Running head: TIME-BASED PROSPECTIVE REMEMBERING

Is Time-Based Prospective Remembering Mediated by Self-Initiated Rehearsals? Role of Incidental Cues, Ongoing Activity, Age and Motivation

Lia Kvavilashvili [1] and Laura Fisher [2]

[1] University of Hertfordshire, UK

[2] Canterbury Christ Church University College, UK

Keywords: Time-based prospective memory, self-initiated vs. automatic retrieval, incidental cues, prospective memory and aging, time estimation

Address for correspondence:

Lia Kvavilashvili

School of Psychology

University of Hertfordshire

College Lane

Hatfield, Herts, AL10 9AB

United Kingdom

Tel. +44 (0) 1707 285121

Fax +44 (0) 1707 285073

Email: L.Kvavilashvili@herts.ac.uk

Abstract

The present research examined self-reported rehearsal processes in naturalistic time-based prospective memory tasks (Study 1 and 2) and compared them to the processes in event-based tasks (Study 3). Participants had to (1) remember to phone the experimenter either at a pre-arranged time (a time-based task) or after receiving a certain text message (an event-based task), and (2) record the details of occasions when they thought about this intention during a 7-day delay interval. The rehearsal and retrieval of time-based tasks was mediated by more automatic than deliberate self-initiated processes. Moreover, the number of reported rehearsals without any apparent triggers was reliably higher in time- than in event-based tasks. Additional findings concern the effects of age, motivation and ongoing activities on rehearsal and prospective memory performance.

Is Time-Based Prospective Remembering Mediated by Self-Initiated Rehearsals? Role of Incidental Cues, Ongoing Activity, Age and Motivation

Prospective memory is defined as remembering to perform an intended action in the future (e.g., making a phone call at 2 p.m. or passing on a message to a colleague) and is usually contrasted with retrospective memory that involves remembering information from the past (e.g., remembering someone's name or the contents of a film) (see Graf & Uttl, 2001; McDaniel & Einstein, 2000). A crucial feature of all prospective memory tasks is an absence of explicit prompts to instigate the recall. For example, no one tells a person that it is now time to make a phone call (i.e., 2 p.m.) or to pass on a message when seeing a colleague in the staff room. Instead, people have to realise this for themselves in order to carry out an intended action.

Einstein and McDaniel (1990; 1996b) have distinguished two broad classes of prospective memory tasks: event-based and time-based. In the former one has to remember to carry out an intended action in response to a certain target event (e.g., posting a letter when seeing a post box), and in the latter to do so at a certain time or after a specified time interval (e.g., remembering to make a phone call at 2 p.m. or in twenty minutes time). A question of fundamental importance for prospective memory research has been about the nature of retrieval in event- and time-based prospective memory. In particular, what brings a representation of intention into one's mind at the right moment given that there is no explicit prompt to initiate the retrieval and a person is involved in ongoing activities that are unrelated to the to-be-remembered intention? Is remembering intentions mediated entirely by automatic processes at the time of retrieval (i.e., intention simply pops into one's mind) or is successful remembering mediated by effortful conscious processes such as periodic rehearsal of intention and/or monitoring the environment for the appropriate event and/or time?

Substantial progress has been made in answering these questions with respect to event-based prospective memory. Remembering of event-based tasks is critically dependent on the nature of the target event (e.g., its familiarity, specificity, distinctiveness, etc.) as well as the strength of association between the target event and an intended action (Guynn, McDaniel, & Einstein, 1998; McDaniel, Guynn, Einstein, & Breneiser, 2004). Several theoretical models have been developed and tested that differ in the degree to which the remembering is assumed to rely on automatic versus self-initiated retrieval processes. For example, a *simple activation* or *automatic associative activation* model posits that retrieval of intentions occurs automatically in response to target events (see Einstein & McDaniel, 1996b; McDaniel, Robinson-Riegler & Einstein, 1998; Nowinski & Dismukes, 2005). The *familiarity plus search* model assumes that initial automatic noticing of the target event is followed by a controlled search for the associated action (Einstein & McDaniel, 1996b; see also McDaniel et al., 2004), and the *strategic/attentional monitoring* view assumes that successful performance is mediated by self-initiated and effortful monitoring of one's environment in search of a target event (Burgess & Shallice, 1997; Guynn, 2003; Shallice & Burgess, 1991; Smith, 2003). Most recently, McDaniel and Einstein (2000) proposed a multiprocess account of event-based prospective memory which states that, depending on circumstances (i.e., properties of target event cues, nature of the task and/or ongoing activity, etc.), prospective memory can be mediated by either automatic or strategic processes. Direct empirical evidence in support of this new framework comes from several recent experiments conducted by McDaniel and Einstein and their colleagues (e.g., McDaniel & Einstein; 2000; Einstein, McDaniel, Thomas, Mayfield, Shank, Morrissette, & Breneiser, 2005).

Thus, our theoretical understanding of mechanisms underlying the retrieval of event-based prospective memory tasks is developing at a rapid pace. It is obvious, however, that the models described above cannot account for the time-based tasks in which there is no target event or cue that could be associated with the intended action. [1] Instead, the retrieval of intention has to be initiated at an appropriate time by a person himself/herself. Unfortunately, there are very few empirical studies that have specifically examined the nature of retrieval in time-based tasks or processes that lead up to self-initiated monitoring (e.g., Ceci & Bronfenbrenner, 1985; Cicogna, Nigro, Occhiniero, & Ésposito, 2005; Cook, Marsh & Hicks, 2005; Costermans & Desmette, 1999; d'Ydewalle, 1996; d'Ydewalle, Luwel, & Brunfaut, 1999; Einstein, McDaniel, Richardson, Guynn & Cunfer, 1995; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; Patton & Meit, 1993; Rendell, & Craik, 2000; Sellen, Louie, Harris, & Wilkins, 1997; Wilkins & Baddeley, 1978). This is surprising given the widespread agreement among researchers that the retrieval of time-based tasks is fundamentally different from event-based tasks (Einstein & McDaniel, 1996a; 1996b; Sellen et al., 1997), on the one hand, and the prevalence and importance of time-based tasks in everyday life, on the other hand. Indeed, successful and independent everyday functioning often depends upon timely execution of intentions at specific times (e.g., paying bills, keeping appointments, etc.).

One interesting finding that has emerged from the few existing laboratory studies on time-based prospective memory refers to participants' time monitoring behaviour prior to the critical time to remember. For example, in an early laboratory study by Harris and Wilkins (1982), participants had to watch a 2 hour film and remember to carry out a simple action at specific times during the viewing (once every 3 or 9 minutes). In order to estimate the elapsed time participants could check a digital clock that was positioned behind them. The analysis of participants' clock monitoring behaviour showed that they tended to check or rehearse at the beginning of each time interval and particularly during the critical period in which they were supposed to act. In other words, they displayed the

J-shaped pattern of monitoring. Moreover, the frequency of rehearsal in a time-based task was positively correlated with prospective memory performance (for similar results see Einstein et al., 1995; Park et al., 1997).

In order to account for their pattern of findings Harris and Wilkins (1982) proposed the Test-Wait-Test-Exit (TWTE) model of time-based prospective memory. According to this model, people encode the future task and then wait for a period of time until a test of memory seems appropriate. If the time is not correct they continue to wait until the critical exit period. Successful performance is therefore dependent on monitoring the time during the critical period. It was also assumed, especially in all subsequent studies, that this monitoring was a deliberate self-initiated process requiring one's attentional resources (see e.g., Einstein et al., 1995; Park et al., 1997).

Although Harris and Wilkins' (1982) TWTE model of time-based prospective memory fits the experimental data and is widely cited, it is largely descriptive as the authors acknowledge themselves. Indeed, it does not provide an answer to a basic question about "how does one make oneself aware of time, or remind oneself of time-based intentions, in the absence of cues? What is the nature of these self-initiated processes?" (Sellen et al., 1997, p. 484). One possibility, as pointed out by Harris and Wilkins (1982), is that the intention periodically (and spontaneously) pops into one's mind. Initial support for this idea comes from a diary study of Ellis and Nimmo-Smith (1993) in which participants reported experiencing on average 1.5 spontaneous recollections per day (SD=.77, range 0-5) for each of the real-life intentions they recorded over a 5-day period.

An alternative possibility, also suggested by Harris and Wilkins (1982), is that intention is actually triggered by some incidental (and subtle) cues in the environment. For example, approximately one third of their participants reported that references to time in the film they were watching (e.g., shots of an airport clock, plane departure timetable or the mentioning of time in the film script) made them aware of the prospective memory task. Similarly, participants in a study of Sellen et al. (1997) reported that seeing or hearing things related to the time (i.e., clocks, calendars) often reminded them of their prospective memory task to operate an electronic device at four specific times a day.

It is interesting that these self-reports seem to support the so called "Random Walk" model of prospective remembering proposed by Wilkins (1979; cited in Harris, 1984) which highlights the importance of incidental external or internal cues in remembering intentions. According to Wilkins, our mind can be conceptualised as a multidimensional semantic space. When an intention is formed to make a phone call at 2 p.m. then a certain trace is formed in a particular area of this multidimensional space representing this intention. However, our thoughts do not stay in this area throughout the delay interval. Instead, "the train of thought" moves through various parts of this space in a statistically random manner, depending on the stimuli we encounter in the environment and the activities we are engaged in. If, near the time (e.g., 1:30 p.m.), this "train of thought" accidentally wanders into an area that is very close to the place representing the intention, then it is highly likely that it will result in conscious realisation that a phone call should be made. If it is too early the "train of thought" will move away (i.e., we will again concentrate on other things) until it again happens to wander close enough to the area associated with making the call.

This model does not ascribe any active qualities to the representation of intention, in other words, it does not regard the retrieval of intention as a self-initiated process. Instead, it assumes that the timely remembering of intention is entirely due to incidental factors. For example, if nearer the time of intended phone call we come across the telephone or somebody mentions the word telephone this will act as a trigger and remind us of our intention. If, however, no such accidental cues are available then the intention will not be remembered on time because the "train of thought" will be far away from the relevant area in the multidimensional space.

The aim of the present study is to test the two models described above (TWTE and Random Walk) in order to provide an answer to the question about what brings a time-based prospective memory task into one's mind during the retention interval. In particular, we wanted to see whether this monitoring or rehearsal is largely a self-initiated process, as posited by the TWTE model (occurring during the natural pauses in between the activities when a person deliberately thinks about the future upcoming tasks as part of everyday planning), or whether this is predominantly occurring in response to incidental external (and/or internal) cues as suggested by the Random Walk model.

In order to address this question three studies were conducted. In all three studies, participants were asked to remember to make a (single) phone call at their chosen time on the seventh day from their initial meeting with the experimenter (a time-based prospective memory task). In addition, they had to keep a structured diary throughout the week and record every instance when they recalled or rehearsed their intention to make the phone call. In order to elucidate the nature and origin of these rehearsals participants were asked to record a number of variables associated with the cognitive, environmental and temporal aspects of each rehearsal. For example, they had to record what they were doing at the time of rehearsal, whether there was any trigger that elicited their memory of future intention and if so, what the trigger was.

A naturalistic task of making a single phone call was chosen in the present study, instead of a laboratory paradigm, for several reasons. Although we were interested in prospective memory performance, our primary interest was to examine the rehearsals of the task, and therefore we had to choose a simple task that the majority of participants would remember to carry out. Moreover, several researchers have expressed serious doubts as to whether current laboratory methods are capable of adequately capturing the crucial aspects of time-based prospective remembering as it occurs in everyday life (i.e., single, one-off tasks with delay intervals of several hours if not days) (*cf.* Marsh, Hicks, & Landau, 1998). In the laboratory, time-based tasks have to be carried out several times during the ongoing activity often with intervals as short as 1 or 2 minutes. Under these circumstances it is likely that the prospective memory task never leaves awareness and it is not clear whether one studies prospective memory or participant's ability to estimate the length of elapsed time (see e.g., Graf & Uttl, 2001; Park et al., 1997; Sellen et al., 1997).

The aim of Study 1 was largely exploratory as we wanted to obtain initial information on the nature and conditions of monitoring (or rehearsal) in an everyday time-based task using a large sample of psychology undergraduates (N=40). The aim of Study 2 was to replicate the findings of Study 1 and to extend the study by examining the effects of age and motivation on time-based prospective memory rehearsal and performance. The inclusion of these two additional variables in Study 2 was motivated by a desire to identify variables that may underlie a paradoxical finding in current research on prospective memory and aging: a reliable age effect inside the laboratory (particularly in time-based tasks) and no age effect outside the laboratory (Rendell & Craik, 2000; Rendell & Thompson, 1999). Finally, by using improved methodology, Study 3 further validated the findings obtained on young participants in Study 1 and 2, and provided crucial information on underlying mechanisms of time-based prospective memory. This was achieved by comparing the nature and distribution of reported rehearsals in time- and event-based tasks that were closely matched on important task characteristics, including the delay interval and the prospective memory action. In all three studies, an underlying assumption was that studying the conditions in which participants report experiencing thoughts about the prospective memory task in the delay interval provides important insights about the processes involved in the retrieval of these tasks at the designated time (*cf*. Ellis, & Nimmo-Smith, 1993; Sellen et al., 1997).

Study 1

The major aim of Study 1 was to examine if, in everyday life, thoughts about time-based tasks are mediated by deliberate and effortful self-initiated processes or whether they are triggered by incidental external and/or internal cues. Several related issues were also examined. For example, laboratory studies of time-based prospective memory have established a positive relationship between the amount of time monitoring (rehearsal) and subsequent performance on the task. It is, however, not clear whether this pattern will generalise to a naturalistic task with a long time delay.

Moreover, previous research on time-based prospective memory has produced some discrepant findings between laboratory and naturalistic studies. In all experimenter controlled studies, the frequency of monitoring substantially increases in the final critical period for responding, thus, producing a J-shaped curve. [2] However, in the only existing naturalistic study on frequency of rehearsal in time-based prospective memory task no such pattern was observed (see Sellen et al., 1997). It was therefore anticipated that the results of the present study could be instrumental in solving this discrepancy.

By asking the participants to record the activities they were engaged in at the time of rehearsal we also wanted to examine whether these predominantly occurred while people were engaged in relatively habitual automatic activities that require little attentional resources (such as tidying up a room, having a shower, lying in bed, etc.). A couple of previous naturalistic studies have shown that this may be the case. For example, in the study of Sellen et al. (1997) participants tended to think about the time-based task in transitional places like staircases and corridors rather than their offices where they would be engaged in more attentionally demanding activities (*cf.* Ellis & Nimmo-Smith, 1993).

Method

Participants. Forty psychology undergraduate students (8 males and 32 females) aged between 18 to 47 years took part in the study. They received course credit for their participation.

Materials and Procedure. All participants individually attended an initial Monday session between 11:00 a.m. and 1:00 p.m. After being introduced to the general aims of the study (i.e., how people remember to carry out an everyday task in the future without the help of external reminders), participants were informed that their task was to telephone the experimenter on the seventh day of the experiment (i.e., on Sunday) at a convenient time for them between 10:00 a.m. and 1:00 p.m. Participants were asked to choose the time for the telephone call themselves because it was important that they would be free to make the call at that particular time. It was pointed out that if they forgot to ring the number at this pre-arranged time they had to ring as soon as possible afterwards. The times were always scheduled at 30-minute intervals and the experimenter made sure that two participants did not choose the same time for the call. After this, participants were provided with a pocket size diary in which to record those instances when they happened to recall or rehearse their intention to give the phone call to the experimenter. The diaries had to be kept from the moment participants left the laboratory up until the specified call in time on the following Sunday. It was emphasised that participants had to refrain from using any external memory aids such as making notes in personal diaries or calendars or asking someone to remind them of their intention.

Next, participants were given detailed instructions how to fill in the diary (a copy of these instructions was given to them to take home). Whenever they rehearsed the telephone task, participants had to record the following information on a separate page of the diary: the date and time of the rehearsal, the time it was recorded, where they were, who they were with, any thoughts they had immediately before the rehearsal, the nature of any triggers/cues considered to prompt the rehearsal, and the activity they were engaged in at the time. Participants had to record each case immediately or as soon as possible after the rehearsal of the task had taken place. If no rehearsals were experienced participants were asked to try not to generate them on purpose.

Finally, participants were informed that it was necessary to keep the diary with them at all times during the week and preferably out of their sight. They were advised to keep the diary in a place where the likelihood of their seeing it in the course of the day was minimal (e.g., in a part of their bag that they did not normally use or in a pocket that they did not normally refer to).

When participants telephoned the experimenter on Sunday the time of their call was noted and any feedback from the participants concerning the task and/or the procedure was recorded. In addition, participants had to indicate how motivated they had been to ring on time on a 7-point scale (1 = not very motivated to 7 = very motivated). Finally, a meeting with the experimenter was arranged so that participants could return their diary and receive course credit for participation.

Results

The rejection level for all analyses reported in this and subsequent studies was set at .05. The effect sizes were estimated by using the partial eta-squared (η^2).

All 40 participants kept a diary for the 7-day period and recorded a total of 363 rehearsals (M= 9.08, SD=7.18). However, 10% of these rehearsals (N=36) belonged to one participant who was a clear outlier in the initial screening of the data. Therefore, the data of this participant were excluded from all the analyses reported in this section. This resulted in a total of 327 rehearsals with a range of 2 to 26 and a mean of 8.38 (SD=5.77).

None of the participants forgot completely to make a designated telephone call on Sunday. There was, however, a fair amount of variability in the length of time that elapsed from designated time to the time of actual phone call. Thus, 23 participants (59%) remembered to call within the 10 minutes of critical time (which was counted as on-time response), and 16 participants (41%) were more than 10 minutes late. Out of these, six participants called after 10 minutes but within one hour, and ten participants were more than one hour late (with the latest response being 8 hours late). However, their post-experimental ratings of motivation to make a phone call at a designated time on Sunday was not statistically different (M=4.69, SD=1.20) from that of the participants who remembered to call on time (M=5.04, SD=1.72) ($F<1$). Moreover, out of 16 late callers only three indicated that they remembered but were unable to make a phone call at a designated time. The other participants who were late admitted they had forgotten about the task and remembered only at some later point.

Results will be presented in two parts. In the first part we will report the analyses of the conditions in which the rehearsals were experienced (and recorded). The primary focus in this section will be on the relationship between the rehearsals and reported triggers (whether external or internal), if any. In addition, the idea that rehearsals are more likely to occur when one is engaged in habitual automatic activities will also be examined. In the second part, we will examine participants' prospective memory performance and its relation to the number of recorded rehearsals as well as a distribution of rehearsals over the 7-day period.

Conditions of reported rehearsals

Types of reported triggers. We first examined whether each recorded rehearsal was reported as being triggered by a cue. Out of 327 rehearsals recorded by 39 participants, 247 (76%) were reported as being triggered by something whereas 80 (24%) were reported to have occurred without any trigger (i.e., the intention was thought to have popped into mind for no apparent reason).

Two raters (the first and the second author) independently read the descriptions of triggers provided by participants for the 247 triggered rehearsals. A trigger was categorised as external if it referred to something in the participants' environment, and as internal if it referred to something in their own thoughts. Agreement between the raters was excellent (Cohen's Kappa=.98, SE=.06), and any discrepancies were resolved by discussion. Thus, out of 247 triggered rehearsals, 147 (60%) were classed as triggered externally and 100 (40%) as triggered internally. This difference was statistically significant (χ^2=8.94, df=1, p=.003).

Tables 1a and 1b display the types of external and internal triggers reported by participants. Table 1a shows that the majority of external triggers were thematically related to the task of making a phone call (e.g., seeing a phone, a diary or a clock). It was also common to experience triggers from seeing, reading or hearing things associated with the experiment such as a lecturer talking about memory, seeing someone resembling the experimenter or reading a passage "little of your overt behavior sheds any light on what is going inside your mind". There were also a small number of cues that seemed to be completely unrelated to the task of making the phone call (for examples see Table 1a). Thus, there is a great variety of possible cues in one's environment that could act as incidental triggers reminding participants of their future intention.

Table 1b shows that the majority of internal triggers involved thinking about future plans, other intentions or things that were only associatively related to the task of making a phone call. Only thinking about future plans could be considered as triggers for deliberate self-initiated rehearsal. It appears that at certain points in the course of their daily activities our participants would deliberately engage in thinking about their plans for the day, for the weekend or for their general schedule. If the intention to make a phone call occurred while being engaged in such planning this should be classed as deliberate self-initiated rehearsal (see Ellis & Nimmo-Smith, 1993). In contrast, thinking about work, deadlines, or about other intentions, such as phoning someone, would be examples of incidental (internal) triggers. Incidental triggers related to other intentions are particularly interesting, as they did not always have a direct association with the task. For example, reminding oneself to post a letter or remembering to buy groceries have no direct relation to the telephone task apart from being other prospective memory tasks.

Categorization of all internal triggers as either self-initiated planning or incidental thoughts was highly reliable (Kappa=.95, SE=.10). Out of the 100 internal triggers, 29% were classed as self-initiated planning and 71% as incidental thoughts. Thus, internal triggers were more likely to be incidental than self-initiated (χ^2=17.64, df=1, p<.001).

In conclusion, out of a total of 327 recorded rehearsals only 9% (N=29) were coded as being cued by self-initiated planning thoughts. Forty-five percent were coded as being triggered by incidental external (N=147) and 22% by incidental internal cues (N=71). In 24% of cases (N=80) the rehearsals were reported to have no apparent triggers (i.e., intention would simply pop into one's mind).

The mean number of rehearsals as a function of trigger can be seen in Table 2 (Panel A). A one way within subject ANOVA on these means resulted in a significant effect of trigger category (F(3,114)=10.88, MSe=5.72, p<.001, η^2=.22). Post hoc analyses showed that the number of reported rehearsals in the incidental external trigger category was significantly higher than in the no trigger category (t=-2.38, df=38, p<.03). Although the number of rehearsals in the no trigger category was numerically higher than in the incidental internal category this difference was not statistically significant ($t<1$). Finally, the number of rehearsals in the incidental internal category was significantly higher than in the self-initiated category ($t=-5.15$, $df=38$, $p<.001$).

Activities. Activities that do not put heavy demands on attentional resources such as walking or cleaning teeth were regarded as automatic activities whereas activities that have heavy attentional demands, such as being in a lecture, reading a book or writing an essay, were categorised as controlled activities (*cf*. Berntsen, 1998; Kvavilashvili & Mandler, 2004; Norman, & Shallice, 1986). Agreement between the two raters was excellent (Kappa = .95, SE=.06) and the discrepancies were resolved by discussion. Out of the 320 activities recorded by participants 62% (N=198) were classed as automatic, and 38% (N=122) as controlled. [3] Thus, participants were more likely to report experiencing rehearsals when they were engaged in automatic than in controlled activities ($\chi^2 = 18.05$, $df=1$, $p<.001$). Moreover, the majority of rehearsals (217 rehearsals out of 327, i.e., 66%) were reported to take place at home rather than in the outside world, work, or university where one is generally less likely to be relaxing or engaged in automatic activities.

Prospective memory performance and its relation to frequency of rehearsals

As noted earlier, none of the participants forgot to make a phone call on Sunday. The majority of the calls (N=23) were made on time (i.e., within ±10 minutes of the critical time) but as many as 16 calls were made more than 10 minutes late. The former were classified as HIT and the latter as LATE responses. However, the response of one participant who reported remembering on time but being unable to make a phone call was classed as HIT whereas the data of two participants who reported being late because they slept in were eliminated from these analyses. There was a reliable and positive correlation between the number of recorded rehearsals and the type of prospective memory response (Point-Biserial correlation r(36)=.39, p<.02) with those in the HIT group reporting more rehearsals (M=10.21, SD=6.43) than those in the LATE group (M=5.46, SD=2.75).

We also examined the pattern of rehearsals over the seven days of the study as a function of response group (HIT vs. LATE). Because on Monday, and especially on Sunday, participants had less time available to experience (and record) their rehearsals, it was decided to use a proportional measure of rehearsals by dividing the number of rehearsals on each day by the total number of possible waking hours available on that day. For Monday the initial session with the participants ended on average at 12:00 p.m., therefore the number of hours available was taken from 12:00 p.m. to 24:00 a.m. (12 hours). For Tuesday to Saturday the time was taken from 08:00 a.m. to 24:00 a.m. (16 hours). On Sunday the number of hours was taken as the difference between 08:00 and the time each participant was required to call (i.e., between 10:00 a.m. and 1:00 p.m.).

The mean proportional scores as dependent variables were entered into a 2 response group (HIT vs. LATE) x 7 days (Monday vs. Tuesday vs. Wednesday vs. Thursday vs. Friday vs. Saturday vs. Sunday) mixed ANOVA with the repeated measures on the last factor.[4] There was a main effect of response group (F(1,35)= 9.22, MSe=.034, p<.005, η^2=.21) as well as days (F(6, 210)= 8.37, MSe=.034, p<.002, η^2=.19). These main effects were, however, qualified by a significant group by days interaction (F(6,210)= 4.68, MSe=.034, p<.02, η^2=.12).

The tests of simple main effects showed that although the two response groups did not reliably differ in the proportion of recorded rehearsals on Monday (F(1,35)=1.43, p=.24), Wednesday (F(1,35)=1.88, p=.18), Thursday (F(1,35)=2.00, p=.17) and Friday (F(1,35)=1.25, p=.27), participants in the HIT group recorded significantly more rehearsals on Tuesday (F(1,35)=6.31, p<.02, η^2=.15) and especially on the last two days of the task:

Saturday ($F(1,35)=11.02$, $p<.005$, $\eta^2=.24$) and Sunday ($F(1,35)=8.31$, $p<.01$, $\eta^2=.19$). In other words, the HIT group displayed a clear J-shaped pattern of rehearsals (see Figure 1): the proportions of rehearsals on Monday and Tuesday did not significantly differ from each other and were reliably higher than on Wednesday, Thursday, Friday and Saturday (all $p_s<.02$), whereas the proportion of rehearsals on the final day of the study (i.e., on Sunday) was reliably higher than on any other day of the study (all $p_s<.005$). This pattern was absent in the LATE group as the proportion of recorded rehearsals on Sunday was not statistically different from those on any other day of the study (all $p_s\geq.47$).

Discussion

In conclusion, several novel findings emerged from Study 1. The most important finding concerns the nature of retrieval processes in time-based prospective memory tasks with a long delay interval. The results showed that once the intention is formed it is either triggered by incidental cues or it periodically pops into one's mind without any apparent reason. Self-initiated rehearsal was reported to occur in only 9% of cases. Therefore, the retrieval of time-based tasks could be a more automatic process than thought previously.

Successful performance on the phone task was positively related to the number of recorded rehearsals and, importantly, the distribution of rehearsals in the HIT group was different from the LATE group and resembled the J-shaped curve. These findings clearly contrast the results of Sellen et al. (1997) who failed to obtain the J-shaped curve for a naturalistic time-based task in which participants had to remember to press an electronic badge four times a day for a 5-day period. Instead, the results of the present study replicate previous laboratory and controlled studies of time-based prospective memory with considerably shorter delay intervals of 3 to 30 minutes (e.g., see Ceci & Bronfenbrenner, 1985; Einstein et al., 1995; Harris & Wilkins, 1982).

Finally, the rehearsals were reported to occur more frequently when participants were engaged in relatively automatic (62%) rather than in attentionally demanding controlled activities (38%), thus replicating earlier findings of Ellis and Nimmo-Smith (1993) and Sellen et al. (1997). It appears that certain amount of unused attentional resources must be available for one to become conscious of the future intention despite the fact that the act of retrieval itself may not be a cognitively demanding task (*cf.* Kvavilashvili & Mandler, 2004; Mandler, 1994). [5]

It is, of course, possible that the present finding reflects the difficulty or reluctance to record the rehearsals that occurred during attentionally demanding activities. However, in the study of Sellen et al. (1997) where the interference from recording a rehearsal was minimal (participants had to simply click on the electronic badges that they wore during the study), the rehearsals were still more likely to be reported during the automatic than controlled activities. Another possibility is that the obtained result reflects general prevalence of automatic activities in everyday life as shown by Ellis and Nimmo-Smith (1993). However, in their study, participants did report reliably lower levels of concentration on concurrent activities when thinking about future intentions than when being stopped at random time intervals in the baseline condition. Thus, the available evidence including the current study, seems to suggest that rehearsals are more likely to occur during relatively undemanding activities. The results of Ellis and Nimmo-Smith (1993), however, highlight the importance of measuring concentration in addition to obtaining the descriptions of ongoing activities. These measures were obtained in Study 2 and 3 (see below).

Study 2

Study 1 is the first empirical investigation on the nature of rehearsal and retrieval processes in remembering everyday time-based tasks with a long delay of several days.

The aim of Study 2 was to replicate these findings on new samples of both young and old participants in order to learn more about the possible mechanisms underlying the retrieval of time-based tasks. The rationale for testing a group of older adults was to determine if the pattern of results observed in Study 1 would generalise to another population.

The investigation of age effects is one of the most intensively studied areas in prospective memory research (*cf.* Ellis & Kvavilashvili, 2000; see also Henry, MacLeod, Phillips, & Crawford, 2004). This is partly due to the importance that preserved prospective memory skills play in maintaining a successful and independent life-style in old age. However, despite considerable progress that has been made over the past decades in studying aging and prospective memory, recent research has revealed a paradoxical finding. Although age effects have been obtained in several laboratory studies of prospective memory (e.g., Maylor, 1993; 1998; Park et al., 1997; West & Craik, 1999) no such effects have been observed in studies conducted outside the laboratory. If anything, in the naturalistic studies conducted by Rendell and Thompson (1999) and Rendell and Craik (2000) old participants consistently outperformed young participants in both event- and time-based prospective memory tasks that were embedded in the course of their everyday activities (see also Henry et al., 2004).

Several explanations have been put forward to account for this paradoxical finding. According to one view, older adults might be using external aids more frequently and/or efficiently than the young (Cavanaugh, Grady & Perlmutter, 1983; Maylor, 1990; Moscovitch, 1982). Alternatively, they may have more opportunities to rehearse the task due to being engaged in habitual and attentionally less demanding activities (*cf.* Maylor, 1998). It has been also suggested that older adults may be more motivated to remember to execute actions in naturalistic settings (see Patton & Meit, 1993; Rendell & Craik, 2000). However, the explanation concerning the increased use of external aids by older adults has not received empirical support. Several naturalistic studies that directly addressed this question failed to find any age effects in self-reported use of external aids, both in terms of frequency and effectiveness of their use (see e.g., d'Ydewalle, 1996; Freeman & Ellis, 2003; Rendell & Thomson, 1999). To date, the remaining two explanations concerning increased rehearsal and motivation in older adults have not been examined in detail.

The aim of Study 2 was not only to replicate the findings from Study 1 but also to examine which of these explanations might be contributing to the absence of age effects on prospective memory outside the laboratory. Thus, we wanted to determine whether older adults rehearse the prospective memory task more frequently than younger adults, and if so, whether this is related to their performance success. Moreover, following Patton and Meit (1993), we expected that old participants could be intrinsically more motivated than young to perform the task. It was therefore hypothesised that experimentally manipulating levels of motivation should influence prospective remembering more in young than older adults.

Participants in Study 2 were required to complete the same task as in Study 1. However, to manipulate and measure motivation, participants from both age groups were allocated to a high and low motivation condition and were also required to rate their motivation levels before and after the task.

Method

Participants. A total of 74 volunteers took part in the study. Thirty-six participants were young (20 females and 16 males) with a mean age of 23 years (range 19-30), and 38 were old (24 females and 14 males) with a mean age of 73 years (range 62 - 82). All old and 11 young participants were recruited from an existing subject pool of volunteers. The remaining 25 young participants were recruited from the local community (N=7), University staff (N=8), and undergraduate (N=7) and postgraduate students in psychology (N=3).

All older participants were retired, healthy adults. They did not report any vision, hearing and physical mobility problems or any serious physical/mental health conditions diagnosed by their physician. Their mean rating of self-reported health on a 5-point scale (1=poor; 3=average; 5=excellent) was high (M=4.09; SD=.63) and did not differ ($F<1$) from that of the young group (M=4.11, SD=.79). When participants had to rate their health in comparison to their peers (1=worse, 3=same and 5=significantly better), older participants' ratings (M=3.82, SD=.81) were reliably higher than those of young participants (M=3.29, SD=71), $F(1,66) = 8.35$, $MSe = .58$, $p < .02$, $\eta^2 = .11$. There were no reliable age effects in participants' scores on the Hospital Anxiety and Depression Scale (HADS; Zigmund & Snaith, 1983; on both scales scores can vary from 0 to a maximum of 21 with higher scores indicating higher levels of anxiety and depression). The mean anxiety scores were 7.11(SD=3.83) and 5.93(SD=3.11) in the young and old group, respectively ($F(1,66)=1.91$, $MSe=12.26$ $p=.17$). The mean depression scores were 3.68 (SD=2.94) in the young and 3.27(SD=2.24) in the old group ($F<1$).

All older participants had previously scored above the cut off point of 24 on the Mini Mental State Examination in a study by Kvavilashvili, Kornbrot, Mash, Cockburn and Milne (2005). The older sample in that study obtained significantly higher scores than the young group on the vocabulary sub-test (Spot-the-Word Test) of the Speed and Capacity of Language Processing Test (Baddeley, Emslie, & Nimmo-Smith, 1993).

Materials and Procedure. These were similar to Study 1 except for minor modifications in the diary format, the place of initial meetings, and the timing of call-in times. Participants individually attended an initial Monday session, between 9:00 a.m. and 7:00 p.m. either in participants' homes (38 old and 16 young) or at the university (20 young). Participants were free to choose any time for a telephone call on Sunday. This was done to minimise the chances of remembering to make a call on time but being unable to do so due to some other engagements. Although the majority of participants chose the time between 11:00 a.m. to 3:00 p.m., the earliest time chosen was 9:00 a.m. and the latest was 9:00 p.m.

The motivational manipulation involved telling half of the participants in each age group that it was very important that they called exactly within ten minutes of their chosen time. If they did not call within ten minutes all their diary entries were to be discarded as the study was allegedly only interested in those thinking processes that result in successful, on time remembering. In the low motivation condition participants were simply asked to call within ten minutes of the designated time as in Study 1.

Participants were provided a diary to record any subsequent thoughts about the task (i.e., rehearsals). The information to be recorded was same as in Study 1 except for the following. First, in addition to describing the activities they were engaged in during the reported rehearsal participants had to also rate how much they were concentrating on this activity on a 5 point rating scale (1=not concentrating at all, 5=fully concentrating). Second, in order to obtain a more accurate measure of number of rehearsals conditionalized on the number of waking hours on each day, the participants had to indicate at what times they usually woke up and went to sleep on each day of the week.[6]

At the end of the initial session participants were asked to rate how motivated they felt to call the experimenter on time on a five point rating scale (1=not motivated at all, 3=moderately motivated, 5=very motivated). When the participants telephoned the experimenter the time of their call was noted and they had to make a second (this time retrospective) rating of their motivation on the same 5-point rating scale.

Results

All 74 volunteers, except one young participant, kept a diary for a 7-day period and a total of 1092 rehearsals were recorded (M=14.96, SD=15.13). However, 20.5% of these rehearsals was recorded by one young (N=73) and two old participants (N=112, and N=39) who were clear outliers as shown by the initial data screening. The data of these three participants were excluded from all the analyses reported in this section. The final sample therefore consisted of 34 young and 36 old participants who recorded a total of 868 rehearsals with the mean of 12.40 (SD=6.64; range 2-26).

Two young and one old participant did not call on Sunday. When contacted next morning they admitted having completely forgotten to make the phone call. Out of the remaining 67 participants who called on Sunday, 52 (78%) remembered to call on time, and 15 (22%) were more than 10 minutes late. In the latter group, six participants called after 10 minutes but within one hour, and nine were late for more than one hour (with the latest response being 7 hours and 20 minutes late). None of the participants who were late indicated that they remembered on time but were unable to make a call at that time.

The experimental manipulation of motivation did not have reliable effects on prospective memory performance, number of reported rehearsals, pre- and post-test ratings of motivation and did not interact with age (all F<1). The only effect that approached significance was the age by motivation interaction for the number of reported rehearsals ($F(1, 66)=3.55$, $p=.06$, $\eta^2=.05$), with old group reporting more rehearsals than the young in the high motivation condition (M=14.83 and M=10.29, respectively) but not in the low motivation condition (M=11.50 for old, and M=12.88 for young). All the analyses reported in this section are therefore based on the data pooled across the motivation manipulation.

Effects of age on prospective memory and the number of reported rehearsals

Following Study 1, calls made within ± 10 minutes of the pre-arranged time were classed as HITs and those made after 10 minutes as LATE responses. A failure to make this call on Sunday (3 participants) was also classed into the latter category. In the young group 68% (N=23) remembered to call on time and 32% (N=11) were late. In the old group 81% (N=29) remembered on time and 19% (N=7) were late. Although older participants displayed numerically better performance than young participants this difference was not statistically significant (χ^2 = 1.52, df=1, p=.21).

Next, we examined age effects on those variables that could potentially explain why old participants were as good as young in remembering to make the phone call. For example, it is possible that good prospective memory performance in older adults was maintained by either a larger number and different pattern of recorded rehearsals, higher levels of self-reported motivation or both. It was also interesting to see if older people were more likely to report being engaged in automatic activities than young people.

Effects of age on number and distribution of reported rehearsals

In total, 34 young participants recorded 394 rehearsals (range 2-26) and 36 old participants – 474 rehearsals (range 5-26). Hence, the mean number of recorded rehearsals was 11.59 (SD=6.91,) in the young group and 13.17 (SD=6.39) in the old group. The difference between these means was not statistically significant (F<1). There was also no age effect (F<1) in the distribution of rehearsals across the seven days of the study as revealed by the 2 (age group) x 7 (days) mixed ANOVA. The only significant effect that emerged from this analysis was the main effect of days (F(6,402)=15.90, p<.005, MSe=.07,η^2=.19). Figure 2 shows that both age groups exhibited a clear J-shaped pattern: the proportion of rehearsals per hour reported on the first and last day of the task was reliably higher than those reported during the middle five days of the study (all p_s<.001), and the proportion of rehearsals on Sunday (M=.44) was almost twice as high than on Monday (M=.24) (p<.05). Importantly, when the same 2 (age) x 7 (days) ANOVA was repeated on those 11 young and 7 old participants who were late none of the above effects were significant (all F_s<2.13), indicating that the J-shaped pattern is due to the participants who remembered to call on time.

Like in Study 1, there was a significant positive correlation between successful performance and number of recorded rehearsals in the young group (r(33)=.53, p=.001). However, this correlation was not significant in the old group (r(35)=.14, p=.43), the majority of old participants (81%) remembered to make a phone call on time irrespective of the number of reported rehearsals that ranged from 5 to 26.

Effect of age on self-reported levels of motivation

All participants rated the levels of their intrinsic motivation to remember to make a phone call on a 5-point scale (1=not motivated at all, 5=very motivated). These ratings were entered into 2 age group (young vs. old) x 2 time of rating (before vs. after the study) mixed ANOVA with the repeated measures on the last factor (for means see Table 3). There was a marginally significant effect of time of rating (F(1,68)=3.94, MSe= .47, p=.05, η^2=.06) with ratings of importance being somewhat lower after the study (M=3.81, SD=.92) than at the beginning of the study (M=4.04, SD=.89). Most importantly, there was the main effect of age (F(1,68)= 23.79, MSe=.89, p<.001) with a large effect size (η^2=.26). Old participants' self-rated levels of intrinsic motivation were significantly higher (M=4.31, SD=.59) than those of young participants (M=3.55, SD=.74) irrespective when the ratings were taken (before or after the study). Interaction between the independent variables was not significant (F<1).

Effects of age on type of ongoing activities and ratings of concentration

The activities reported by participants were categorised as automatic or controlled by two raters using the same coding procedure as in Study 1. Agreement between the raters was excellent (for the young group Kappa = .95, SE=.02; for the old - Kappa=.93, SE=.02), and discrepancies were solved by discussion. Out of 392 descriptions provided by the young group, 54% of cases (N=213) were classed as automatic and 46% (N=179) as controlled. In the older group, 66% of reported activities (N=310) were classed as automatic, and 34% (N=161) as controlled. This difference between the age groups was statistically significant (χ^2=11.81, N=863, df=1, p=.001). [7] Given that older group consisted of retired people it is perhaps unsurprising that older participants were also more likely to report experiencing rehearsals at home (84%) than young participants (55%) (χ^2 =92.66, N=686, df=1, p<.0001).

However, the analysis of participants' self-reported levels of concentration on a 5-point scale (1=not concentrating at all, and 5=fully concentrating) showed an opposite pattern. For this analysis, scale points 1 and 2 were categorised as "low concentration", point 3 as "medium concentration" and points 4 and 5 as "high concentration". The number of cases as a function of age group and concentration level (low vs. moderate vs. high) are presented in Table 4. This table shows that while young participants are more likely to report low levels of concentration (40%) than the old group (30%), the latter is more likely to report high levels of concentration (45%) than the young group (35%) (χ^2=10.23, df=2, p=.006). Taken together, these results provide support for the idea that with increased age automatic activities may require more attentional resources and higher levels of concentration on these tasks (see e.g., Lindenberger, Marsiske & Baltes, 2000).

Effects of age on the types of reported triggers

Finally, we addressed the most important question concerning the triggers of recorded rehearsals. Our aim was to replicate the pattern of results in Study 1 in the young group and to see if there were any age effects in the types of reported triggers. For this purpose, the diary entries of all participants were examined to see whether they were reported as being triggered by something or whether the task just popped into mind without any obvious triggers. Next, those rehearsals that were reported as being triggered were categorised by two independent raters according to whether the trigger was something external in the environment or internal in one's thoughts. Further, those rehearsals that were categorised as being triggered by internal thoughts were further classified into those cued accidentally by related thoughts or cued by self-initiated planning thoughts. The agreement between the raters was excellent (Cohen's Kappas were .92 and .91, respectively) and any disagreements were solved by discussion.

The mean number of rehearsals in each of these four trigger categories (no trigger, incidental external, incidental internal, self-initiated planning thoughts) as a function of age group is presented in Table 2 (Panel B). These means were entered into 2 (age group) x 4 (trigger category) mixed ANOVA with the repeated measures on the last factor. There was no significant effect of age (F(1,68)=1.06, MSe=11.02, p=.31) but there was a highly significant effect of trigger category (F(3,204)=21.39, MSe=9.03, p<.001, η^2=.24). Planned comparisons showed that the mean number of reported rehearsals in the no trigger category (M=5.30, SD=4.60) was significantly higher than in the external trigger category (M=3.37, SD=2.81) (t=2.96, df=69, p=.004) which, in turn, was significantly higher than in the internal trigger category (M=2.30, SD=2.20) (t=3.05, df=69, p=.003). The difference between the latter and the self-initiated category (M=1.40, SD=2.18) was also statistically significant (t=-2.62, df=69, p=.01). Although older participants recorded numerically more rehearsals with no reported triggers (M=6.22, SD=5.30) than the young group (M=4.32, SD=3.56), the age by trigger category interaction was not statistically significant (F(3,204)=2.41, MSe=9.03, p=.09).

Discussion

On the whole, the results of Study 2 replicated the main findings from Study 1 and, additionally, provided us with some important insights about the effects of age on remembering time-based tasks outside the laboratory. Thus, the old group was as good as the young group at making a phone call on time. This high level of performance was not, however, achieved by older adults reporting higher number of rehearsals than younger adults. Most importantly, there were no age differences in the type of reported rehearsals with the smallest number of rehearsals falling into the category of self-initiated rehearsals in both groups (15% in young and 8% in old). In addition, both young and old participants appear to have similar J-shaped pattern of rehearsal over the 7 days of the study.

Results concerning intrinsic motivation and ongoing activities are also interesting, especially in relation to the prospective memory and aging paradox. Thus, old participants reported higher levels of intrinsic motivation for the prospective memory task and were more likely to report being engaged in automatic activities than young participants. However, old participants were also more likely to report concentrating their attention on these activities. In other words, for older adults simple automatic activities may be more demanding than for younger adults. Taken together, this pattern of results appears to indicate that the discrepancies across laboratory and naturalistic studies of prospective memory and aging could be due to possible differences between young and old participants' levels of motivation and attentional demands of ongoing activities in and outside the laboratory. These points will be examined in more detail in the discussion.

Finally, the experimental manipulation of motivation did not produce any significant effects on prospective memory and rehearsal. This was surprising given that participants in the high motivation group knew that all their rehearsals recorded during the one-week period would be discarded even if they were only 30 seconds over the critical 10-minute period. This contrasts the results of laboratory studies in which the effects of motivation have been obtained by simply telling participants that their performance in the prospective memory task is more important than in the ongoing task (Kliegel, Martin, McDaniel, & Einstein, 2001) or that they will be very helpful to the experimenter if they do not forget the task (Kvavilashvili & Ellis, 2001, July). The fact that effects of motivation can be obtained in the lab with relatively weak verbal manipulations but not outside the laboratory is in itself an interesting finding and may be indicative of somewhat different processes being in operation in and outside the laboratory. It is also possible that, in the present study, intrinsic motivation to perform the naturalistic task was so high that any additional verbal manipulation could not further increase it. Indeed, the majority of participants in the low motivation condition were choosing the ratings on the upper end of the 5-point scale (points 4 and 5) in both young and especially old participants (59% and 79%, respectively). None of the old and only one young participant chose the ratings of 1 or 2 on the scale.

Study 3

The major finding that emerged from Study 1 and 2 is that the occurrence of reported rehearsals in time-based tasks, and ultimately their retrieval, is mediated by three different routes in both young and old participants. In stark contrast to most currently prevailing ideas about time-based prospective memory only one of these routes involved deliberate self-initiated retrieval, and importantly, this route was reported to have been used least frequently. The remaining two routes seemed to involve involuntary automatic processes with thoughts about the task being reported to pop into one's mind in response to incidental cues or with no apparent triggers at all.

If time-based prospective memory is primarily mediated by automatic processes, as these results seem to suggest, does this mean that the retrieval of time-based tasks in everyday life is not different from that of event-based tasks? For example, according to McDaniel and Einstein's (2000) influential multiprocess account there is a general bias to rely on spontaneous retrieval processes in event-based tasks even though under some conditions people may adopt more effortful and conscious monitoring strategies. An important question that needs to be answered in the light of our findings is to find out in what ways, if at all, is the retrieval of naturalistic time- and event-based tasks different.

One obvious difference is that the successful remembering in the event-based tasks may require less number of rehearsals because people rely on the target event, especially if this event is distinctive and salient, to act as a cue to remind them of the task (e.g., Brandimonte & Passolunghi, 1994; McDaniel & Einstein, 1993). For example, in the naturalistic study that directly compared event- and time based tasks (Sellen et al., 1997) participants reported thinking about (i.e., rehearsing) a time-based task more frequently than an event-based task (for similar results obtained in the laboratory on young and old participants see Kvavilashvili et al., 2005). However, no previous study has examined the processes/triggers that bring the event-based task to one's mind in the delay interval and compared these to the ones in the time-based tasks.

Study 3 was conducted to answer this important question by testing two groups of young participants one of which was assigned to a time-based task of making a phone call at a pre-arranged time in one week's time, and another to an event-based task of making a phone call in response to a certain event (a text message from Lycos.co.uk) which occurred in exactly one week from the initial session. Like in Study 1 and 2, all participants had to keep a diary and record their thoughts about the task during the delay interval.

Based on previous findings, it was predicted that participants in the time-based condition would report experiencing more thoughts about the task than those in the event-based condition. In addition, while J-shaped pattern was expected to occur in the time-based task, no such pattern was expected in the event-based task with the number of thoughts being at a relatively low rate throughout the delay period. Most importantly, it was predicted that while time- and event-based conditions would not differ in the number of rehearsals triggered by incidental (external and internal) cues, participants in the time-based condition would report significantly more rehearsals instigated by self-initiated planning thoughts and especially rehearsals with no triggers and than those in the event-based condition.

Method

Participants. Forty-three psychology undergraduates (7 males and 36 females) whose age ranged from 18 to 24 years, took part in a study in exchange of course credit. Twenty-two participants were assigned to the event-based condition and 21 participants to the time-based condition.

Materials and Procedure. These were similar to those in Study 1 and Study 2 (the condition with no motivation manipulation) except for the following modifications. First, the day of initial meeting was changed from Monday to either Tuesday or Wednesday (between 3:00 p.m. and 6:00 p.m.). This was done to eliminate the possibility that the increased number of rehearsals reported in Study 1 and 2 on the final day of the task coincided with the weekend (i.e., Sunday) when people are involved in more undemanding leisurely activities.

Second, all participants were instructed to start the diary-keeping task the day after the initial meeting (i.e., on Wednesday or Thursday) and to record only those rehearsals that occurred between 9:00 a.m. and 9:00 p.m. This would ensure that the diary was kept for the same number of hours each day and eliminate the necessity of using proportionalized scores when assessing the pattern of rehearsals across the 7 days of the study. Indeed one could argue that the J-shaped curve was obtained in Study 1 and 2 because there were fewer hours available for recording rehearsals on Monday and especially on Sunday.

Furthermore, the experimenter used an iMac computer to generate the text message from Lycos.co.uk to all participants who took part in the event-based task. In particular, a user name coined Lycos.co.uk was set up on the Lycos.co.uk site in order to construct and send out text-messages. The message read ‘ Have a nice day!’ which was placed three lines down from the page. This initial text message was sent to a Sony Ericsson T610 mobile phone, one of two phones the experimenter had. It was from this phone that all text-messages were generated to all participants. Due to the fact that this phone had status report facility, it was possible for the experimenter to know the exact time when the participant received the text message. An additional 6310i Nokia mobile was used to answer the calls made by participants.

Upon their arrival at the laboratory, all participants were asked to fill in a short 4-item questionnaire assessing their mobile phone use and habits. All participants reported to own a mobile phone and use it on daily basis. Participants were then informed in detail of the required task. Participants in the time-based condition were told that they had to call the experimenter in seven days time at a time most convenient for them. The seventh day was either on Tuesday or Wednesday. The available time-slots were arranged in intervals of 30 minutes, starting at 7:00 p.m. and ending at 9:00 p.m. Minor time adjustments of ±15 minutes were made for those who could not call during these times. Participants had to keep a diary from 9:00 a.m. next morning until the time of their arranged phone call on Tuesday or Wednesday evening.

In contrast, participants assigned to the event-based condition were informed that they had to call the experimenter immediately after receiving a text-message from Lycos.co.uk. They were asked to keep a diary from 9:00 a.m. next morning until the moment they received this text message which could occur any day during the next ten days. However, all participants in the event-based condition received the text-message on the seventh day between 7 p.m. and 9 p.m. The text-message was often sent out to participants straight after each participant in the time-based condition executed their intention, i.e. called the experimenter at the pre-arranged time.

On the seventh day, when participants telephoned the experimenter, the time of their call was automatically noted. Participants who were late were questioned about the reasons for their late call. At the end, the experimenter arranged a meeting with the participants for them to return the diary and to receive a full debrief and course credits.

Results

All 43 participants completed the study, however, three participants did not attend their final meeting and thus never returned their diaries. Out of 40 participants who did return their diaries, 19 were in the time-based condition and 21 in the event-based condition. However, initial screening of the data revealed one outlier in the event-based condition with 31 entries that constituted 19% of recorded rehearsals in that condition. The data of this participant was excluded from the analyses, and the final sample consisted of 19 participants in the time- and 20 participants in the event-based condition.

Like in Study 1, none of the participants forgot completely to make the telephone call. In the time-based condition, 10 participants (53%) remembered to call within 10 minutes of critical time and 9 participants (47%) were more than 10 minutes late. Of these, four remembered to call after 10 minutes but within one hour from critical time and five were late for more than one hour with the latest call being made at midnight. Only one of these participants said he remembered on time but was unable to call. The remaining 8 participants all admitted forgetting and remembering at a later time.

In the event based condition, 16 participants (80%) responded on time (i.e., made the call within 10 minutes of seeing the text message on their mobile phone) and only 4 participants (20%) were late in replying to the text message. Of these, three called within an hour and one called after 1 hour and 10 minutes from receiving the text message. In contrast to the time-based condition, none of these 4 participants indicated that their late responses were caused by forgetting. Instead, they provided valid reasons as to why they were unable to read the target message (and call back) immediately after receiving it.

Therefore, when taking into account participants' self-reports, performance in the event-based condition was at ceiling with 100% of prospective memory responses classed as HITs whereas in the time-based condition 58% of responses (N=11) were classed as HITS. This difference in the percentage of on-time responses in two conditions was highly significant (χ^2=8.19, df=1, p<.005, with Yate's correction applied). This finding replicates the results of Sellen et al.'s (1997) naturalistic study in which participants were better at remembering to press the electronic device when they were in a particular location (event-based task) than when they had to carry out this action at particular times (time-based task) (for similar findings see also Rendell & Craik, 2000, Experiment 2).

Number and distribution of rehearsals as a function of task

In total, 19 participants in the time-based condition recorded 178 rehearsals (range 3-22), and 20 participants in the event-based condition -135 rehearsals (range 2-14). In line with our prediction, the mean number or recorded rehearsals in the time-based condition (M=9.37, SD=5.12) was reliably higher than in the event-based condition (M=6.75, SD=3.27) (t=1.91, df=37, p=.03, one tailed).

The distribution of these rehearsals over the 7-day period is presented in Figure 3. Visual inspection of the figure suggests that the distribution of rehearsals differed between the conditions in the predicted direction with the mean number of rehearsals increasing markedly on the last two days of the study in the time-based but not in the event-based condition. However, when the means were entered into a 2 (prospective memory task) x 7 (days) mixed ANOVA with the repeated measures on the last factor the task by days interaction was not significant (F(6, 222)= 1.10, MSe=.76, p=.36). Nonetheless, we conducted further tests of simple main effects to examine the effect of the task on each day of the study. This was deemed acceptable given our strong a priori prediction as well as the large number of degrees of freedom, and the similar shape of distribution between the conditions (except the last day of the study) that would negatively affect the chances of detecting a significant interaction (see McClelland & Judd, 1993). These tests showed that the only significant difference between the conditions occurred on the last, seventh day of the study ($F(1,37)=6.31$, $MSe=1.23$, $p=.017$, $\eta^2=.14$). Participants in the time-based condition recorded almost twice as many rehearsals ($M=1.84$, $SD=1.34$) than those in the event-based condition ($M=.95$, $SD=.83$).

Furthermore, like in Study 1 and 2, the number of recorded rehearsals in the time-based condition was positively correlated with prospective memory performance ($r(18)=.50$, $p=.04$). This correlation could not be calculated for the event-based condition due to a near ceiling performance in that group.

Effect of task on types of reported triggers

For this analysis, the descriptions of triggers provided by participants for their recorded rehearsals were categorised by two independent raters (the first author and the research student) using exactly the same procedure as in Study 1 and 2. Agreement between the raters was excellent (Kappa=.93, SE=.03) and some minor disagreements were solved by discussion. The mean number of rehearsals as a function of prospective memory task and 4 trigger categories (no trigger, incidental external, incidental internal, self-initiated planning) are presented in Table 2 (Panel C).

These means were entered into a 2 (task) x 4 (trigger) mixed ANOVA with the repeated measures on the last factor. This analysis resulted in the main effect of triggers ($F(3,111)=23.73$, $MSe=4.49$, $p<.001$, $\eta^2=.39$). However, this effect was qualified by a significant interaction with the type of task ($F(3,111)=2.93$, $p=.047$, $\eta^2=.07$). The tests of simple main effects showed that participants in the time-based condition had significantly higher number of rehearsals in the no trigger category (M=4.37, SD= 3.08) than those in the event-based condition (M=2.15, SD=1.66) (F(1,37)=7.96, MSe=6.03, p=.008, η^2=.18). Although participants in the time-based condition had higher number of rehearsals in the self-initiated category (M=.53), SD=.84) than those in the event-based condition (M=.20, SD=.41), this difference was not significant (F(1,37)=2.41, MSe=.43, p=.12). There was also no significant difference between the conditions in terms of the number of rehearsals in the incidental external and incidental internal categories (F_s<1).

Ongoing activities and concentration ratings as a function of task

Finally, we examined the activities that participants were engaged in when they reported rehearsals and the ratings of concentration on these tasks. In Study 1 young participants were more likely to report being engaged in the automatic than controlled activities at the time of rehearsals (in 62% and 38% of cases, respectively). However, in Study 2 young participants were equally likely to report to be engaged in the automatic and controlled activities (in 54% and 46% of cases, respectively). It was therefore interesting to see if the pattern of findings obtained in Study 2 would be replicated in Study 3 in time- and event-based conditions.

Two raters independently read the descriptions of activities provided by participants and classed them as automatic or controlled using the same coding criteria as in Study 1 and 2. Agreement between the raters was high and any disagreements were solved by discussion (Kappa=.91, SE=.04). Out of 178 descriptions provided by participants in the time-based condition, 53% of cases (N=95) were classed as automatic and 47% (N=83) as controlled. In the event-based condition, 49.6% of reported activities (N=67) were classed as automatic, and 50.4% (N=68) as controlled. Thus, the activities were equally likely to be classed as automatic and controlled and there was no significant difference between the time- and event-based conditions in this respect (χ^2<1). There was also no significant difference between the two conditions in terms of the percentage of activities that were rated by participants as requiring low (ratings 1 and 2), medium (rating 3) and high (ratings 4 and 5) concentration as shown in Table 5 ($\chi^2<1$). Although participants in time-and event-based condition were equally likely to report being engaged in automatic and controlled activities they rated their concentration to be high on only one third of occasions (34%). Rest of the times they reported low (38%) and medium (28%) levels of concentration. This pattern of results fully replicated those obtained on young participants in Study 2.

Discussion

In summary, the results seem to replicate findings on young sample in Study 2 and also extend our knowledge about time-based prospective memory by examining possible differences and/or similarities between the latter and a comparable event-based task. Despite important changes in methodology (e.g., diaries being kept for equal number of hours each day and the last day of the study being a weekday rather than Sunday), the results showed that the number or recorded rehearsals did increase on the last day of the study in the time-based condition. In line with our prediction, no such increase was present in the event-based condition.

Somewhat surprisingly, in both conditions, participants recorded significantly more rehearsals on the first day of the study than on subsequent days and in the time-based condition the number of recorded rehearsals on the first and the last day of the study was identical ($F<1$). In other words, instead of the J-shaped pattern there was a U-shaped pattern in the time-based condition, and instead of the predicted flat line there was an inverted J-shaped pattern in the event-based condition.

The U-shaped pattern has also been obtained in the study of Ceci and Bronfenbrenner (1985) in which children had to remember to remove cup cakes from an oven or re-charge the batteries in 30 minutes time while simultaneously playing a video game. According to Ceci and Bronfenbrenner (1985) the increased monitoring in the first five minutes of the delay period helped children to calibrate their internal clocks with the time shown on the real clock. However, in the present study with a delay period of 7 days there did not seem to be a need for calibrating internal clock especially in the event-based condition. Instead, it appears that the heightened number of rehearsals on the first day may have been due to the changes in methodology, i.e., that participants had to start recording only from the morning of the following day after their initial meeting with the experimenter.

Furthermore, our results showed that although participants reported significantly more rehearsals in the time-based condition, the percentage of correct HIT responses was significantly lower in the time- than in the event-based condition. This pattern of findings fully replicates the results of Sellen et al.'s (1997) naturalistic study and supports the idea, repeatedly expressed in the literature, that event-based tasks with distinctive targets are easier to remember than time-based tasks.

However, the most important finding that emerged from the study concerns the nature of triggers that elicit the rehearsals in the time-and event-based conditions. Thus, in both conditions the rehearsals triggered by self-initiated planning thoughts were recorded least often (on only 6% and 3% of cases, respectively) and there was no reliable difference between the conditions in terms of mean number of such rehearsals. In line with our predictions, the major difference between the time- and event-based prospective memory lies in the number of recorded rehearsals with no apparent triggers. This finding suggests that the representations of time-based tasks may be activated at a higher level during the delay period than those of the event-based tasks and has important implications for our understanding of the mechanisms involved in the remembering of time-based prospective memory tasks.

General Discussion

Prospective memory research has been mainly focused on event-based prospective memory. There are very few studies that have specifically examined the processes involved in remembering time-based tasks. The present paper fills this gap by examining the nature of thought processes that bring the time-based intention to mind in both young and old participants, and how these processes differ from those involved in remembering event-based tasks.

It has been assumed that the successful retrieval of time-based tasks depends on periodic rehearsal of intention especially during a period immediately preceding the critical time. This is reflected in the J-shaped pattern of rehearsals during the delay interval as shown by the results of a few laboratory studies on time-based prospective memory (e.g., Einstein et al., 1995; Harris & Wilkins, 1982; Park et al., 1997; see also Ceci & Bronfenbrenner, 1985 who obtained the U-shaped pattern). Furthermore, given that there is no external event to signal that the time for the execution of intention has arrived, it has been assumed that this periodic rehearsal or reminding is mediated by deliberate retrieval processes that are instigated by participants themselves (e.g., 'what do I need to do next?' 'what are my plans for today?', etc.). Since laboratory studies have mostly utilised very short time delays (in the order of few minutes) it is quite likely that participants do keep the task in mind for the entire delay period and occasionally check the time when they think that sufficient time has elapsed (*cf.* Harris & Wilkins, 1982; Sellen et al., 1997). In this sense the retrieval processes in short-term laboratory tasks can be regarded as self-initiated and deliberate.

However, it is unlikely that the remembering of time-based tasks in everyday life with long delay intervals of several hours or days occur in a similar fashion. It is obvious that after forming an intention to do something at a particular time in the future, people have to focus on other tasks that require their immediate attention. Nevertheless, thoughts about the task may occasionally enter their mind throughout the delay interval. For example, participants in our studies did report thinking about their future task to call the experimenter (*cf.* Ellis & Nimmo-Smith, 1993). The primary goal of the present investigation was to find out whether these thoughts were instigated by the self-initiated planning processes or were triggered by incidental external and/or internal cues.

The nature of retrieval in time-based prospective memory

The results from all three studies clearly show that self-initiated rehearsals, occurring when people are engaged in deliberate planning of their daily activities, were reported on very few occasions by both young and old participants. The mean number of such rehearsals varied from .50 to 1.70 during the 7-day long delay period (comprising 6% to 15% of recorded cases) and was significantly lower than rehearsals triggered by incidental cues in the environment or by one's own thoughts. The examination of these incidental triggers showed that there was a great variety of cues that could act as triggers with some cues being completely unrelated to the content of the to-be-performed task (see Tables 1a and 1b for examples).

This finding confirms the informal feedback provided in some earlier studies. For example, one third of the participants in the Harris and Wilkins (1982) study indicated that references to time in the film they were watching (e.g., shorts of airport clock, plane departure times, etc.) reminded them of the time-based task they were supposed to be carrying out (see also Sellen et al., 1997). However, Harris and Wilkins (1982) report that references to time were difficult to determine objectively. When three independent raters were asked to watch the film and record any references to time the consistency between the raters was so low that it discouraged any further analyses. This indicates that only when one forms a future intention one becomes sensitive to incidental external cues that are not otherwise easily noticeable to people who do not hold such intention.

Perhaps most surprisingly, the largest number of rehearsals (at least in Study 2 and 3) was reported to have occurred without any external or internal incidental cues, i.e., they just seemed to pop into one's head without any apparent reason. Since participants did not seem to exercise any control over these spontaneously occurring rehearsals it is difficult to regard them as self-initiated (i.e., mediated by deliberate effortful retrieval processes). How do these findings fit existing models of time-based prospective memory?

The Random Walk model does not ascribe any active properties to the representation of to-be-performed intention. Periodic rehearsal and ultimately the retrieval of intention at an appropriate time are entirely determined by random incidental cues in one's environment or thoughts (Wilkins, 1979, cited in Harris, 1984). Although our study showed that such "accidental" cued rehearsals did indeed occur fairly frequently they were by no means the only type of rehearsals experienced by participants. On the whole, it appears that the obtained results are more in line with the Test-Wait-Test-Exit model as originally proposed by Harris and Wilkins (1982). According to this model, the successful performance is mediated by a series of Test-Wait-Test loops (the test being synonymous with the rehearsal), especially towards the end of the delay period, until a final test is made within the appropriate critical period which is then followed by successful execution of an intention signifying Exit from the TWT loops. The pattern of rehearsals observed in the present study is generally in agreement with this model. Most importantly, the results of the present study extend the Harris and Wilkins model by providing the missing information about the processes that elicit the tests (i.e., rehearsals) in the delay period. [8]

In particular, our results suggest that the representation of intention formed when one decides to carry out a time-based task at some point in the future is likely to remain activated at subthreshold level, possibly during the entire delay period (see also Ellis, 1996 and Mäntylä, 1996 for a similar view). Moreover, this sustained subthreshold activation appears to periodically reach levels that result in conscious thoughts about the intention (i.e., non-cued rehearsals when intention pops into mind without any apparent cues). In addition, it may sensitise people to chance encounters with incidental cues that would not necessarily be perceived as related to the task without having this intention (see Table 1a, for examples).[9] These periodic conscious thoughts about the task may, in turn, serve an important function of further reactivating the representation of intention during the retention interval, increasing the chances that it will eventually be remembered at the appropriate moment which may be hours or even days ahead (see also Ellis, 1996, and Freemen & Ellis, 2003). The positive role of such rehearsals was revealed by the results of all three studies on young participants showing significant positive correlations between the number of recorded rehearsals and the probability of on-time prospective memory response in the time-based task.

Theoretically, rehearsals that spontaneously pop into mind without any cues are most interesting as they may hold a key to performance success in everyday (and possibly laboratory) prospective memory tasks. Given that the likelihood of encountering relevant incidental external cues or instigating conscious planning thoughts during the critical time period is probably not very high, the successful retrieval of time-based tasks may ultimately depend on these thoughts about the task that occur without any apparent triggers. The importance of such non-cued thoughts is emphasised by the findings of both Study 2 and 3 showing that participants recorded a significantly higher number of such rehearsals in comparison to all other trigger categories (incidental external, incidental internal and self-initiated planning). In addition, when we separately examined the relation between the rehearsals in each of these trigger categories and the probability of HIT response, the significant correlations emerged for only non-cued (r(33)=.35, p=.04) and self-initiated (r(33)=.34, p=.046) rehearsals in Study 2 and for non-cued rehearsals in Study 3 (r(18)=.46, p=.047). Although these initial findings need to be treated cautiously they do suggest an interesting idea that the activation levels of everyday long-term intentions can be measured by the number of non-cued rehearsals occurring in the delay interval.

Another interesting point in relation to these non-cued rehearsals is that they imply the existence of some kind of internal (and subconscious) counter or clock which ensures that the intention is not only occasionally brought to mind during the delay interval, but also nearer the critical time (*cf*. Einstein & McDaniel, 1996a; 1996b; Harris & Wilkins, 1982). The results of the present study provide some initial support for this idea. For example, although the mean number of reported rehearsals significantly increased in the last day of the task, the actual numbers were not particularly high with a range of 0 to 5 rehearsals and a mean of 1.84 (see Figure 3). Neither were these rehearsals recorded predominantly in the final hour immediately preceding the pre-arranged time for the phone call (*cf.* Sellen et al., 1997). In all three studies, only 30% of rehearsals recorded on the final day of the task were recorded in the hour immediately preceding the critical time. It is therefore unlikely that participants would have succeeded in calling the experimenter on time without the operation of this internal clock that would bring the task to one's mind near the critical time and thus, eliminate the necessity of excessive time-checking.

It is interesting that a similar subconscious clock may be in operation when one needs to wake up unusually early (e.g., at 5:00 am). Everyday observations and some empirical evidence seem to suggest that people often succeed in this seemingly impossible task. For example, in one large scale questionnaire study (N=1080), 53% of respondents reported that they could sometimes wake up from sleep at a particular self-chosen time (Fraisse, 1964, p. 44). In a laboratory study of Zung and Wilson (1971), participants were indeed able to wake up within ±10 minutes of the designated target times, set between 02:00 and 05:00 a.m., on 32% of occasions. This level of performance is well above chance and is comparable to conscious time estimations of similar durations obtained by Webb and Ross (1972) in awake participants (see Block, 1979 for further discussion). It is also interesting that the successful awakenings were independent of pre-selected times and the stage of sleep participants were in immediately before waking up (for similar findings, see Tart, 1970).

An important question for future research is to examine a precise mechanism of this internal clock that can bring up the time-based intention to consciousness both during sleep (as described above) and waking hours (as shown in the present study). [10] It is unlikely that this clock is mediated primarily by biological factors such as circadian periodicity in activation levels or physiological rhythms during normal sleep (in case of waking up at pre-selected time). Tart (1970), for example, argues that these rhythms usually last longer than 60 minutes and would be unable to account for performance requiring precise responding in minutes rather than hours (*cf.* Zakay & Block, 1997).

On the other hand, Block (1979) argues that the operation of this clock is mediated by “subconscious (dissociated) information-processing mechanisms” (p. 200). However, current theories of time estimation (especially prospective time estimation) are primarily based on studies in which participants have to estimate very brief time intervals in the order of few seconds (Allan, 1998; Block & Zakay,1997; Grondin, 2001; Zakay & Block, 1997). It is therefore unclear whether they can account for the operation of an internal clock in time-based prospective memory tasks with delay intervals of hours, days and weeks (but see Block & Zakay, in press).

It is, of course, possible that current theories of time-estimation are more relevant and useful to account for time-based prospective memory studied in the laboratory, particularly as they use shorter time intervals (typically, from 1 to 10 minutes). However, preliminary results from Mäntylä and Carelli (in press) show that participants' prospective time-estimation was not related to time-monitoring frequency and performance in a laboratory time-based prospective memory task. It is obvious that more research needs to be conducted in future to address these issues. Present findings, together with the earlier results of Zung and Wilson (1970) on waking at pre-arranged times, open up interesting avenues for fruitful collaboration and cross fertilization of currently disparate areas of time estimation and prospective memory. It appears that the Zeitgeist for such an endeavour has already arrived (see e.g., Glicksohn & Myslobodsky, in press).

Is time-based prospective memory different from event-based prospective memory?

Overall, the results of all three studies suggest that the rehearsal and retrieval of naturalistic time-based tasks is less self-initiated and more reliant on automatic processes than previously thought. Moreover, the results of Study 3 showed that the retrieval of time- and event-based tasks is not mediated by fundamentally different processes. Indeed, thoughts about the task occurred via three different routes in both time- and event-based conditions (i.e., rehearsals instigated by incidental external or internal cues, by self-initiated planning thoughts or by no apparent triggers). These results suggest that the difference between the time- and event-based tasks is more quantitative than qualitative. In particular, the representations of event-based tasks may generally be at a relatively constant and low level of subthreshold activation. This level of activation is sufficient to sensitise one towards the occurrence of target and/or related events in the environment. However, it may not be enough for the task to pop periodically into one's mind, at least with the same frequency as in the case of time-based tasks. In contrast, the activation levels of time-based tasks may be higher and fluctuate over time resulting in periodic conscious thoughts about the task.

It is encouraging that additional support for this idea comes from a recent (unpublished) laboratory study of the Intention Superiority Effect in which reaction times were faster to intention related contents if participants expected to retrieve these contents in a subsequent time-based than event-based task (Freeman & Ellis, 2002, September). It is interesting, however, that in this experiment, as well as in Study 3, the event-based task had a relatively salient distinctive target that reduced the necessity for its representation to reach high levels of activation. Future laboratory and diary studies will need to compare the activation levels of time-based tasks to that of event-based tasks with a less distinctive target event. It is possible that in these circumstances the activation levels of event-based tasks will be comparable to those of time-based tasks.

Increased accessibility of time- and event-based prospective memory tasks

Results of the present study also provide evidence in support of the idea that both time- and event-based tasks may have increased accessibility in comparison to other (retrospective) memory representations in long-term memory. For example, in recent diary studies of Kvavilashvili and Mandler (2004, Study 4) and Schlagman, Kvavilashvili and Schulz (in press) on *involuntary autobiographical memories,* participants reported low levels of concentration (i.e., points 1 and 2 on the 5-point rating scale) on ongoing activities in 55% and 60% of cases, respectively. However, these percentages were significantly lower in Study 2 and 3 of the present investigation (between 35.5% to 40%, see Table 4 and 5). The differences across the studies indicate to the interesting possibility that, due to their functional importance, thoughts about the time- and event-based tasks are more likely to occur when engaged in relatively demanding controlled activities than involuntary (retrospective) autobiographical memories.

Further evidence in support of this idea comes from the results concerning the effects of age on the number of reported rehearsals. Previous research indicates that with increased age there may be a general tendency to experience less number of spontaneous mental processes irrespective of their content. For example, Giambra (1989) found that in comparison to a young group, older adults (60+ years old) reported up to 50% fewer involuntary task unrelated thoughts during a monotonous vigilance task in the laboratory. Similarly, older adults have reported experiencing less number of involuntary autobiographical memories and involuntary mind pops than young adults in the study of Schlagman et al., (in press) and Kvavilashvili and Mandler, (2001, July), respectively. These findings are in sharp contrast with the results of the present study showing that, in everyday life, old participants did not record less number of thoughts about the prospective memory task than young participants. Future studies should directly compare involuntary autobiographical memories and thoughts about prospective memory tasks within the same samples of young and old participants both in terms of the number of experienced memories and the ratings of concentration on ongoing activities.

Prospective memory and aging paradox

Another set of interesting findings obtained in this study concern the effects of age, intrinsic motivation, and ongoing activity on time-based prospective memory. Old participants were as good as young participants in carrying out the time-based task on time. This is in line with previous findings showing either no age effect (e.g., Moscovitch, 1982; West, 1988; Study 1) or reliable age effects in favour of older adults (Devolder, Brigham, & Pressley, 1990; Martin, 1986; Rendell & Thompson, 1999;

Rendell & Craik, 2000; d'Ydewalle, 1996). It has been suggested that outside the laboratory old people may perform as well as young people (if not better) because they use external reminders more efficiently (i.e., calendars, post-it-notes, etc.) than young people (Martin, 1986; Moscovitch, 1982). In addition, Maylor (1998) has suggested that in order to achieve the same level of performance as young people older adults may need to think about (rehearse) the task more frequently (*cf.* Rendell & Craik, 2000). However, in the present study all participants were actively discouraged from using any external mnemonic aids. Nor did the older sample report thinking about the task more frequently than the young sample (for similar findings see Costermans & Desmette, 1999; Patton & Meit, 1993; Experiment 1). There were also no age effects in the types of rehearsals recorded by participants.

However, age effects were obtained in self-rated levels of motivation and the type of ongoing activities people were engaged in at the time of rehearsal. Older adults reported to have reliably higher levels of (intrinsic) motivation both before and after the completion of the task than younger adults. On the other hand, although old participants were more likely to be engaged in seemingly automatic activities at the time of reported rehearsals they were also more likely to be concentrating on these activities which were apparently attentionally more demanding for them (*cf.* Lindenberger et al., 2000). Taken together, these results provide some insights into possible reasons for obtaining paradoxical findings in prospective memory and aging research concerning significant age effects in the laboratory (especially with time-based tasks) and no age effects or superior performance of older adults outside the laboratory.

It appears that successful performance on time-based prospective memory tasks may be partly mediated by a certain combination of one's level of motivation to carry out the task and the nature of ongoing task which can be attentionally undemanding (i.e., automatic) or demanding (controlled). Previous studies have shown that prospective memory performance is affected by both motivation and attentional demands of ongoing activity. Higher levels of motivation (i.e., interest, incentives, etc.) improve performance (see e.g., Kliegel, et al., 2001; Kvavilashvili, 1987), and attentionally demanding ongoing tasks impair it (e.g., Einstein, Smith, McDaniel, & Shaw, 1997; Marsh & Hicks, 1998).

Our study shows that older adults report being more highly motivated than younger adults to carry out prospective memory tasks in a timely fashion (for similar findings see Patton & Meit, 1993). However, outside the laboratory, in their everyday life they are generally involved in relatively automatic habitual activities even though they may find some of these fairly demanding. Therefore, the combination of high motivation and relatively undemanding and familiar ongoing tasks may result in prospective memory performance that is comparable or even better than that of young adults. In the laboratory, however, although old participants may continue to be more highly motivated than young participants they are usually asked to perform tasks that are unfamiliar and cognitively demanding. [11] The overall result is that performance levels of older adults may drop both in terms of the number of clock checks and on-time responses.

This line of argument implies that age effects may be eliminated in the laboratory if participants are engaged in fairly undemanding and familiar activities such as watching a film on TV. Few studies that have used watching a film as an ongoing activity in the laboratory have indeed found no significant age effects either in performance or in the number of clock checks (e.g., Costermans & Desmette, 1999; d'Ydewalle, 1996; Patton & Meit, 1993, Experiment 1). Therefore, future laboratory studies of prospective memory and aging will need to manipulate the level of familiarity of ongoing tasks and motivation in order to examine these ideas in more depth.

Some methodological considerations and conclusions

Finally, a couple of methodological issues need to be considered in relation to a diary method used in the present study. First, the overall compliance rate was good as on average participants recorded between 8.38 and 13.17 rehearsals in the time-based task across the three studies. In addition, most of the rehearsals (70%) were recorded within an hour after experiencing them and therefore it was less likely that participants would have forgotten some crucial details of their rehearsal experience (*cf.* Ericsson & Simon, 1980). Second, it was also less likely that some participants were consistently under-recording the instances of experienced rehearsals. If this were the case we would not have obtained a positive correlation between the number of rehearsals and prospective memory performance (HIT vs. LATE). Furthermore, although on some occasions participants were probably unable to notice subtle cues in their environment or thoughts (e.g., see Bowers, Farvolden & Lambros, 1995), it is less likely that the majority of reported rehearsals with no triggers would fall into this category. Thus, on the whole, participants were quite willing to describe the triggers for recorded rehearsals and the descriptions of these triggers would often bear very little semantic relation to the prospective memory task (e.g., see idiosyncratic cues in Tables 1a and 1b)

In conclusion, the present study has provided new insights into the processes and mechanisms that are involved in remembering time-based prospective memory tasks in everyday life. It has enabled us to further develop the TWTE model of Harris and Wilkins (1982) and to make crucial comparisons between processes involved in remembering naturalistic time- and event-based tasks. Most importantly, the study has generated several interesting avenues for future research and shows that the diary method is a useful and reliable method for collecting this type of naturalistic data (*cf.* Berntsen, 1998; Ellis & Nimmo-Smith, 1993; Kvavilashvili & Mandler, 2004).

References

Allan, L. G. (1998). The influence of the scalar timing model on human timing research. *Behavioural Processes, 44*, 101-117.

Baddeley, A., Emslie, H., & Nimmo-Smith, I. (1993). The spot-the-word test: A robust estimate of verbal intelligence based on lexical decision. *British Journal of Psychology, 32,* 55-65.

Berntsen, D. (1998). Voluntary and involuntary access to autobiographical memory. *Memory, 6,* 113-141.

Block, R. A. (1979). Time and consciousness. In G. Underwood and R. Stevens (Eds.), *Aspects of consciousness (vol. 1*, pp. 179-217). London: Academic Press.

Block, R. A., & Zakay, D. (1997). Prospective and retrospective duration judgements: A meta-analytic review. *Psychonomic Bulletin and Review, 4,* 184-197.

Block, R. A., & Zakay, D. (in press). Prospective remembering involves time estimation and memory processes. In J. Glicksohn, & M. S. Myslobodsky (Eds.), *Timing the future: The case for a time-based prospective memory* (pp. 25-49). London: World Scientific.

Bowers, K. S., Farvolden, P., & Lambros, M. (1995). Intuitive antecedents of insights. In S. Smith, T. B. Ward, & R. A. Finke (Eds.), The creative cognition approach. London: MIT Press.

Brandimonte, M. A., & Passolunghi, M. C. (1994). The effect of cue-familiarity, cue-distinctiveness, and retention interval on prospective remembering. *The Quarterly Journal of Experimental Psychology, 47A*, 565-587.

Burgess, P.W., & Shallice, T. (1997). The relationship between prospective and retrospective memory: Neuropsychological evidence. In M. A. Conway (Ed.), *Cognitive models of memory* (pp. 247-272), London: Psychology Press.

Cavanaugh, J. C., Grady, J. G., & Perlmutter, M. (1983). Forgetting and use of memory aids in 20 to 70 year olds everyday life. *International Journal of Aging & Human Development, 17*, 13-122.

Ceci, S. J., & Bronfenbrenner, U. (1985). "Don't forget to take the cupcakes out of the oven": Prospective memory, strategic time-monitoring, and context. *Child Development, 56,* 152-164.

Cicogna, P. C., Nigro, G., Occhiniero, M., & Ésposito, M. J. (2005). Time-based prospective remembering: Interference and facilitation in a dual task. *European Journal of Cognitive Psychology, 17*, 221-240.

Cook, G. I., Marsh, R. L., & Hicks, J. L. (2005). Associating a time-based prospective memory task with an expected context can improve or impair intention completion. *Applied Cognitive Psychology, 19*, 345-360.

Costermans, J., & Desmette, D. (1999). A method for describing time-monitoring strategies in a prospective memory setting. *Current Psychology of Cognition, 18*, 289-306.

Devolder, P. A., Brigham, M. C., & Pressley, M. (1990). Memory performance awareness in younger and older adults. *Psychology and Aging, 5,* 291-303.

d'Ydewalle, G. (1996). Are older subjects necessarily worse in prospective memory tasks? In J. Georgas, M. Manthouli, E. Besevegis, & A. Kokkevi, A. (Eds.), *Contemporary psychology in Europe: Theory, research and practice* (pp. 161-172), Bern: Hogrefe & Huber Publishers.

d' Ydewalle, G., Luwel, K., & Brunfaut, E. (1999). The importance of on-going concurrent activities as a function of age in time- and event-based prospective memory. *European Journal of Cognitive Psychology, 11*, 219-237.

Einstein, G. O., & McDaniel, M. A. (1990). Normal ageing and prospective memory. *Journal of Experimental Psychology: Learning Memory and Cognition, 16,* 717-726.

Einstein, G. O., & McDaniel, M. A. (1996a). Remembering to do things: Remembering a forgotten topic. In D. Herrmann, C. McEvoy, C. Hertzog, P. Hertel, & M. K. Johnson (Eds.), *Basic and applied memory research: Practical applications* (vol. 2, pp.79-94). Mahwah, NJ: Erlbaum.

Einstein, G. O., & McDaniel, M. A. (1996b). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 115-141). Mahwah, NJ: Erlbaum.

Einstein, G. O., McDaniel, M. A., Richardson, S. L., Guynn, M. J., & Cunfer, A. R. (1995). Ageing and prospective memory: Examining the influence of self-initiated retrieval processes. *Journal of Experimental Psychology: Learning, Memory and Cognition, 21,* 996-1007.

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring and spontaneous retrieval. *Journal of Experimental Psychology: General, 134,* 327-342.

Einstein, G. O., Smith, R. E., McDaniel, M. A., & Shaw, P. (1997). Aging and prospective memory: The influence of increased task demands at encoding and retrieval. *Psychology and Aging, 12*, 479-488.

Ellis, J. A. (1996). Prospective memory or the realization of delayed intentions: A conceptual framework for research. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 1-22). Mahwah, NJ: Erlbaum.

Ellis, J.A., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present and future directions. *Applied Cognitive Psychology, 14,* S1-S9.

Ellis, J. A., & Nimmo-Smith, I. (1993). Recollecting naturally occurring intentions: A study of cognitive and affective factors. *Memory, 1,* 107-126.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87,* 215-251.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6,* 409-434.

Fraisse, P. (1964). *The psychology of time*. London: Eyre & Spottiswoode.

Freeman, J. E., & Ellis, J. A. (2002, September). *Aging and the role of motoric information in the intended enactment effect*. Paper presented at the British Psychological Society Cognitive Section Conference, University of Reading, UK.

Freeman, J. E., & Ellis, J. A. (2003). The intention superiority effect for naturally occurring activities: The role of intention accessibility in everyday prospective remembering in young and older adults. *International Journal of Psychology, 38*, 215-228.

Giambra, L. M, (1989). Task-unrelated thought frequency as a function of age: A laboratory study. *Psychology and Aging, 4*, 136-143.

Giambra, L. (1995). A laboratory method for investigating influences on switching attention to task-unrelated imagery and thought. *Consciousness and Cognition, 4,* 1-21.

Glicksohn, J. & Myslobodsky, M. S. (Eds.) (in press). *Timing the future: The case for a time-based prospective memory*. London: World Scientific.

Graf, P., & Uttl, B. (2001). Prospective memory: A new focus of research. *Consciousness and Cognition, 10*, 437-450.

Grondin, S. (2001). From physical time to the first and second moments of psychological time. *Psychological Bulletin, 127*, 22-44.

Guynn, M. J. (2003). A two-process model of strategic monitoring in event-based prospective memory: Activation/retrieval mode and checking. *International Journal of Psychology, 38,* 245-256.

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (1998). Prospective memory: When reminders fail. *Memory & Cognition, 26*, 287-298.

Harris, J. E. (1984). Remembering to do things: A forgotten topic. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory, actions and absent-mindedness* (pp. 71-92). London: Academic Press.

Harris, J. E., & Wilkins, A. J. (1982). Remembering to do things: A theoretical framework and an illustrative experiment. *Human Learning, 1,* 123-136.

Henry, D. H., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging, 19*, 27-39.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2001). Varying the importance of a prospective memory task: Differential effects across time- and event-based prospective memory. *Memory, 9*, 1-11.

Kvavilashvili, L. (1987). Remembering intention as a distinct form of memory. *British Journal of Psychology, 78,* 507-518.

Kvavilashvili, L., & Ellis, J. A. (1996). Varieties of intention: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 23-51). Mahwah, NJ: Erlbaum.

Kvavilashvili, L., & Ellis, J.A. (2001, July). *"It is important that you do not forget": Effects of subtle motivational manipulation interact with preceding task complexity in activity-based prospective memory*. Paper presented at the 3rd International Conference in Memory, University of Valencia (Spain).

Kvavilashvili, L., & Mandler, G. (2001, July). *Out of one's mind: A study of involuntary semantic memories*. Paper presented at the 3rd International Conference in Memory, University of Valencia (Spain).

Kvavilashvili, L., & Mandler, G. (2004). Out of one's mind: A study of involuntary semantic memories. *Cognitive Psychology, 48,* 47-94.

Kvavilashvili, L., Kornbrot, D. E., Mash, V., Cockburn, J., & Milne, A. (2005). *Effects of age on prospective and retrospective memory*. Manuscript in preparation.

Lindenberger, U., Marsiske, M., & Baltes, P. B. (2000). Memorizing while walking: Increase in dual-task costs from young adulthood to old age. *Psychology and Aging, 15*, 417-436.

Mandler, G. (1994). Hypermnesia, incubation, and mind popping: On remembering without really trying. In C. Umilta, & M. Moscovitch (Eds.), *Attention and performance XV* (pp. 3-33). Cambridge, MA: The MIT Press.

Mäntylä, T. (1996). Activating actions and interrupting intention: Mechanisms of retrieval sensitization in prospective memory. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 93-113). Mahwah, NJ: Erlbaum.

Mäntylä, T., & Carelli, M. G. (in press). Time monitoring and executive functioning: Individual and developmental differences. In J. Glicksohn, & M. S. Myslobodsky (Eds.), *Timing the future: The case for a time-based prospective memory* (pp. 191-211). London: World Scientific.

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory and Cognition, 24,* 336-349.

Marsh, R. L., Hicks, J. L., & Landau, J. D. (1998). An investigation of everyday prospective memory. *Memory & Cognition, 26*, 633-643.

Martin, M. (1986). Ageing and patterns of change in everyday memory and cognition. *Human Learning, 5,* 63-74.

Maylor, E. A. (1990). Age and prospective memory. *The Quarterly Journal of Psychology, 42A*, 471-493.

Maylor, E. (1993). Aging and forgetting in prospective and retrospective memory tasks. *Psychology and Aging, 3,* 420-428.

Maylor, E. A. (1998). Changes in event-based prospective memory across the adulthood. *Aging, Neuropsychology, and Cognition, 5,* 107-128.

McDaniel, M. A., & Einstein, G. O. (1993). The importance of cue familiarity and cue distinctiveness in prospective memory. *Memory, 1*, 23-41.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14,* S127-S144.

McDaniel, M. A., Guynn, M. J., Einstein, G. O., & Breneiser, J. (2004). Cue-focused and reflexive-associative processes in prospective memory retrieval. *Journal of Experimental Psychology: Learning, Memory and Cognition, 30,* 605-614,

McDaniel, M. A., Robinson-Riegler, B., & Einstein, G. O. (1998). Prospective remembering: Perceptually driven or conceptually driven processes? *Memory & Cognition, 26*, 121-134.

McClelland, G. H., & Judd, C. M. (1993). Statistical difficulties of detecting interactions and moderator effects. *Psychological Bulletin, 114*, 376-390.

Moscovitch, M. (1982). A neuropsychological approach to memory and perception in normal and pathological aging. In F.I.M. Craik & S. Trehub (Eds.), *Aging and cognitive processes* (pp. 55-78). New York: Plenum Press.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation* (vol. 4, pp. 1-17). New York: Plenum Press.

Nowinski, J. L., & Dismukes, R. K. (2005). Effects of ongoing task context and target typicality on prospective memory performance: The importance of cueing. *Memory, 13*, 649-657.

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. B. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging, 12,* 314-327.

Patton, G. W. R., & Meit, M. (1993). Effect of ageing on prospective and incidental memory. *Experimental Aging Research, 19,* 165-176.

Rendell, P. G., & Craik, F. I. M. (2000). Virtual week and actual week: Age-related differences in prospective memory. *Applied Cognitive Psychology, 14,* S43-S62.

Rendell, P. G., & Thompson, D. M. (1999). Aging and prospective memory: Differences between naturalistic and laboratory tests. *Journal of Gerontology: Psychological Sciences, 54B,* 256-269.

Schlagman, S., Kvavilashvili, L., & Schulz, J. (in press). Effects of age on involuntary autobiographical memories. In J. Mace (Ed.), *Involuntary memories*. Blackwell.

Sellen, A. J., Louie, G., Harris, J. E., & Wilkins, A. J. (1997). What brings intentions to mind? An in situ study of prospective memory. *Memory, 5,* 483-507.

Shallice, T., & Burgess, P. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain, 114*, 727-741.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 347-361.

Tart, C. T. (1970). Waking from sleep at a preselected time. *Journal of the American Society of Psychosomatic Dentistry and Medicine, 17*, 3-16.

Webb, W.B. & Ross, W. (1972). Estimation of the passing of four consecutive hours. *Perceptual and Motor Skills, 35*, 768-770.

West, R. L. (1988). Prospective memory and aging. In M. M. Gruneberg, P. E. Morris, & R. N Sykes (Eds.), *Practical aspects of memory: Current research and issues* (vol. 2, pp. 119-125). Chichester: Wiley.

West, R., & Craik, F. I. M. (1999). Age-related decline in prospective memory: The roles of cue accessibility and cue sensitivity. *Psychology and Aging, 14*, 264-272.

Wilkins, A. J., & Baddeley, A. D. (1978). Remembering to recall in everyday life: An approach to absent-mindedness. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 27-34). London: Academic Press.

Yaniv, I., & Meyer, D. E. (1987). Activation and metacognition of inaccessible stored information: Potential bases for incubation effects in problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 187-205.

Zakay, D., & Block, R. A. (1997). Temporal cognition. *Current Directions in Psychological Science, 6,* 12-16.

Zigmund, A., & Snaith, R. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavia, 63*, 361-370.

Zung, W. W. K., & Wilson, W. P. (1971). Time estimation during sleep. *Biological Psychiatry, 3,* 159-164.

Author Note

Lia Kvavilashvili, School of Psychology, University of Hertfordshire, UK; Laura Fisher, Centre for Social and Psychological Development, Canterbury Christ Church University College, UK.

We are grateful to Philip Baker and Laurina Ramsay for collecting data in Study 1 and Study 3, respectively. We also wish to thank George Mandler, Steven Lindsay, Peter Lovatt, Géry d'Ydewalle and anonymous reviewers for their helpful comments on an earlier version of this paper. Portions of research described in this paper were presented at the British Psychological Society Cognitive Section Conference in September 2002 (University of Canterbury) and at the 2nd International Conference on Prospective Memory in July 2005 (Zurich).

Correspondence concerning this article should be addressed to Lia Kvavilashvili, School of Psychology, University of Hertfordshire, College Lane, Hatfield, Herts, AL10 9AB, UK. Email: *L.Kvavilashvili@herts.ac.uk*

Footnotes

[1] This applies even to the attentional/strategic monitoring view. The hallmark of this model is that one monitors the environment for the occurrence of the target event. It is, however, impossible to assume that in case of time-based task one constantly monitors the environment (i.e., the clock) for the critical time.

[2] In some studies a U-shaped curve has been obtained (see e.g., Ceci & Bronfenbrenner, 1985).

[3] Although 327 rehearsals were recorded in total, on 7 occasions the activity was not specified, hence the number of cases for this analysis was 320.

[4] In this and all subsequent analyses of variance with repeated measures, if the sphericity assumption was violated the reported probability levels were adjusted accordingly (Greenhouse-Geisser corrections).

[5] Similar findings have emerged in research on other forms of involuntary cognitions such as task unrelated images and thoughts (TUITS; Giambra, 1995), involuntary autobiographical memories (Berntsen, 1998) and involuntary semantic memories or mind-popping (Kvavilashvili & Mandler, 2004).

[6] There was a marginally significant age effect on the average number of hours awake during the week ($F(1,67)=3.76$, $MSe= 1.60$, $p=.057$) with older people reporting being awake slightly longer ($M=16.55$, $SD=1.30$) than young people ($M=15.96$, $SD=1.22$).

[7] Although a total of 868 rehearsals were recorded, on two occasions in the young group and on three occasions in the old group activity descriptions were not provided, hence, 863 cases.

[8] As pointed out in the introduction, the TWTE model, as formulated by Harris and Wilkins (1982), was fairly open about the possible processes that may instigate periodic tests. It was only in subsequent studies that tests were assumed to be instigated by self-initiated, attentionally demanding monitoring processes.

[9] It is interesting that a similar account is put forward by Yaniv and Meyer (1987) for the processes involved in the phenomenon of incubation, i.e., when a solution to a problem suddenly pops into mind much later, after one has abandoned solving the problem and switched to other unrelated activities. According to their *memory-sensitization hypothesis* "the initial unsuccessful attempt to solve a problem may partially activate stored, but currently inaccessible, memory traces critical to the problem's solution. Then, during a subsequent intervening period of other endeavors, the activation may sensitize a person to chance encounters with related external stimuli that raise the critical traces above threshold and trigger their integration with other available information"(p. 200).

[10] It is interesting that one old participant in Study 2, who had to call the experimenter at 9:30 a.m. on Sunday, reported waking up from sleep at 4:10 a.m. and 7:35 a.m. with the thought about having to make a phone call.

[11] Even when performance levels in ongoing laboratory tasks are matched in young and old participants, it does not mean that old participants would not need to put more effort into the cognitive task than young participants (Eysenck & Calvo, 1992).

Table 1a

Numbers and Percentages of Different Types of External Cues Recorded by Participants in Study 1

Content of the External Cue	(N)	%
(1) Cues related to phones and phoning *(e.g., phone ringing, seeing a phone or a phone number, someone mentioning a phone call/phone number, wake up calls in B&B, making a phone call, checking calls on the answer phone)*	(45)	31%
(2) Cues related to diaries *(e.g., seeing an experimental diary, personal diary, calendar, reminder note, other diaries in a shop, someone mentioned diaries)*	(31)	21%
(3) Cues related to the actual study/experiment *(e.g., seeing the research participation form, the word 'forgot', chapter title "Building blocks of thought", hearing the words 'task analysis', someone talking about thoughts, research credits)*	(27)	18%
(4) Cues related to time *(looking at/seeing a clock, watch, hearing/setting an alarm, coming across the word 'week', 'time', friend said he would visit on Sunday)*	(21)	14.3%
(5) People or places act as a reminder *(e.g., seeing someone who looked like the experimenter, in the same room when first met the experimenter)*	(12)	8.2%
(6) Idiosyncratic cues that were seemingly unrelated to the task *(e.g., seeing Christmas food, the word "boring", computer, a good looking girl, the police arriving, having cold feet)*	(11)	7.5%

Table 1b

Numbers and Percentages of Different Types of Internal Cues Recorded by Participants in Study 1

Content of the Internal Cue	(N)	%
(1) Thinking of future plans, planning	(29)	29%
(e.g., thinking of plans for Sunday, plans in general, plans for today)		
(2) Thinking of other intentions and tasks	(30)	30%
(e.g., thinking/reminding oneself to give a phone call to someone, to post a letter or to buy toothpaste, deciding what time to have a lunch, putting off doing a lab report)		
(3) Thinking of work and university	(16)	16%
(e.g., thinking about projects, labs, stats lecture, essay question on cognition, courses taught at the university and college)		
(4) Thinking about things related to the study/experiment	(10)	10%
(e.g., " what was my son's train of thoughts? ", questionnaire that was filled in, motivation, memory lecture)		
(5) Thinking about experimental diary	(4)	4%
(6) Thinking about time, timetables, deadlines/dates	(5)	5%
(7) Thinking about what happened today or yesterday	(4)	4%
(8) Any other thought	(2)	2%
(e.g., feeling frustration, a ringing tone in my head)		

Table 2

Mean Number of Recorded Rehearsals as a Function of Trigger Type (No Trigger vs. Incidental External vs. Incidental Internal vs. Self-Initiated) in Study 1 (Panel A), as a Function of Trigger Type and Age (Young vs. Old) in Study 2 (Panel B), and as a Function of Trigger Type and Prospective Memory Task (Time- vs. Event-Based) in Study 3 (Panel C). Standard Deviations in Brackets.

(Panel A) Study 1

	Trigger Category			
	No triggers	Incidental Triggers		Self-Initiated Planning
		External	Internal	Thoughts
	2.10	3.77	1.79	.72
	(3.22)	(3.33)	(1.67)	(1.12)

(Panel B) Study 2

	Trigger Category			
	No triggers	Incidental Triggers		Self-Initiated Planning
		External	Internal	Thoughts
Young	4.32	3.06	2.44	1.70
	(3.56)	(2.39)	(2.35)	(2.55)
Old	6.22	3.66	2.17	1.11
	(5.30)	(3.16)	(2.08)	(1.75)

Table 2 (continued)

(Panel C) Study 3

	Trigger Category			
	No triggers	Incidental Triggers		Self-initiated Planning
		External	Internal	Thoughts
Time-based	4.37	3.26	1.21	.53
	(3.08)	(2.84)	(1.91)	(.83)
Event-based	2.15	3.40	1.00	.20
	(5.30)	(2.37)	(1.17)	(.41)

Table 3

Means of Self-Rated Motivation to Make a Phone Call on Sunday as a Function of Age (Young vs. Old) and the Time of Rating (Before vs. After the Study) in Study 2. Ratings were Made on a 5-Point Scale (1=Not Motivated, 3=Moderately Motivated, 5=Very Motivated). Standard Deviations in Brackets.

	Motivation Ratings	
	Before the study	After the study
Young	3.70 (.92)	3.39 (.93)
Old	4.39 (.73)	4.22 (.72)

Table 4

Numbers and Percentages of Recorded Rehearsals in Study 2 as a Function of Age (Young vs. Old) and Self-Reported Level of Concentration on the Ongoing Activity (Low vs. Medium vs. High). Concentration was Rated on a 5-Point Scale (1=Not Concentrating at all, 5=Fully Concentrating). Ratings 1 and 2 were Classed as Low, 3 as Medium and 4 and 5 as High Levels of Concentration.

	Level o f Concentration			
	Low	Medium	High	Total
Young	158	97	138	393
	(40%)	(25%)	(35%)	(100%)
Old	144	116	213	473
	(30%)	(25%)	(45%)	(100%)
Total	302	213	351	866*
	(35%)	(25%)	(40%)	(100%)

* Although a total of 868 rehearsals were recorded, on two occasions (one in young and one in old group) concentration rating was omitted, hence, 866 cases.

Table 5

Numbers and Percentages of Recorded Rehearsals in Study 3 as a Function of Condition (Time- vs. Event-Based) and Self-Reported Level of Concentration on the Ongoing Activity (Low vs. Medium vs. High). Concentration was Rated on a 5-Point Scale (1=Not Concentrating at all, 5=Fully Concentrating). Ratings 1 and 2 were Classed as Low, 3 as Medium and 4 and 5 as High Levels of Concentration.

	Level of Concentration			
	Low	Medium	High	Total
Time-Based	72 (40%)	47 (26%)	59 (33%)	178 (100%)
Event-Based	45 (35.5%)	41 (30.5%)	48 (35%)	134 (100%)
Total	117 (38%)	88 (28%)	107 (34%)	312* (100%)

* Although a total of 313 rehearsals were recorded, on one occasion in the event-based condition concentration rating was omitted, hence, 312 cases.

Figure Captions

Figure 1. Mean proportion of recorded rehearsals per hour as a function of prospective memory response group (HIT vs. LATE) and day (Monday vs. Tuesday vs. Wednesday vs. Thursday vs. Friday vs. Saturday vs. Sunday) in Study 1.

Figure 2. Mean proportion of recorded rehearsals per hour as a function of age group (young vs. old) and day (Monday vs. Tuesday vs. Wednesday vs. Thursday vs. Friday vs. Saturday vs. Sunday) in Study 2.

Figure 3. Mean number of recorded rehearsals as a function of condition (time- vs. event-based task) and day (Day 1 vs. Day 2 vs. Day 3 vs. Day 4 vs. Day 5 vs. Day 6 vs. Day 7) in Study 3.

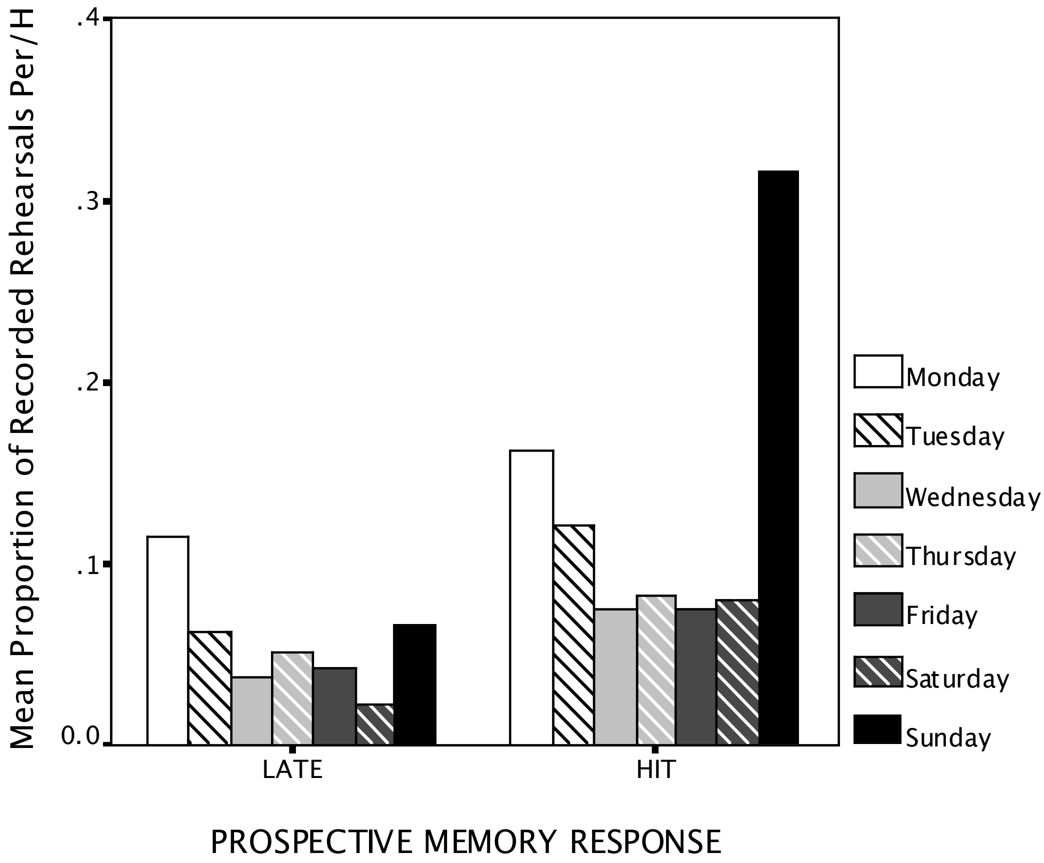
Mean Proportion of Recorded Rehearsals Per/H
.4
.3
.2
.1
0.0
LATE
HIT
PROSPECTIVE MEMORY RESPONSE
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday

Figure 1

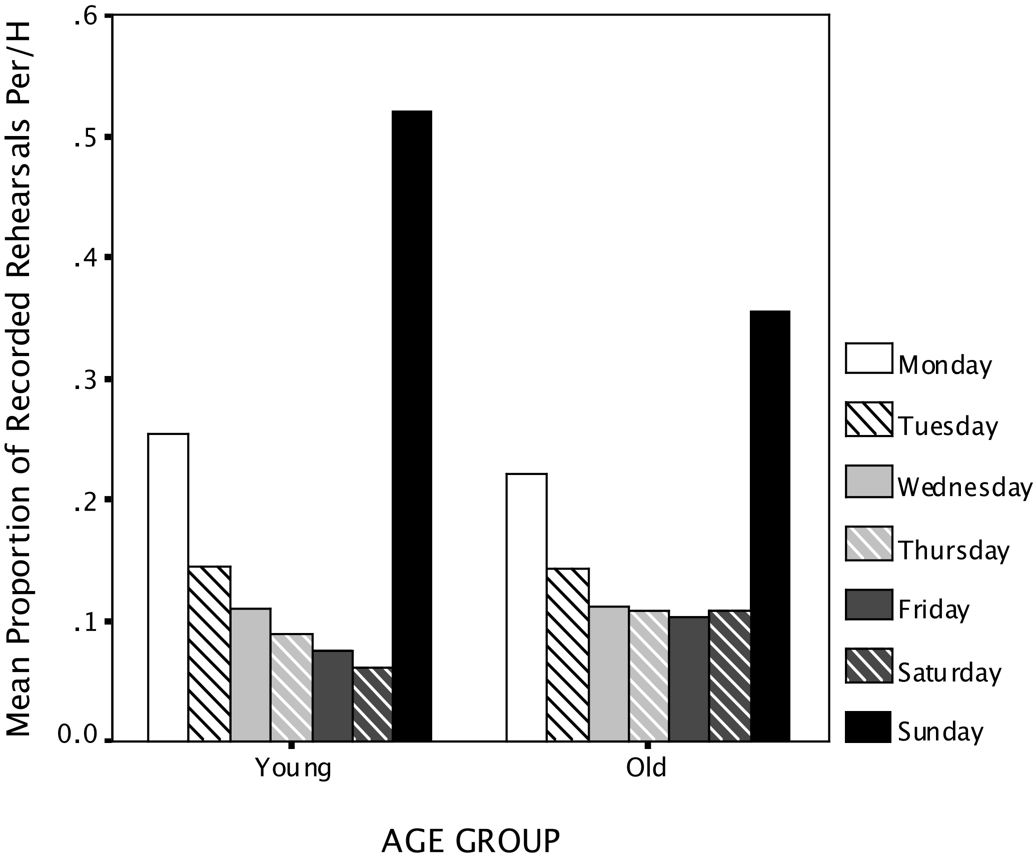
Mean Proportion of Recorded Rehearsals Per/H
.6
.5
.4
.3
.2
.1
0.0
Young
Old
AGE GROUP
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday

Figure 2

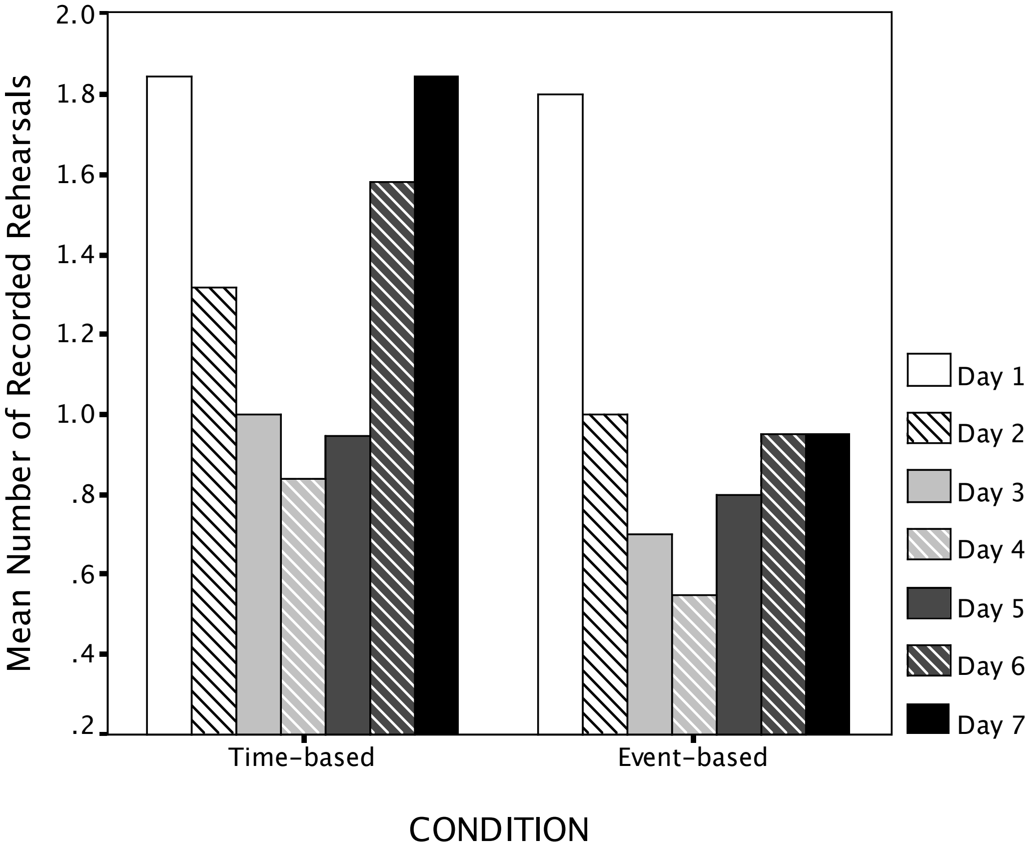
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
Mean Number of Recorded Rehearsals
Time-based
Event-based
CONDITION
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7

Figure 3