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Aberle, Ingo, Rendell, Peter G., Rose, Nathan S., McDaniel, Mark A. and Kliegel, Matthias

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The Age Prospective Memory Paradox: Young Adults May Not Give Their Best Outside of the Lab

Ingo Aberle,
Department of Psychology, Technische Universität Dresden, Dresden, Germany

Peter G. Rendell,
School of Psychology, Australian Catholic University, Melbourne, Australia

Nathan S. Rose,
Department of Psychology, Washington University in St. Louis

Mark A. McDaniel, and
Department of Psychology, Washington University in St. Louis

Matthias Kliegel
Department of Psychology, Technische Universität Dresden, Dresden, Germany

Abstract

Previous research has identified the age prospective memory paradox of age-related declines in laboratory settings in contrast to age benefits in naturalistic settings. Various factors are assumed to account for this paradox, yet empirical evidence on this issue is scarce. In 2 experiments, the present study examined the effect of task setting in a laboratory task and the effect of motivation in a naturalistic task on prospective memory performance in young and older adults. For the laboratory task (Experiment 1, $n = 40$), we used a board game to simulate a week of daily activities and varied features of the prospective memory task (e.g., task regularity). For the naturalistic task (Experiment 2, $n = 80$), we instructed participants to try to remember to contact the experimenter repeatedly over the course of 1 week. Results from the laboratory prospective memory tasks indicated significant age-related decline for irregular tasks ($p = .006$) but not for regular and focal tasks. In addition, in the naturalistic task, the age benefit was eliminated when young adults were motivated by incentives ($F < 1$). In conclusion, the present results indicate that the variability of age differences in laboratory prospective memory tasks may be due in part to differences in the features of the prospective memory task. Furthermore, increases in motivation to perform the prospective task seem to help remedy prospective memory deficits in young adults in the naturalistic setting.

Keywords

prospective memory; age paradox; task setting; motivation; delayed intentions

Prospective memory is referred to as the ability to remember delayed intentions (e.g., taking medication at prescribed times, keeping an appointment at 3 p.m., or giving a message when meeting a friend; McDaniel & Einstein, 2000). Conceptually, prospective memory is contrasted with retrospective memory, which is defined as remembering information from

Correspondence concerning this article should be addressed to Matthias Kliegel, Department of Psychology, Technische Universität Dresden, D-01062 Dresden, Germany. kliegel@psychologie.tu-dresden.de.

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the past (e.g., recalling a word list, remembering what one did last summer or where one put the keys; Einstein & McDaniel, 1990). Prospective memory is an essential ability to meet everyday life challenges across the lifespan, constitutes a key element of developing autonomy and independence, and is especially important in old age with its increasing health-related prospective memory demands. Therefore, understanding mechanisms underlying prospective memory in old age has become a major effort in applied developmental research (e.g., Kliegel, Rendell, & Altgassen, 2008; McDaniel & Einstein, 2007).

Thus far, research on prospective memory in old age has revealed an intriguing age-related pattern: On average, younger adults tend to outperform older adults in laboratory-based prospective memory tasks (defined as studies carried out in the laboratory during a testing session controlled by the experimenter; e.g., d'Ydewalle, Luwel, & Brunfaut, 1999; Maylor, 1993a, 1996; Vogels, Dekker, Brouwer, & de Jong, 2002), whereas older adults outperform younger adults in naturalistic tasks (defined as studies carried out in the everyday environment of the participant; e.g., Devolder, Brigham, & Pressley, 1990; Rendell & Thomson, 1993, 1999). These results have been reinforced in a meta-analysis on 26 prospective memory studies showing that for naturalistic tasks, older adults displayed substantially higher prospective memory performance than did younger adults (Henry, MacLeod, Phillips, & Crawford, 2004). Moreover, the age-related deficits of older adults in laboratory-based prospective memory tasks seemed equivalent in magnitude to the age-related benefits observed in naturalistic prospective memory tasks. Together, these findings have been referred as the *age prospective memory paradox* (Rendell & Craik, 2000), and it remains a major puzzle for applied developmental research (Phillips, Henry, & Martin, 2008; Rendell, McDaniel, Forbes, & Einstein, 2007).

In further considering the paradox, recent reviews have identified a handful of factors that may be associated with this pattern, for example, use of reminders, task setting, motivation, structuredness of life, and personality factors such as attitudes of politeness (Kliegel, Rendell, & Altgassen, 2008; McDaniel, Einstein, & Rendell, 2008; Phillips et al., 2008). Findings on the structuredness of life as a possible mediator are mixed and unclear (see, e.g., Rendell & Craik, 2000; but see also Rendell & Thomson, 1999). In addition, there is very little research bearing on the speculation that attitudes of politeness are involved in the paradox (see Phillips et al., 2008), and we did not focus on those factors in the present study. Perhaps the most popular explanation to date in the literature has been the greater use of reminders and external cues by older adults in naturalistic settings, but Phillips et al.'s (2008) review convincingly demonstrated that there is little empirical support for this prevailing view. Indeed, these researchers observed that studies often cited as providing evidence for the reminder/external cue explanation (e.g., Maylor, 1990; Rendell & Craik, 2000) clearly do not support the claim that the age benefits in naturalistic settings were a function of older adults' greater use of external cues. For instance, Rendell and Craik (2000) explicitly instructed participants not to use external reminders and found that older adults outperformed young adults on naturalistic prospective memory tasks. Further, Rendell and Thomson (1999) did not instruct participants on use of reminders in their naturalistic prospective memory task but found that young adults reported greater use of external reminders. Nevertheless, older adults still outperformed young adults on the naturalistic prospective memory task. In their review, McDaniel et al. (2008) pointed out the importance of task setting (e.g., task focality) in accounting for the emergence of age differences in laboratory tasks. Phillips et al. (2008) argued that motivation to perform a prospective task might be the critical factor regarding the paradoxical findings, especially in naturalistic tasks. As those two factors have been suggested as key mechanisms potentially underlying the paradox, the present study targeted these variables.

For laboratory-based studies, McDaniel et al. (2008) have argued that task setting may affect the amount of processing resources required by the prospective memory task. Pertinent to the present concerns, these authors argued that variations in age effects may be a function of whether the prospective memory tasks depend (a) on strategic, attention-demanding processes, which would lead to an age deficit, or (b) on more automatic processes, which would lead to spared age-related performances. Two task features have been highlighted that may particularly determine the amount of strategic processing resources involved: task focality (Einstein & McDaniel, 2005; McDaniel & Einstein, 2000) and task regularity (Kliegel, Rendell, & Altgassen, 2008; Rose, Rendell, McDaniel, Aberle, & Kliegel, in press).

Task focality represents the extent to which the prospective memory task involves overlapping processing with the ongoing task (McDaniel & Einstein, 2000; McDaniel et al., 2008). A task is referred to as focal if the cue of the prospective memory task is directly processed while performing the ongoing task. For example, when the ongoing task consists of naming famous faces, remembering to circle the item number whenever *John* is the name of the famous person might be regarded as a focal (event-based) prospective memory task. In contrast, remembering to circle the item number whenever the famous person is wearing glasses can be regarded as nonfocal to the ongoing task of recalling names of famous persons shown (Rendell, McDaniel, et al., 2007). Whereas only a few studies have explicitly tested this assumption, a recent meta-analysis that classified available paradigms as rather focal (e.g., Logie, Maylor, Della Sala, & Smith, 2004; while watching a film, participants were instructed to look out for animals and respond by saying “animal” whenever seeing one) versus rather nonfocal (e.g., Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; words were presented and participants were asked to keep the last three words in memory; in addition, one of the six background patterns served as prospective cue) suggested that prospective memory tasks using rather nonfocal cues showed significantly greater age deficits than tasks using rather focal cues (see Kliegel, Jäger, & Phillips, 2008).

The second task feature targeted in the present study, *task regularity*, concerns the pattern of cue presentations in a prospective memory task. In regular tasks, the cues are presented in a consistent routine. Thus, the appearance of a prospective memory cue is more predictable, because preceding situational cues can be used to prepare for the appropriate moment. In contrast, as in most laboratory studies, irregular tasks show no consistent pattern and occur somewhat arbitrarily. In consequence, this should result in a higher monitoring load, thereby producing significant age-related deficits in prospective memory. Thus far, only one published study has directly tested this expectation. Using a Virtual Week paradigm to simulate everyday life across a number of days, Rendell and Craik (2000) instructed younger and older adults to perform regular and irregular prospective memory tasks. The regular tasks were repeated each virtual day and were the same tasks with the same prospective memory targets, simulating, for example, taking medication at breakfast each day, whereas irregular tasks were one-time only tasks and simulated one-off tasks such as returning a library book when being at the library next. Importantly, task regularity was the one feature to interact with age, with age-related deficits being substantially attenuated on regular tasks compared with irregular tasks.

In Experiment 1, we considered both of the above task features in order to confirm and extend the previous results just described. Specifically, using a new computer version of the Virtual Week paradigm, we directly compared young and older adults' performances in regular and irregular tasks. We predicted that an age deficit should only emerge in irregular tasks, whereas regular tasks should show no or reduced age differences. Besides regular and irregular daily activities embedded in the original board game Virtual Week, Rendell and Craik (2000) also reported substantial age deficits in a third task type, in which participants were instructed to monitor a continuous external timer to perform regular time-check tasks. In the original board game, this timer was placed next to the board outside of participants' focal awareness. In contrast, in the present version, we have increased the focality of this task by placing the timer prominently in the middle of the virtual board, directly in focal awareness. Following the multiprocess framework, the researchers predicted that increasing the focality of this task should result in diminishing age deficits on a time-check task compared with the reported age differences by Rendell and Craik (2000).

A second factor, motivation, has been assumed to underlie age differences in prospective memory performance (Phillips et al., 2008). Thus far, no published study has experimentally tested the effect of motivation on age differences in prospective memory.[1] With regard to motivational effects in the naturalistic age benefit, a potential mechanism might be that either older adults are more motivated to perform a prospective memory task in their everyday life or younger participants may show a suboptimal performance level in naturalistic tasks as a result of a lower level of motivation to complete prospective memory tasks in their everyday life. The latter might be due to prospective memory instructions competing with current concerns and real everyday tasks. This might be particularly true when the incentive to perform the prospective memory task consists of course credits in academic studies, which is the case in most studies where undergraduate students take part as the young participants group (Maylor, 1993b). Importantly, course credits do not necessarily provide an incentive, as they typically are not dependent on the level of performance. Yet, other factors (e.g., less structured lifestyle; see Henry, Rendell, Kliegel, & Altgassen, 2007) might also affect low performance of younger adults in naturalistic prospective memory tasks. In this case, increasing motivation might help young adults to overcome those restraints. In Experiment 2, we examined the effects of motivation on age-related performance in a naturalistic prospective memory paradigm. In order to induce a high motivation level, the researchers provided a monetary incentive to half of the sample (see Touron, Swaim, & Hertzog, 2007). A decreased age benefit was expected, with motivation especially benefiting younger participants.

Experiment 1

Method

Participants—Forty participants took part in the study: 20 young adults and 20 older adults from the city and surrounding area of Zurich, Switzerland (see Table 1 for participants' characteristics). Young adult participants were undergraduate students at the University of Zurich, Switzerland, recruited through announcements in classes, and given course credits or 20 Swiss francs (approximately 19 U.S. dollars) for their participation in the study. The older adults were recruited from local senior citizen groups and were given 20 Swiss francs for their participation. All participants were Swiss–German native speakers and of White European background; family socioeconomic status was not assessed. Participants were asked to rate their current health as well as their health over the previous month on a 5-point Likert scale, ranging from 1 (*poor*) to 5 (*excellent*). Young and older participants did not differ in current health, $t(37) = 0.73$, $p > .05$, or in previous health, $t(37) = 1.27$, $p > .05$, but more older adults than younger adults took medication, $\chi^2(1) = 4.67$, $p < .05$. Furthermore, the two age groups did not differ significantly in years of education, $t(37) = 0.56$, $p > .05$. Older adults had significantly higher Mehrfachwahl-Wortschatz-Test (MWT) vocabulary scores than did younger adults (a German word vocabulary test; Lehrl, 2005), $t(37) = 2.71$, $p < .01$; Cohen's d = 0.86; (Cohen, 1988, defines effect sizes of 0.2 as

[1]In an unpublished data set from our own lab, results indicate that by manipulating motivation, age differences between younger and older adults were eliminated in a laboratory setting (see Kliegel, Martin, McDaniel, & Einstein, 2001, 2004, for motivation effects only in younger adults).

small, 0.5 as medium, and 0.8 as large). In contrast, younger adults outperformed older adults on the Digit Substitution test (German version of the Wechsler Adult Intelligence Scale [WAIS]; Wechsler, 1981), $t(37) = 6.41$, $p < .001$, Cohen's $d = 2.03$; the Digit Span test of the WAIS, $t(37) = 2.11$, $p < .05$, Cohen's $d = 0.67$; and the Stroop test (Stroop, 1935), $t(37) = 11.41$, $p < .001$, Cohen's $d = 3.61$. No age differences were found at baseline on the Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford, Smith, Maylor, Della Sala, & Logie, 2003), neither on prospective errors, $t(37) = 0.85$, $p > .05$, nor on retrospective errors, $t(37) = 0.35$, $p > .05$.

Materials—A computer version of the board game Virtual Week was used as the laboratory measure of prospective memory. This measure was designed to represent prospective remembering in daily life. Virtual Week has revealed robust prospective memory deficits both in the context of normal adult aging (Rendell & Craik, 2000) and in relation to various clinical groups (Henry et al., 2007; Rendell, Gray, Henry, & Tolan, 2007; Rendell, Jensen, & Henry, 2007; see also Rendell & Henry, 2009, for a review of the psychometric properties of Virtual Week). This computer version closely followed the original manual version outlined in Rendell and Craik (2000) and was developed to provide a more efficient and flexible measure. The computer version did not change the essential elements of the activity. Figure 1 shows the Virtual Week board as it was displayed on the computer screen except that the screen display was in color. In addition, in the current study, all of the text was presented in German.

Virtual Week has a board game format that simulates a course of a week in everyday life. The consecutive hours of the day people are typically awake are marked on the board, and one round on the board represents one virtual day. As participants move around the board, they are required to make choices about plausible daily activities that are relevant to the virtual time of day and remember to carry out life activities (i.e., prospective memory tasks). Participants must roll a six on the dice before starting to move on the board, simulating waking up from sleep. The choices about daily activities occur when reading the event cards, which take place whenever passing or moving on an event square on the board (squares labeled E). When passing such an event square, participants must select the event-card button, whereon a window appears with the information of a daily activity; participants must then choose between three options. Choosing an option determines the roll of dice that is required to move forward (e.g., roll an even/odd number, a set number, or any number). These three types of possible dice rolls are randomly allocated to the three activity choices on each event card. In summary, each event card describes an activity and gives three options for participants to choose with different dice-rolling consequences. The activities on the event cards correspond to the virtual time of day (e.g., an event concerning breakfast will appear in the morning). Furthermore, three meals, everyday at the same time of the day, establish some sort of structure on the virtual day. Therefore, these tasks serve as backdrop for the prospective memory tasks, by creating the structure of a typical daily routine.

Similarly, the prospective memory tasks used in Virtual Week are also coherent daily activities: typical daily tasks from daily life and tasks that are plausibly connected to the daily activities revealed in the event cards. As in the original Virtual Week study, participants did not have to complete these hypothetical but plausible tasks; rather they told the experimenter about them at set times. Each day (circuit) of Virtual Week includes 10 prospective memory tasks (four regular, four irregular, and two time-check tasks), and in this study, participants completed five virtual days. The four regular prospective memory tasks simulate the kinds of regular tasks that occur as one undertakes normal duties, two of which are time-based (i.e., triggered by passing a particular time on the board) and two of which are event-based (i.e., triggered by some information shown on an event card serving as a cue and can therefore only be performed after the appropriate event occurred). The tasks are “take asthma medication at 11 a.m. and 9 p.m.” and “take antibiotics at breakfast and dinner” (triggered by event cards featuring breakfast and dinner). These tasks had the same content (e.g., take antibiotics) and same target (e.g., breakfast) for every day. Rendell and Henry (2009) noted that this time-and event-based distinction needs qualifying, as the time-based tasks could be characterized as event-based tasks given that the time of day was indicated by consecutive hours of the day marked on squares of the board. Previous studies with Virtual Week have not revealed differences on time- versus event-based prospective memory tasks; therefore, the present study did not focus on this distinction.

The two time-check tasks require the participant to break set from the board game activity and monitor real time on the stop-clock that was displayed prominently. The stop-clock starts every virtual day and participants are asked “to do a lung test” at two occasions—at 2 min 30 s and at 4 min 15 s—by telling the experimenter. Together, the critical feature of the regular tasks and the time-check tasks are that they are the same every day of the game, and participants are informed about the tasks before the start of the game. The stop-clock times are not connected to the events or the virtual time of day in Virtual Week, whereas the targets for the regular events are either events or virtual times of day in Virtual Week. In addition, the regular event-based tasks were at similar virtual times of day.

The four irregular prospective memory tasks represent unforeseen tasks that occur while doing normal daily activity (e.g., returning a library book for a friend when being at the library or phoning a plumber at 4 p.m.). Here, the critical features of irregular tasks are that the participants are informed during the game and the tasks are all different, that is, one-at-a-time tasks that are not repeated (each day had a different set of irregular tasks). The instructions of those tasks occur either at the beginning of each circuit on the start card that has to be displayed at the beginning of each day or is displayed during a virtual day on an event card. Like regular tasks, the irregular tasks consist of two time-based and two event-based prospective memory tasks.

At the beginning of each virtual day, one time-based task and one event-based task were presented on the start card, whereas one time-based task and one event-based task occurred during the game. As in the original version, participants completed a trial day that included four irregular prospective memory tasks but were not informed about the regular tasks and the time-check tasks until after they had completed the trial day. This was to avoid overwhelming participants with information prior to the trial day. Participants were able to become familiar with Virtual Week during the trial game and before learning the four regular tasks and two time-check tasks. They were instructed to carry out the prospective memory task by telling the experimenter about the tasks at the set times. An experimenter sat behind the participant as they played the game at the computer.

Procedure—Participants were tested individually in a session lasting up to 2 hr. At the beginning of the session, participants were informed about the following procedure, and informed consent was obtained. Afterwards, the board game was introduced. In the introduction, the purpose of Virtual Week was described to the participants. The participants were told that we were interested in their ability to remember to do things later and in the choices they will make during the game. Then the game was explained in detail. With regard to the prospective memory tasks, participants were told that tasks had to be performed at prescribed events or at a specific time square. The participants were instructed to carry out these tasks by telling the experimenter what they wanted to do. They were asked to try to remember to carry out the tasks on time but to still carry out these tasks even if they were late. In order to become engaged in the game, participants were told to read aloud the information on every event and start card. After the introduction, participants completed a practice day where the experimenter explained the procedures, checked that participants had understood the procedure, and provided an opportunity for participants to ask questions. After completing the practice day, the experimenter introduced regular and time-checking tasks, which were not included in the practice day. Before starting the regular game, participants were asked to recite three times verbatim the regular and time-check prospective memory tasks detailed. During the game, the researcher sat quietly behind the participants, who sat at a desk and played the game on their own. Participants completed five circuits of the board: five virtual days. Following Virtual Week, participants completed the questionnaires and cognitive abilities tests (for further information see Participants section).

Results

We conducted a mixed 2 × 3 analysis of variance (ANOVA) on the proportion[2] of prospective tasks correct with the within-subject variable of prospective memory task type (regular, time check, irregular) and the between-subject variable of age (young, old). The analysis revealed a significant main effect of task type, $F(2, 76) = 43.61$, $MSE = 0.03$, $p < .001$, $\eta^2 = .534$, as well as an interaction effect, $F(2, 76) = 5.73$, $MSE = 0.03$, $p = .005$, $\eta^2 = .131$, but no significant main effect of age group, $F(2, 38) = 1.23$, $MSE = 0.05$, $p > .05$, $\eta^2 = .031$ (see Figure 2). Tests of simple effects were conducted to analyze the significant interaction effect. As predicted, there were no age differences on either the regular prospective memory task or the time-check tasks (Fs < 1), but younger adults outperformed older adults on the irregular prospective memory tasks, $F(1, 38) = 8.32$, $p = .006$, $\eta^2 = .180$.

Discussion

One main finding that emerged from Experiment 1 was that task regularity affected age-related prospective memory performance in a laboratory-based study. Concerning task regularity, predictions were clearly confirmed, as age differences were eliminated in regular tasks while an age deficit emerged in irregular tasks. These results are in line with the initial findings of Rendell and Craik (2000) and directly show task regularity to be a potent factor in modulating age-related differences in prospective memory performance (see also Einstein, McDaniel, Smith, & Shaw, 1998).

A second important finding was the absence of age difference in this study on the time-check task with the stop-clock presented within focal awareness. This contrasts with the substantial age differences on the time-check task in the original study, where the stop-clock was not presented in focal awareness (Rendell & Craik, 2000). An analysis comparing performance on the focal time-check task in this study with the nonfocal time-check task in Rendell and Craik (2000, Experiment 1) indicated a significant interaction between the nature of the stop-clock task (focal—present study; nonfocal; Rendell & Craik, 2000) and the presence of age-related prospective memory decline[3] (see Footnote 3 for the complete

[2]Testing the effects applying transformed data to correct for high-level proportional scores and using nonparametric simple effects tests confirmed the pattern reported.

[3]As suggested by an anonymous reviewer, we used previously collected data from a nondigital version of Virtual Week (Rendell & Craik, 2000, Experiment 1) to provide a control group with a nonfocal clock version of the time-check task. On the time-check task, the young and older adults in this study were compared with the comparable age groups of young adults and young-old adults (61–73 years) in Rendell and Craik (2000). Applying a 2 × 2 ANOVA with the between-group variables of age group (young, old) and study (focal, nonfocal) revealed a significant interaction effect, $F(1, 76) = 9.24$, $MSE = 0.05$, $p = .003$, $\eta^2 = .108$. Further tests of simple effects indicated significant age-related deficits in the nonfocal condition, $F(1, 38) = 12.32$, $MSE = 0.05$, $p = .001$, $\eta^2 = .245$, whereas there were no age differences in the focal condition ($F < 1$). In addition, younger adults did not significantly differ in focal and nonfocal conditions, $F(1, 38) = 2.92$, $MSE = 0.04$, $p = .096$, $\eta^2 = .071$, but older adults performed worse in the nonfocal than in the focal conditions, $F(1, 38) = 6.35$, $MSE = 0.060$, $p = .016$, $\eta^2 = .143$. In the nonfocal condition (Rendell & Craik, 2000), proportion correct on the time-check task was .73 ($SD = .17$) and .49 ($SD = .25$) for young and older adults, respectively. Interestingly, in contrast, there was no difference between the results of this study and those of Rendell and Craik (2000) for the regular and irregular tasks. We conducted separate 2 × 2 ANOVAs with Study (this study, Rendell & Craik, 2000) × Age Group (young, old), comparing the regular tasks and irregular tasks. These analyses revealed that there was no significant main or interaction effect of study for regular or irregular tasks. Yet, while confirming our reasoning, conclusions from this analysis should still be drawn with caution as a result of the different data sources.

description of this analysis). This finding is further in accord with the theoretical perspective provided by the multiprocess model (McDaniel & Einstein, 2000). Moving the stop-clock into focal attention of participants presumably led to more automatic processing of the time-check task, resulting in a decrement of age-related differences, as less attention-demanding processes were needed. Interestingly, from a broader conceptual perspective, the time-check task contains various features that could be seen as constituting a traditional time-based prospective memory task. Importantly, the previous literature on time-based tasks mostly reported age deficits in older adults when presented in a laboratory setting (d'Ydewalle, Bouckaert, & Brunfaut, 2001; Park et al., 1997). Present results indicate that in time-based prospective memory tasks as well, the feature of task focality may affect age-related task performance. This pattern suggests that if presentation of a clock (used to monitor time) intrudes in focal awareness, the typically reported age decrement in time-based prospective memory performance can be attenuated. However, to directly test this conclusion, researchers will need to conduct a within-study comparison of focal and nonfocal presentation.

As Experiment 1 has demonstrated, task setting seems to affect the deficit in prospective memory performance in laboratory-based studies. Yet, this is only one half of the age prospective memory paradox. In the present laboratory-based tasks, older adults at best performed no worse than younger adults. When a naturalistic prospective memory task is used, however, older adults were found to significantly outperform younger adults (Henry et al., 2004; Rendell & Thomson, 1999). In an attempt to isolate a factor that might account for the superior performance of older adults in such tasks, Experiment 2 investigated age differences in a naturalistic task when motivation was varied (by incentives).

Experiment 2

The second experiment was conducted to test possible effects of motivation on the age benefit in a naturalistic prospective memory task. Motivation is assumed to be a key factor associated with age differences in naturalistic prospective memory performance in younger and older adults (Phillips et al., 2008). The role of motivation was examined by inducing high motivation among half of the sample through monetary incentives that were directly related to the level of performance.

Method

Participants—Participating in this experiment were 80 participants from the city and surrounding area of Zurich, Switzerland (for participants' characteristics see Table 2).[4] Young participants were undergraduate students at the University of Zurich, Switzerland, recruited through announcements in classes; older adults were recruited from local senior citizen groups. Young and older adults reported regular use of a mobile phone. Everyone received 5 Swiss francs (approximately 5 U.S. dollars) as reimbursement for actual costs of sending text messages to the experimenter. In addition, participants were compensated for study participation with either course credits or 20 Swiss francs. All participants were Swiss–German native speakers and of White European background; family socioeconomic status was not assessed. The young and older participants did not differ in current health, $t(78) = 0.47$, $p > .05$, or in previous health, $t(78) = 0.58$, $p > .05$, but more older than younger adults took medication, $\chi^2(1) = 7.53$, $p < .01$, $\varphi_c = .309$. Furthermore, the two age groups did not differ significantly in years of education, $t(78) = 1.32$, $p > .05$. Older adults outperformed the younger adults on the MWT vocabulary test (Lehrl, 2005), $t(78) = 2.43$, *p*

[4]Half of these participants also participated in Experiment 1. However, the pattern of incentive effects did not change depending on the previous laboratory prospective memory experience.

< .05, Cohen's $d = 0.53$. Younger adults outperformed older adults on the Digit Substitution test of the WAIS (Wechsler, 1981), $t(78) = 8.44$, $p < .001$, Cohen's $d = 1.89$; the Digit Span test of the WAIS, $t(78) = 2.59$, $p < .05$, Cohen's $d = 0.58$; and the Stroop test (Stroop, 1935), $t(78) = 6.89$, $p < .001$, Cohen's $d = 1.54$. No age differences were found at baseline on the PRMQ (Crawford et al., 2003), either on prospective errors, $t(78) = 1.59$, $p > .05$, or on retrospective errors, $t(78) = 0.03$, $p > .05$.

Materials—For the naturalistic phone task, participants were asked to send a text message with their mobile phone to the experimenter twice a day for a period of five consecutive days. The text message consisted of the initials of the participants as well as a one-digit identification number. As receiving device of the text messages, a Motorola V360 was used, which provides exact time stamps for received text messages. Participants were told to send the three-character text messages with their mobile phone at two set times: 11 a.m. and 9 p.m. These times matched the virtual times of day for the regular task in the board game (Experiment 1). Participants were asked to remember to send the message on time, but if they were not able, to send the message when they remembered or had the chance to do so. They were told that in this study, on time was defined as 5 min on either side of set time (e.g., 10:55 to 11:05), and late was considered as being later than 5 min but before the next set time. Furthermore, participants were advised to try to avoid switching off their mobile phone, but if mobile phone use would be restricted, to consider switching to vibrate or mute. Participants were not restrained from using external reminders. As revealed by a post hoc interview, older and younger adults did not differ in the use of reminder, $\chi^2(1, N = 80) = 2.28$, $p = .131$, $\varphi_c = 0.171$. Interestingly, younger adults used their cell phone more often as a reminder (e.g., alarm clock function), whereas older adults preferred analogous reminders (e.g., schedule), $\chi^2(1, N = 56) = 6.60$, $p < .01$, $\varphi_c = 0.343$.

Motivational manipulation—Half of the participants in each age group (the incentive groups) were told that they and 19 other participants taking part in this task had a chance to win a lottery prize of 100 Swiss francs (approximately $96 U.S. dollars). Specifically, the participants were told that their chance to win depended on how many entries they had in the lottery: each on-time text message would earn them three entries, and each late response would earn them one entry. Sending no message would result in no entry at all. Thus, a maximum of 30 entries could be reached, with a minimum of zero. The other half of the participants (no-incentive groups) were entered into a similar lottery but were not informed about the lottery at the outset of the experiment. Importantly, whereas the 20 Swiss francs (approximately $19 U.S. dollars) or course credits given as compensation for study participation (see Participants section) were not performance based, the motivational incentive was performance based and was in addition to the regular compensation.

Results and Discussion

We analyzed the number of correct prospective memory responses by a 2 × 2 ANOVA, with between-groups variables of age (young, old) and incentive (no incentive, incentive). This analysis revealed no significant main effects of age group ($F < 1$) or incentive group, $F(1, 76) = 2.31$, $MSE = 7.01$, $p > .05$, $\eta^2 = .030$, but there was a significant interaction effect, $F(1, 76) = 4.11$, $MSE = 7.01$, $p = .046$, $\eta^2 = .051$ (see Figure 3).

We further investigated the interaction effect with tests of simple effects. Younger adults were significantly more accurate at sending the short message in the incentive group than in the no-incentive group, $F(1, 76) = 6.29$, $p = .014$, $\eta^2 = .076$. In contrast, for older adults, there was no significant effect of incentive on prospective memory performance ($F < 1$). Further analyses examined simple main effects for age within each incentive group. Age differences were not significant for the incentive group ($F < 1$), but for the no-incentive group, the older adults tended to display higher prospective memory performance than did the younger adults, $F(1, 76) = 4.37$, $p = .040$, $\eta^2 = .054$.

The results of Experiment 2 indicated that participants' motivation affected prospective memory performance in a naturalistic environment. Specifically, only young adults' prospective memory performance was affected by motivational incentives, whereas there were no differences between the two incentive conditions in the older adult group. This is in line with previous assumptions, that in real-life tasks older adults exhibit a greater level of intrinsic motivation (Rendell & Craik, 2000).

General Discussion

Various factors have been proposed to contribute to paradoxical results of previous studies regarding age-related differences in laboratory versus naturalistic prospective memory tasks. Therefore, the aim of the present study was to explore this paradox, applying both a laboratory-based task and a naturalistic task. Through the modality of the Virtual Week game, participants performed irregular as well regular tasks and additionally a focal time-check task. Outside of the laboratory, the impact of motivational incentives on prospective memory performance in a naturalistic setting was examined.

Our findings clearly indicated that age effects in laboratory tasks are affected by task regularity, as age deficits emerged in irregular tasks but disappeared in regular tasks. Furthermore, moving the time-check task into focal awareness eliminated the previously reported age deficits (Rendell & Craik, 2000). This finding supports theoretical proposals that assume that focal presentation of prospective memory cues leads to more automatic and less resource-demanding processing of the task, thereby resulting in reduced deficits in older age (McDaniel & Einstein, 2000). In addition, Experiment 2 for the first time showed that in a naturalistic task, providing incentives affects younger but not older adult participants' performance. This finding is in line with previous conceptual proposals that suggest that older adults may have higher motivation than younger participants in naturalistic prospective memory tasks (Maylor, 2008; Phillips et al., 2008). These results have important conceptual and methodological implications.

First, the present results indicated the importance of task setting for prospective memory task performance within laboratory conditions: Remarkably, although embedded in a complex multi-intention laboratory setting, a more regular task enabled older participants to perform on an equal level with young adults, attenuating age-related deficits in prospective memory performance. Conceptually, a critical feature of regular tasks might be the predictability of the occurring tasks. This may enable participants to make plans, either explicit or implicit, on the future performance of these tasks. As McDaniel and Einstein (2000) proposed, planning to perform a prospective memory task can affect the extent to which prospective memory performance is supported by relatively automatic, low-resource-demanding processes. Therefore, regular presentation of a prospective memory task might lead to more automatic processing of relevant information, which in turn facilitates prospective performance. Particular older adults might benefit from the change to more automatic processing, as age-related decreases in cognitive resources are attenuated (see Kliegel, Martin, McDaniel, Einstein, & Moor, 2007, for evidence showing beneficial effects of intention planning on prospective memory performance in older adults). In addition, as another possible feature of regular tasks that might help older adults to facilitate prospective remembering, the regular occurrence and performance of a reoccurring task might result in a person's acquiring more cues and therefore (earlier and more automatically) trigger the prospective action, thus saving the application of resource-demanding monitoring processes.[5]

Second, moving the stop-clock into focal awareness eliminated the age differences in the time-check task previously reported (e.g., Rendell & Craik, 2000). In general, this result is in line with the rationale of the multiprocess framework (McDaniel & Einstein, 2000), suggesting that focal cue presentation stimulates automatic processing of a prospective cue in event-based tasks. However, this finding is the first to indicate that focality is also relevant for time-based tasks and that even time-based prospective memory performance of older adults who are outperformed in cognitive ability tests may be equal to that of young adults when the time-based prospective memory task is more focal to the ongoing task. However, we acknowledge that further research involving within-study comparison of focal and nonfocal presentation is needed to corroborate this conclusion.

Third, the present study suggested differential incentive effects between young and older adults for a naturalistic prospective memory task, with highly motivated younger but not older adults outperforming their normally motivated counterparts (Experiment 2). It is important to recognize that the young no-incentive group represented the average motivated students who normally participate in prospective memory studies and not an especially low-motivated condition. Therefore, age benefits found in previous studies might be overestimated when student populations comprise the young adult group, and these young student groups have been used for most prospective memory and aging studies (Rendell & Craik, 2000; Rendell & Thomson, 1999; Kvavilashvili & Fisher, 2007). This might be the case especially when young adults are given course credit for experimental participation.

In general, age benefits in naturalistic prospective tasks might not be due to better performance of older adults, which has been assumed to be mediated, for example, by the use of reminders (Dobbs & Reeves, 1996; Logie et al., 2004). Instead, the present results showed that providing motivation helped to remediate prospective-memory deficits in younger adults. Accordingly, an important factor underlying previously reported age benefits in naturalistic tasks (Henry et al., 2004) might be young adults' inferior performance. For instance, Rendell and Thomson (1999) suggested that younger adults were possibly more likely to have difficulties keeping an organizer with them the whole day, resulting in poorer prospective memory performance. In line with the present results, older adults in the study of Kvavilashvili and Fisher (2007) reported higher intrinsic motivation to complete the task than their younger counterparts. Similarly, the older participants of Patton and Meit (1993) reported a higher importance of the prospective memory task than did the younger adults. In addition, comments of participants from Rendell and Craik (2000) imply that older participants took the prospective tasks more seriously than did young participants.

It is also possible that the prospective memory deficits for young adults reported in previous naturalistic studies might be driven by other factors (e.g., that they have less routine schedules than older adults; e.g., Henry et al., 2004; Rendell & Thomson, 1999), but increased motivation because of monetary incentives might have led young adults to work harder to overcome those factors. Interestingly, normally motivated younger adults in the present study (no-incentive group in Experiment 2) performed better than the younger age groups in Rendell and Thomson's (1999) study. In the present study, the recording device (personal mobile phone) presumably favored the young adults (relative to Rendell & Thomson, 1999); nonetheless, without extra motivation, the young participants performed at a lower level than did older participants in Experiment 2. In contrast, performance of older adults was relatively similar in Rendell and Thomson compared with the current study. However, to test the conclusion that increasing motivation can rehabilitate inferior performance more fully, further research is needed in which the presence of an incentive is tested by a within-study comparison of conditions with incentive and no-incentive for

[5]We thank an anonymous reviewer for pointing out this possible mechanism.

prospective memory tasks conducted in laboratory and naturalistic settings. In addition, as the current study did not assess subjective self-report data on participants' motivation, the observed effect of experimentally manipulating motivation by providing monetary incentives awaits corroboration in future research that includes direct measures of motivational levels for each experimental condition before and after performing the prospective memory task.

Whereas younger adults increased their performance when an incentive was provided, older adults' prospective performance was not affected. One possible reason for this finding might be the nature of the incentives. In the present study, the possibility of winning money was used to increase motivation. Perhaps, presenting a monetary incentive was not sufficient to boost motivation in older adults. However, Touron et al. (2007) recently showed that performance of older adults on a retrieval task was enhanced when monetary incentives were provided but not when doing well was emphasized by instructions alone. Another possible reason for failing to find incentive effects in the older age group might be that older adults were already highly motivated (see, e.g., Maylor, 2008) and that therefore incentives did not affect performance. Following this rationale, older adults might perform at their maximum level in naturalistic tasks as a result of a high intrinsic motivation.

Finally, a few methodological issues need to be considered. With regard to Experiment 1, although a board game should be familiar to most participants, attentional resources that are needed to perform the ongoing task might vary between and within age groups. In addition, using a computer version of the board might be more demanding for older than for younger participants. If this is the case, then the differential resource demands of the ongoing task across age groups could lead to decreased prospective task performance in the group for whom the task was more demanding (i.e., the older adult group). Yet, this would hold for the entire paradigm and cannot explain the differential task setting effects obtained. Nevertheless, future studies should account for ongoing task costs by controlling for performance in the ongoing task.

With regard to the naturalistic task (Experiment 2), participants had to send messages at two given times. Previous research has indicated that younger adults tend to have a less structured, less predictable, and busier lifestyle (e.g., Henry et al., 2004; Rendell & Thomson, 1999). Because the naturalistic part of the present study required carrying out tasks at a fixed time, a structured lifestyle could facilitate successful performance. Therefore, the two groups of participants in the present study might not have matched adequately regarding structure of the lifestyle. Yet, age differences in lifestyle might, in fact, be one of the constituting factors underlying the age benefit previously observed in naturalistic prospective memory performance. An option to directly address this issue in future research would be to examine young employees and old employees, ideally within an equivalent occupation.

In sum, our findings help advance the prospective memory paradox literature showing that age differences in prospective memory may be less pronounced and paradoxical than is assumed in the literature (cf. Henry et al., 2004). It seems too simplistic to suggest that age differences invariably occur in laboratory prospective memory tasks, as performance is related to the applied task type. As proposed by the multiprocess framework (McDaniel & Einstein, 2000, 2007), age differences are attenuated in regular tasks and at focal presentation. Furthermore, in naturalistic tasks providing incentives to perform the prospective task can help remedy prospective memory deficits in young adults.

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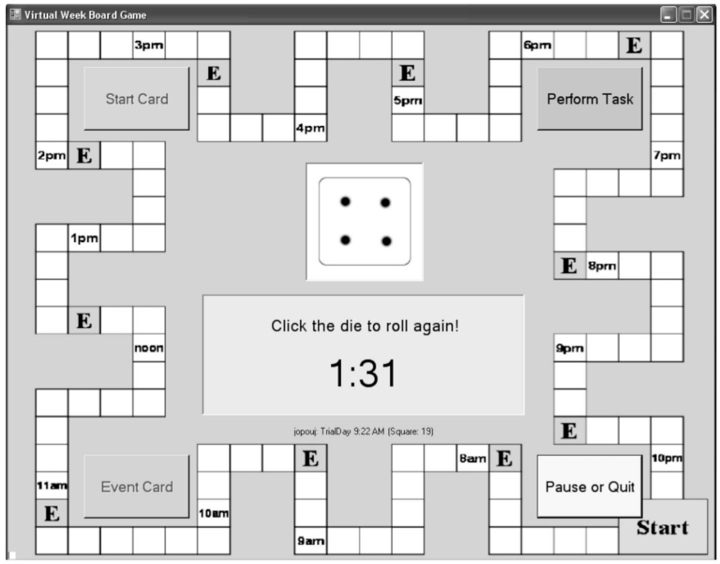

Figure 1.
Black-and-white computer screen display of English version of Virtual Week.

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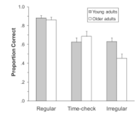

Figure 2.

Mean proportions of correct responses on the laboratory prospective memory task by age group. Error bars represent one standard error of the mean.

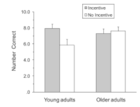

Figure 3.
Mean number of correct responses (out of 10 possible) on the naturalistic prospective memory task by each age group for the two incentive conditions. Error bars represent one standard error of the mean.

Table 1
Characteristics of Participants in Experiment 1

Variable	Young adults (n = 20)	Old adults (n = 20)
Sex: (women/men)	80%/20%	65%/35%
Age (in years)	26.25 ± 8.27	63.26 ± 5.09
Self-rated-health[a]		
Day of test	4.15 ± 0.67	4.32 ± 0.75
Over last 2 months	3.85 ± 0.81	4.16 ± 0.67
Percentage taking medication	5%	30%
Education (in years)	14.05 ± 2.61	14.11 ± 3.48
Word vocabulary test (MWT)	29.85 ± 4.16	32.80 ± 2.55
Digit substitution	65.10 ± 9.72	46.30 ± 8.80
Digit span	14.20 ± 3.90	12.05 ± 2.35
Stroop (in seconds)	18.10 ± 3.74	39.30 ± 7.42
PRMQ[b]		
Prospective	18.20 ± 3.97	17.25 ± 3.02
Retrospective	18.65 ± 4.34	18.25 ± 2.69

Note. Unless specified otherwise, data are given in $M \pm 1$ *SD*. MWT = Mehrfachwahl-Wortschatz-Test; PRMQ = Prospective and Retrospective Memory Questionnaire.

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

[b]PRMQ subscale scores ranged from 8 (*no memory errors*) to 40 (*very often memory errors*).

Table 2

Characteristics of Participants in Experiment 2

Variable	Young adults (n = 40)	Old adults (n = 40)
Sex (women/men)	82.5%/17.5%	50%/50%
Age (in years)	24.58 ± 7.03	62.46 ± 4.64
Self-rated health[a]		
Day of test	4.10 ± 0.63	4.03 ± 0.78
Over last 2 months	3.83 ± 0.78	3.90 ± 0.82
Percentage taking medication	10%	35%
Education (in years)	13.60 ± 2.13	14.41 ± 3.23
Word vocabulary test (MWT)	30.33 ± 3.31	32.10 ± 3.32
Digit substitution	65.98 ± 10.25	46.28 ± 10.61
Digit span	14.40 ± 3.68	12.50 ± 2.84
Stroop (in seconds)	18.08 ± 3.82	30.50 ± 10.74
PRMQ[b]		
Prospective	18.65 ± 3.70	17.35 ± 3.55
Retrospective	19.05 ± 3.96	19.03 ± 3.83

Note. Unless specified otherwise, data are given in $M \pm 1$ *SD*. MWT = Mehrfachwahl-Wortschatz-Test; PRMQ = Prospective and Retrospective Memory Questionnaire.

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

[b]PRMQ subscales ranged from 8 (*no memory errors*) to 40 (*very often memory errors*).