late responses. In the case of time-check responses, there were many late responses but they did not vary widely with age. As with the regular tasks the main source of age-related errors was a failure to respond. The pattern for the irregular task was somewhat different in that wrong responses were made — especially by the two older groups. Nearly all the wrong responses involved the participants remembering that *something* should be done, but forgetting what it was. That is, the errors for the two older groups appear to reflect a failure of retrospective memory to some extent. However, even for these irregular tasks the major source of PM errors is again a failure to respond at all, suggesting that the major age-related difficulty is in the prospective component of the task; that is, in remembering that some response is required when a specific time or event is encountered.

The main findings of interest from the study are that older adults showed substantial performance decrements on the Virtual Week task despite their obvious motivation to do well and the apparent involvement of real-life daily structures in the task; despite the fact in addition that almost half of the PM targets were events as opposed to times. These clear findings go against our own prediction that the age decrement often observed in laboratory-based PM tasks would be eliminated or even reversed in the present task, in which we supposed that participants could use strategies based on the structures of their daily lives. The findings also contradict claims in the literature that age-related decrements are restricted to time-based, as opposed to event-based tasks (Einstein *et al.*, 1995; McDaniel and Einstein, 1992); in the present study there was no interaction between age group and type of task.

The age-related drop in performance was substantially less in the repeated ‘regular’ tasks than in the non-recurring ‘irregular’ tasks. This finding may go some way to explaining the difference between previously reported laboratory studies, which have typically used ‘irregular’ tasks and have mostly found an age-related decline, and naturalistic studies, which have typically used ‘regular’ tasks and found no age differences or superior performance by older adults. On the other hand, the factor of regular versus irregular tasks cannot be the whole story given the substantial age decrement found in the present time-check task–which *was* a recurring ‘regular’ task (see also Einstein *et al.*, 1998). Unlike the regular PM tasks, both the time-check task and the habitual PM task used by Einstein and colleagues (1998) were linked arbitrarily and not logically to the ongoing activity. It may be that a laboratory PM task must be both regular and connected to the ongoing activity to reduce age-related decrements. Plausibly, such factors would increase the environmental support provided by the task, and in this way support the efficient performance of older adults. Another possibility is that there is a difference between targets referring to clock time of day and those involving arbitrary times. Older adults with more structured daily activities, may have greater awareness of clock time of day, as time of day could be linked to their routine activities. Rabbitt (1996) argues that there are strong links between time and activity in real life but in laboratory PM task situations there is a dissociation between time and activities. On Virtual Week there was an absence of repetition errors (in medication terms, double dosing) whereas Einstein *et al.* (1998) found repetition errors on their habitual (laboratory) PM task. Rendell and Thomson (1993, 1999) found few repetition errors on their naturalistic PM tasks.

The time-check task gave older adults considerable trouble despite its recurring nature. Table 2 shows that participants often remembered later to make a response, yet the old–old group failed to respond at all on almost 40% of occasions. One likely factor here is the dual-task set-up; concurrent performance of the board game and the time-check resulted in a divided attention situation, and this may be especially troublesome for older adults (Craik, 1977). This account is consistent with the finding by Einstein and colleagues (1998) that divided attention conditions increased the errors of young and old participants on a habitual PM laboratory task. Finally, it is worth noting that the age decrements in Virtual Week were not restricted to differences between the young participants and the others; marked differences were also found between the young–old and old–old groups, in the time-check and irregular tasks at least.

The somewhat unexpected pattern of results on Virtual Week led us to wonder what would happen if the board game was translated back into a real-life setting. Would the same pattern of strengths and weaknesses be found, or would the *actual* structures of real-life routines compensate for age-related losses? Accordingly we designed a further set of tasks to be performed over the course of an actual week of participants' lives. We called this second study 'Actual Week' and attempted to duplicate the PM tasks of Virtual Week as accurately as possible. In addition, given the enthusiastic participation of our older volunteers in Virtual Week we recruited the majority of them to participate again in Actual Week. The same young participants were not available, and so a new group of young adults was recruited from the same source as before. The motivation for the second study was exploratory; we wished to compare age-related trends on the two tasks using the same (or similar) participants.

EXPERIMENT 2 ACTUAL WEEK

This experiment takes the next step in resolving the paradoxical age-related findings on previous naturalistic and laboratory studies. In Experiment 1, the paradox was explored with Virtual Week. This is a laboratory PM task that was made as naturalistic as possible replicating everyday PM tasks within a simulation of real life. The finding of a substantial age-related decline on PM tasks within Virtual Week was consistent with previous demanding laboratory tasks rather than with previous naturalistic PM studies. This experiment takes the critical next step by simulating the laboratory PM study within a naturalistic setting. Actual Week was designed to replicate Virtual Week in a naturalistic setting over seven chronological days. In a sense, Actual Week takes the virtual reality full circle. The PM tasks in Actual Week are either a replication or a close match of the

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plausible PM tasks in Virtual Week. The regular tasks are repeated while the time-check and irregular tasks are matched closely. The PM tasks are still hypothetical. As in Virtual Week, participants do not have to undertake the tasks physically but instead of telling the researcher about the PM task, they tell a micro-recorder about the task at set times (time-based tasks) or when set events occur (event-based tasks). A micro-recorder with time-stamp function was used to verify the time participants carried out the PM tasks. A distinguishing feature of laboratory tasks is the restriction of the use of external aids, such as written notes. Actual Week participants were explicitly instructed not to use such external memory aids.

The Virtual Week and Actual Week paradigms provide for the first time a direct comparison of the age-related performance on naturalistic and laboratory PM tasks. Unlike previous studies, the comparison of naturalistic and laboratory PM tasks does not confound the type of task. On the basis of the Virtual Week findings, a substantial age-related decline was expected on the irregular and time-check PM tasks, with minimal age differences on the regular tasks. The findings of previous PM studies also suggest an age-related decline on the irregular PM tasks. Contrary to the predictions based on Virtual Week, however, the findings of previous naturalistic studies suggest superior performance by older adults on the regular PM tasks. The regular tasks were similar to typical PM task in previous naturalistic PM studies where superior performance by older adults has been demonstrated. On the other hand, the irregular tasks were different from the tasks typically used in previous naturalistic PM studies and were somewhat similar to those used in previous laboratory PM studies that have demonstrated an age-related decline.

Method

Participants

A total of 48 adults participated in the experiment; 16 young, 16 young–old, and 16 old–old. The older adults were those who participated in Experiment 1; four young–old and four old–old participants from the first experiment were not available to participate in Experiment 2. The young adults were undergraduate students from the University of Toronto, as in Virtual Week; their ages ranged from 18–36 years ($M = 23.1$ years, $SD = 4.2$ years). They were all in good health and were paid for their participation. The mean ages for the young–old and old–old groups were 67.9 years ($SD = 3.4$ years) and 78.9 years ($SD = 2.2$ years) respectively. These older participants were not paid but were reimbursed for travel expenses.

Materials and procedures

In Actual Week, participants were given 10 PM tasks to perform on each of seven successive days. As in Virtual Week there were four regular (recurring) tasks, four irregular and two time-check tasks. As in Experiment 1, participants did not actually carry out the PM tasks but recorded them on a portable micro-recorder which had a time-stamp function. Participants received full instructions about the regular and time-check tasks in a briefing before the experiment started. Instructions for the four additional irregular tasks on each day were given on a daily task sheet that was read at the beginning of each day.

The four regular tasks were the same ‘take medication’ tasks as in Virtual Week; two of these were time-based (at 11 a.m. and 9 p.m.) and two were event-based (at breakfast and dinner). The four irregular tasks presented on each day always comprised two time-based

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tasks and two event-based tasks, for example 'at 12 noon, phone insurance to arrange an appointment' and 'when you first open the fridge in the afternoon or evening, check there is enough butter'. The event-based tasks were similar in content to those in Virtual Week but they had different targets. In Virtual Week, the targets were the hypothetical events described in the event cards that participants were required to read as they circuited the board to complete a virtual day. In Actual Week, the targets for event-based tasks were actual events in the participants' lives. The tasks and events were the same for each participant. The events chosen were those we thought very likely to happen in normal daily living. It was emphasized in the briefing that these target events must occur before participants responded with the hypothetical task. The irregular tasks were selected so that the requirement to do a task at a certain time (or in relation to a set event) was plausible. Connections that are too obscure and too obvious were avoided. Other tasks and event targets included 'lock back door, the first time you put on outdoor shoes and/or coat'; 'close curtains when switching the lights on in the evening'; 'check you have some small change when eating lunch'. The two time-check tasks simulated the time-check tasks in Virtual Week by requiring participants to do a time-check in relation to the two daily event-based irregular PM tasks; 60 minutes after first 'daily event' and 30 minutes after the second 'daily event'.

Procedures

The older adults completed Actual Week about six months after completing Virtual Week. All participants were given a pre-task briefing on the day prior to commencing, involving an introduction to Actual Week, briefing on the regular, irregular and time-check tasks, briefing on general procedures, and training in use of the micro-recorder. They were given a package containing daily task sheets (in separate envelopes) and an instruction sheet outlining the general procedures and information on using the micro-recorder. The instruction sheet did not contain any details of the PM tasks and could be checked at any time, but the daily task sheet was not to be read until the morning of the appropriate day. After reading the daily task sheet, participants were instructed to return the sheet to the envelope and not check it again. Briefly, the general procedures involved: instructions on how participants were to get the details of the four irregular tasks for each day; the need to try to remember the precise message at set times without making notes; what to do if participants were unable to record a message at a set time; what to do if late, and what to do if not sure of the precise message. If not sure of a message at a set time or event, the instructions were to still record a message, even if the message was of the type 'It is 10 a.m.; I know I have to do something, but can't remember what it is'. Finally, participants were strictly instructed that they should NOT use notes of any kind.

Results

As in Virtual Week, responses on the PM task were classified with regard to accuracy of content and how close they were to the target time or event. In Actual Week 'on-time' was defined as within 5 minutes. In this experiment there were some occasions on which participants could not carry out the PM task; for example, the event did not occur, the person was in a meeting, or a target time was missed because the participant slept late. The percentages of such occasions were 10%, 4%, and 4% for the young, young–old, and old–old groups respectively. The proportions of correct responses are therefore expressed as proportions of the total number of possible PM tasks.

The overall results are shown in Figure 3. The pattern of results is clearly different from Virtual Week; in the present case the older adults mostly outperform the young adults. In particular, the older groups scored well on the irregular tasks, in contrast to their poor performance on this category in Virtual Week. A 3(age) × 3(type of task) ANOVA was carried out on the data shown in Figure 3. The analysis revealed main effects of both age group, $F(2, 45) = 3.97$, $MSE = 0.11$, $p < 0.05$, and task, $F(2, 90) = 102.00$, $MSE = 0.03$, $p < 0.001$, as well as of their interaction, $F(4, 90) = 2.86$, $MSE = 0.03$, $p < 0.05$. Analysis of the significant interaction between age and PM task revealed a significant effect of PM task within each age group: $F(2, 90) = 29.23$, 20.33 and 58.15, $MSE = 0.03$, all ps < 0.001, for young, young–old and old–old respectively. Tukey *post-hoc* tests showed that for each age group the proportion correct on time-check tasks was significantly lower than on both regular and irregular tasks. The young and old–old groups were both significantly more accurate on the regular than irregular tasks, but the performance of young–old participants did not differ between these two tasks. Further analyses revealed that age was a significant main effect within regular tasks, $F(2, 45) = 5.86$, $MSE = 0.02$, $p < 0.01$, and irregular tasks, $F(2, 45) = 6.04$, $MSE = 0.04$, $p < 0.01$, but age was not significant within time-check tasks, $F(2, 45) = 2.34$, $MSE = 0.11$, $p > 0.05$. Tukey *post-hoc* tests showed that the young group had lower proportions correct than both young–old and old–old groups on regular and irregular tasks, but that on these tasks the young–old and old–old groups did not differ significantly.

With regard to the different types of PM task, Table 3 shows the proportions of correct responses on event-based and time-based PM tasks. No differences were found between these two types of task in Virtual Week, but Table 3 shows that event-based tasks were performed better than time-based tasks in Actual Week. Within the regular tasks, an ANOVA revealed significant effects of age, $F(2, 45) = 5.86$, $MSE = 0.04$, $p < 0.01$, and type of task, $F(1, 45) = 57.05$, $MSE = 0.03$, $p < 0.001$, but no interaction between age and type of task, $F(2, 45) = 1.13$, $MSE = 0.03$, $p > 0.05$. Similarly, within the irregular tasks an ANOVA revealed significant effects of age, $F(2, 45) = 6.04$, $MSE = 0.07$, $p < 0.01$, and of event-based versus time-based tasks, $F(1, 45) = 75.23$, $MSE = 0.02$, $p < 0.001$, but no interaction between the two variables, $F(2, 45) = 1.23$, $MSE = 0.02$, $p > 0.05$. In summary,

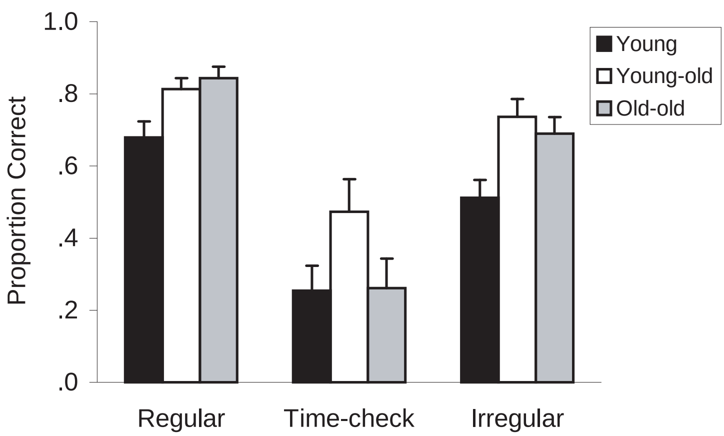

Figure 3. Mean proportions of correct responses on Actual Week by each age group for the three types of PM task. Bars represent one standard error of the mean

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Table 3. Mean proportion of correct responses on the event-based and time-based PM tasks as a function of age group and type of task (Actual Week)

		Age group					
		Young		Young–old		Old–old	
Type of task		Event	Time	Event	Time	Event	Time
Regular tasks	*M*	0.85	0.51	0.93	0.69	0.95	0.74
	SD	0.16	0.25	0.15	0.23	0.07	0.21
Irregular tasks	*M*	0.66	0.36	0.83	0.64	0.83	0.55
	SD	0.24	0.22	0.20	0.22	0.12	0.28

Note:
'Event' = event-based PM tasks.
'Time' = time-based PM tasks.

there was a similar pattern of results on regular and irregular tasks. On both tasks, participants were significantly better on event-based than on time-based tasks, but this effect did not interact with age. That is, events provided more support to trigger the PM response than times, but older participants were not helped differentially by this factor. There is another possibility that the difference between event and time-based PM tasks reflected the larger time window for event-based tasks. The time-based tasks had to be carried out within 5 minutes of a specified time (as verified by the time-stamp on the micro-recorder) but the event-based tasks had presumably longer periods over which participants could report that they were on-time. This can be illustrated with target event of dinner. Participants may have taken up 1-11/2 hours to have dinner, and over this extended period participants could presumably claim to have responded 'on-time'. This closely follows Ellis's (1988) PM task distinction between *pulses* with a specific point for retrieval, and *steps* with a wider time window.

As in Virtual Week, there was considerable variation in performance of the irregular PM tasks in Actual Week, ranging from 44% to 95% correct. The best-performed tasks tended to be event-based tasks that occurred in the morning (e.g. 'Put pets outside when you first leave the house' 95%; 'check for bill when picking up your mail' 95%), and the worst-performed tasks tended to be time-based tasks that specified times later in the day (e.g. 'book test for new reading glasses at 1 p.m.' 44%; 'meet friend at train at 6 p.m.' 51%). Thus, as in real life, successful performance of PM tasks appeared to be helped by event cues rather than times, and also to be helped by relatively short intervals between forming the intention and the occasion for action.

Table 4 shows the pattern of errors on Actual Week. As in Virtual Week, participants made relatively few wrong responses; when such responses were made, they were to irregular tasks, and the proportions did not vary with age. The young group made more late responses than the two older groups. In all groups late responses were typically made to time-based rather than event-based tasks. On the regular and irregular tasks, young participants were most likely to fail to respond at all ('miss'); but on the time-check task, performance was U-shaped with age in that now the oldest group was most likely to forget to respond.

The main findings of interest in Experiment 2 are first the superior performance of older participants in both regular and irregular PM tasks, and the superior performance of the young–old group on the time-check task. It is noteworthy that the older groups did well on the irregular tasks as well as on the regular ones. This finding makes it less likely that the

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Table 4. Proportions of correct responses and different types of error for three age groups (Actual Week)

PM task:	Regular			Time-check			Irregular		
Age group:	Y	Y–O	O–O	Y	Y–O	O–O	Y	Y–O	O–O
On-time[a]									
Correct	0.68	0.81	0.85	0.24	0.46	0.26	0.51	0.74	0.69
Wrong[b]	0.01	0.00	0.01	0.00	0.00	0.00	0.06	0.07	0.07
Late	0.22	0.15	0.09	0.26	0.20	0.12	0.18	0.09	0.11
Miss[c]	0.09	0.04	0.06	0.51	0.34	0.62	0.25	0.10	0.14

[a]On-time was within 5 minutes.
[b]Includes trials in which participants remembered that they should do something, but had forgotten content.
[c]This category includes occasional responses that were both late and had incorrect content.

previously discussed discrepancy between laboratory-based and naturalistic studies is due to the former using irregular tasks and the latter using regular tasks. Second, all participants performed event-based tasks better than time-based tasks, but this effect did not interact with age. Third, the pattern of errors showed relatively few misses on regular tasks, rather more such failures to respond at all on irregular tasks (especially for the young group), and a U-shaped pattern with age group in the time-check task. In this case the generally excellent performance of the old–old group did not hold up.

GENERAL DISCUSSION

Before contrasting performance on Virtual Week and Actual Week it may be asked to what extent the observed age differences in PM might be due to age-related differences in *retrospective* memory (RM). It seems likely that RM failures played some part but that such failures cannot account for the total pattern of errors show in Tables 2 and 4. RM problems could be associated either with forgetting the PM cues or forgetting of the appropriate PM responses. In the latter case, participants would have given a wrong response or indicated that they had forgotten the response. Tables 2 and 4 show that the older adults did make a substantial number of such errors on the irregular tasks in Virtual Week (17% and 20% for young–old and old–old respectively) but this number decreased in Actual Week, possibly because of the greater opportunity to learn the responses. Failures to respond at all to irregular cues could indicate a failure of either PM or RM; it is not possible to tease these factors apart in the present study. On the other hand, misses on the regularly recurring time-check tasks must be attributable to PM failures, and there are substantial numbers of such errors for older participants in Virtual Week, and for all participants in Actual Week.

The main reason for carrying out the present experiments was to explore the apparently paradoxical results of previous studies regarding age-related differences in PM tasks, namely that whereas older adults are typically poorer than their younger counterparts on laboratory tasks, they are often superior on naturalistic tests of PM. We had hoped to show that older adults could perform well on laboratory-based PM tasks if the task was one in which the older person could use the simulated structure of a typical day to support performance. However, the results of Virtual Week showed a clear age-related fall in

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performance on both time-based and event-based tasks. This age-related decline was less on regularly recurring tasks. The pattern of results on Actual Week was quite different; in this case performance on all three types of PM task (regular, irregular, and time-check) *improved* from the young to the young–old group, with old–old participants performing at the young–old level, for the first two types of tests at least.

With respect to the regular and irregular tasks, the age-related patterns were thus exactly opposite in Virtual Week and Actual Week. Possible reasons for this discrepancy are considered below. For the time-check task, performance levels on Virtual Week and Actual Week were quite similar for the young–old and old–old groups. Tables 2 and 4 show that the young–old group's scores were 0.47 and 0.46 on Virtual Week and Actual Week respectively; the corresponding scores for the old–old group were 0.34 and 0.26. The young group's performance levels were dramatically different however; in Virtual Week they scored 0.72 and for Actual Week only 0.24. It seems that in a short-term game situation the young participants were able to keep the time-check task in mind sufficiently to perform quite well, but that this ability disappeared under the much longer-term conditions of Actual Week, where presumably many other real-life tasks were competing for attention. Much the same account can be given for the regular tasks, where the Virtual Week and Actual Week scores are 0.89 and 0.81 for the young–old group, 0.82 and 0.85 for the old–old group, but 0.93 and 0.68 respectively for the young group. Again it seems that young participants could concentrate on the task during the short-term game situation, but failed to bear the task in mind in the real-life situation.

Age-related comparisons between Virtual Week and Actual Week for the irregular tasks are more complex. Performance of the young group again falls from 0.70 to 0.51 from Virtual to Actual Week, but performance levels *rise* for the two older groups — from 0.41 to 0.74 in the case of the young–old group, and from 0.22 to 0.69 for the old–old group. It therefore seems that the paradoxical reversal of performance levels for younger and older adults between laboratory-based and real-life PM tasks is a consequence both of an inability (for one reason or another) of young adults to maintain the PM task set in real-life situations, and a greater ability of older adults to do so.

The reasons for this age-related switch in abilities are still somewhat unclear, although the present experiments make some factors unlikely. First, the difference between laboratory and real-life tasks does not seem to be simply due to the greater use of aids by older people in naturalistic tasks. Few participants in the Rendell and Thomson (1999) study reported using aids, with older reporting less use than younger participants, and in the present Experiment 2 participants were quite clear in the debriefing interview that they had not used aids. Second, if the greater structure of daily living in older adults is a factor, it is either not a *strong* factor or does not generalize to parallel laboratory tasks, given the poor performance of older adults on Virtual Week. Third, the distinction between event-based and time-based tasks is also not crucial for resolving the paradox, apparently, given the absence of age-related interactions with this factor in both present experiments. The explanation of the age-related switch appears to come down to two key differences between the laboratory and naturalistic PM situation; the nature of ongoing activities (set by researcher versus the participants' real life) and the time span (up to an hour or so versus several days).

The superior performance of older adults on real-life PM tasks cannot be due simply to their (arguably) more structured daily lives, given the age-related decline on Virtual Week where all participants had the same structured (simulated) pattern of daily activities as the backdrop for the PM tasks. Structure alone is not enough apparently; it is possible that the

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older adults' superiority on Actual Week is due to participants having their own real activities as the backdrop for the PM tasks. One way this could be checked is by testing groups of young and old with similar daily activities, such as groups of younger and older adults working in similar occupations. A further consideration for the structure of daily living explanation is the possibility that Virtual Week has not captured some key aspect of daily structure. For example, perhaps Virtual Week did not capture the predictability element, which is also a possible feature of older adults' lives. In Virtual Week, activities reveal themselves slowly as the day unfolds. The event cards remain hidden and unread until the participant passes the appropriate square for each event card. However, some of the activities were predictable, such as the three regular meals each day. Despite the doubts whether Virtual Week captures the predictability element, the comments of participants suggested that Virtual Week does imitate the structure of daily lives. During the game, participants often provided a spontaneous running commentary which showed that they had identified with the PM tasks and the event-card activities. Participants found that Virtual Week did not always match their personal lives exactly, but that the game did provide a reasonable fit and generally captured the ebb and flow of their ordinary daily activities.

The alternative to the structured life explanation relies on another critical difference between Virtual Week and Actual Week: the PM tasks being spread over a much longer time in Actual Week compared to Virtual Week. Typically laboratory PM tasks are confined to time periods of less than one or two hours, whereas naturalistic PM tasks are usually spread over several days. This alternative view involves the rather general suggestions that younger adults were superior on Virtual Week because they can maintain a set of PM intentions over the short term, provided that they are motivated to do so and that no other important tasks intervene. On the other hand, it seemed from participants' comments that the older adults took the Actual Week tasks more seriously than did the young adults, and therefore spent more time thinking about them and also more time in learning the set of irregular tasks for that day. Our suggestion is therefore that younger adults are better than their older counterparts at PM tasks, just as they are at tasks involving retrospective memory, and that this superiority may be most marked in situations involving many irregular time-based and event-based tasks — as in the time-check and irregular tasks in Virtual Week. However, this age-related decline can be compensated for, and even reversed, in real-life situations where there is time and motivation to learn the tasks well and opportunity to contemplate and rehearse them in preparation for the occurrence of the target time or event. The obvious test of this conjecture is to set up a real-life situation in which young adults are strongly motivated to succeed. Our prediction is that in such a situation, young adults would outperform older adults and that performance on laboratory-based and naturalistic tasks would therefore be aligned.

Such an outcome would support the general conclusion that young adults are basically superior on PM tasks, but that this superiority is reversed in naturalistic tasks, where older adults typically exhibit greater levels of motivation. However, this account does not address the contrast between irregular tasks performed in the laboratory and in real life by the present young–old and old–old groups (Tables 2 and 4). Presumably both groups of older adults have similar motivations for the laboratory PM tasks and similar motivation for the naturalistic PM tasks. In any event, it is clear that even with a very challenging naturalistic PM task, older adults are impressively accurate and are able to compensate for the difficulties they have on shorter-term PM tasks in laboratory settings.

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AUTHOR NOTES

Peter Rendell was on leave at the University of Toronto, and has now returned to the Australian Catholic University, Melbourne, Australia. Reprints may be obtained either from: Dr. Peter Rendell, School of Psychology, Australian Catholic University, Locked bag 4115, Fitzory Vic 3065, Australia; or from Dr. Fergus Craik, Rotman Research Institute, Baycrest Centre for Geriatric Care, 3560 Bathurst St., Toronto, ON, Canada, M6A 2E1.

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