MEMORY, 2006, 14 (7), 872–889

Psychology Press
Taylor & Francis Group

Retrieval experience in prospective memory: Strategic monitoring and spontaneous retrieval

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According to the multi-process model of prospective memory (McDaniel & Einstein, 2000), performance in a prospective memory task may be due to spontaneous retrieval processes or due to strategic monitoring. Spontaneous retrieval is typically accompanied by a *pop up* experience and strategic monitoring by a *search* experience. In this study we report two experiments with young adults in which we systematically investigated whether retrieval experience differed across experimental conditions. In Experiment 1 some prospective memory targets were preceded by associated primes. We expected that presenting primes would enhance performance by an automatic activation of the intention and hence lead to an increase in *pop up* experiences. In Experiment 2 half of the participants received instructions containing information about the specific context in which the prospective memory task would occur, whereas the other half of the participants received no such information. We expected that specific context instructions would enhance performance by legitimate anticipation of the prospective memory task and hence would lead to an increase in *search* experiences. The results confirmed these expectations. They indicate that the assessment of retrieval experience can provide valuable insights into the processes underlying prospective memory performance. They also suggest that retrieval experience can vary systematically across experimental situations as predicted by the multi-process model.

Responding on a memory test may reflect different underlying states of awareness or different retrieval modes with correspondingly different processes affecting the response. In prospective memory, remembering can occur as a result of strategic monitoring or by spontaneous retrieval (McDaniel & Einstein, 2000). These two routes are characterised by different retrieval experiences indicating different underlying processes. Strategic monitoring is typically accompanied by a *search* experience and spontaneous retrieval is typically accompanied by a *pop up* experience. The goal of this study was to investigate whether *pop up* and *search* experiences vary systematically with different experimental conditions.

Prospective memory refers to the ability to remember an intention at the appropriate occasion. In contrast to retrospective memory—the ability to remember episodes from the past—prospective remembering is not stimulated by an explicit request to remember. A critical feature that distinguishes prospective memory tasks from retrospective memory tasks is that prospective remembering must be self-initiated when a specific target event occurs during an ongoing activity (Craik, 1986; Einstein & McDaniel; 1996; Graf & Uttl, 2001; Kvavilashvili & Ellis, 1996). Several theoretical explanations have been proposed to explain how a person can accomplish a prospective memory task. In this

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We thank Beatrice Hasler, Manette Ruch-Monachon, and Caroline Zürcher who helped testing the participants. We also thank Josephine Cock for her valuable comments and Sara Hutchison for editorial amendments. This research was supported in part by a grant from the Swiss National Science Foundation (Grant 101411-101754) to B. Meier and W. Perrig. It was also presented at the 2nd International Conference on Prospective Memory in Zurich, Switzerland.

http://www.psypress.com/memory DOI:10.1080/09658210600783774

paper we first contrast two converse accounts, one that focuses on strategic processes and one that focuses on automatic processes. Then we introduce a new method, which includes the assessment of experiential, or phenomenological, aspects of prospective remembering to assess the contribution of each of these processes. In two experiments we present evidence that the relative contribution of strategic and automatic processes as indicated by retrieval experience varies according to experimental conditions.

According to one theoretical approach, recognising the target event (i.e., the prospective memory cue) is the consequence of strategic monitoring for the prospective memory task (Burgess & Shallice, 1997; Guynn, 2003; Smith 2003; Smith & Bayen, 2004). In this view, successful prospective memory performance is due to a resource-demanding, attentional process. Phenomenologically, recognising a prospective memory cue may be experienced as the result of an accomplished *search* for the cue. Strategic monitoring results in a cost that can be measured as a performance deficit in the ongoing task in which the prospective memory task is embedded (cf. Brandimonte, Ferrante, Feresin, & Delbello, 2001; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Smith, 2003). Strategic monitoring may be especially involved in situations where the prospective memory task is important (Kliegel, Martin, McDaniel, & Einstein, 2004), when the occurrence of the prospective memory task can be anticipated within a specific pre-defined time window (cf. "pulses"; Ellis, 1988), and when there are multiple target events (Einstein et al., 2005).

According to another approach, recognising a prospective memory cue is due to a spontaneous and automatic retrieval process (Einstein & McDaniel, 1996; McDaniel & Einstein, 2000). The assumption here is that remembering occurs when the presence of a prospective memory cue initiates successful retrieval. Phenomenologically, encountering a prospective memory cue seems to be characterised by the experience that its significance *pops into one's mind*. It is only at that point that a memory search is initiated for what has to be done (i.e., the intended action; cf. the noticing plus search model, Einstein & McDaniel, 1996). This kind of prospective memory is probably the most common case in everyday life. For example, it has been suggested that noticing a prospective memory cue might involve processes similar to those involved in the experience of familiarity; that is, as a discrepancy between the expected and the actual experience of processing (McDaniel, Guynn, Einstein, & Breneiser, 2004; cf. Whittlesea & Williams, 2001).

Despite the obvious differences between these two accounts, it is quite possible that within one and the same prospective memory task both approaches may contribute to the explanation of prospective memory performance. McDaniel and Einstein (2000) proposed a multi-process model, which takes into account empirical evidence for both monitoring and spontaneous retrieval processes. This model assumes that whether one relies on monitoring or automatic *pop up* depends on the features of the prospective memory task, the ongoing task, and the rememberer. The proportion of individuals remembering the prospective task due to strategic monitoring (i.e., a *search* experience) or due to spontaneous retrieval (i.e., a *pop up* experience) may co-vary with respect to the specific requirements of a given test situation (cf. Einstein et al., 2005; McDaniel & Einstein, 2000; McDaniel et al., 2004). In this study we investigated whether these different experiences can be assessed by simply asking the participants about their retrieval experience immediately after they have noticed a prospective memory cue.

The idea of studying retrieval experience in prospective memory is not completely new. In an early study Kvavilashvili (1987) investigated the influence of intervening activity during the retention interval and the importance of an intention. Importantly, she also asked participants at the end of the experiment whether they engaged in rehearsal of the prospective memory task. The results revealed an interaction between the type of intervening activity during retention and the importance of the intention, but only for those participants who reported not having engaged in rehearsal. It was found that when an interesting intervening activity was performed, only those participants who did not rehearse the intention showed a performance decrement.

In several more recent studies participants were asked to rate how frequently they thought about the prospective memory task during the experiment (Cherry & LeCompte, 1999; Einstein & McDaniel, 1990; Kvavilashvili, Messer, & Ebdon, 2001; Maylor, 1998). Consistently, significant positive correlations between frequency ratings and prospective memory performance were reported. Also, the means of the frequency ratings indicated that many participants thought quite often about the prospective memory task. It is likely that frequency of thinking about a prospective memory task and the particular retrieval experience are highly related. A straightforward hypothesis is that participants who report frequent thoughts about a prospective memory task are also more likely to report a *search* experience.

Reese and Cherry (2002) used an additional online method to investigate the thoughts of participants by prompting them at irregular intervals to report what they were currently thinking about. However, only few participants indicated that they thought about the prospective memory task and these ratings were not correlated with actual performance. Nevertheless, frequency ratings as used in the other studies were, again, correlated with prospective memory performance. This pattern of results demonstrates the difficulty of assessing thoughts online and it indicates that this particular method was not suitable for predicting prospective memory performance.

In a study by Einstein, McDaniel, Williford, Pagan, and Dismukes (2003, Experiment 1) participants were asked at the end of the experiment whether they had rehearsed the prospective memory task or whether they had simply let it "pop into mind". The results showed that participants who performed the task under divided attention conditions performed less well and also reported less rehearsal than in a standard condition. However, because the study involved two prospective memory cues but only one pop/rehearsal rating, which was administered at the end of the experiment, there was no direct measure of what participants did on a specific trial.

In the present study, rather than asking participants at the very end of the experiment about their retrieval experience, we asked them after *each* successful prospective memory trial. In Experiment 1, we investigated whether presenting associated primes before the prospective memory targets would lead to a performance benefit due to an increase of spontaneous retrieval which should be accompanied by an increase in *pop up* experiences. In Experiment 2, we investigated whether specifying the retrieval context would enhance strategic monitoring and consequently lead to a performance benefit accompanied by an increase in *search* experiences. We will outline the specific theoretical rationales for these assumptions in the introduction of each experiment.

EXPERIMENT 1

In cognitive psychology a vast literature exists on priming and its facilitating effects on performance. It is generally assumed that priming effects are attributable to the activation of knowledge structures and that this activation occurs automatically and spontaneously (Bargh & Chartrand, 1999; Graf & Masson, 1993; Schacter, 1987; Underwood, 1996). In prospective memory, activation levels for intentions may be increased by priming prospective memory targets. As a consequence, the threshold for recognising the targets may be lowered and a benefit in prospective memory performance may occur. According to our hypothesis this increase in automatic processes should be accompanied by an increase in *pop up* experiences. The primary aim of Experiment 1 was to test this hypothesis. In addition, we manipulated whether a format overlap between prime and ongoing task would further enhance prospective memory performance and the proportion of *pop up* experiences.

There are several studies that support the assumption that prospective memory can be primed by associative cues. For example, Ellis, Burkes, and Milne (1997) reported that participants who had been asked to respond to the word "boat" did so more often if they had been primed with a synonym of "boat" several trials earlier. Taylor, Marsh, Hicks, and Hancock (2004) studied the impact of partial match cues on prospective memory performance (see also West & Craik, 1999). Prospective memory targets were defined as animal words beginning with the letter L. Partial match cues (or prospective memory lures) were either non-animal words beginning with L (orthographic lure) or animal words beginning with a letter other than L (semantic lure). The results showed that both orthographic and semantic lures improved prospective memory performance. They also showed that repeatedly processing lures was more efficient in improving prospective memory performance than were overt reminders. Taylor et al. suggested that processing lures induced both retrieval and reprocessing of the prospective memory task, while overt reminders induced only the reprocessing of the task.

In contrast to prospective memory lures, which only partially fulfil the criteria of a prospective memory target, associated cues do not fulfil any criterion necessary to perform a prospective memory task. However, these cues are conceptually related to the prospective memory target and may therefore exert a more subtle influence on triggering prospective memory. A study by Mäntylä (1993) provides further support for the idea that conceptual influences of this kind may occur in prospective memory. Mäntylä manipulated the level of semantic activation of prospective memory targets by instructing participants to generate instances of two specific categories at the beginning of the experiment. Later, participants were instructed to perform a particular action whenever instances of four semantic categories were presented. Two of these categories were identical to those used in the initial generation task. The most important result was a better prospective memory performance for cues that were instances of the primed compared to the unprimed categories.

In this study, the prospective memory task was primed by an associated prime occurring during the ongoing task. As an ongoing task we used a complex version of a short-term-memory (STM) task, which was originally introduced into prospective memory research by Einstein and McDaniel (1990). The STM task required participants to simultaneously process line drawings of easy-to-name objects and unrelated nouns. The ongoing task was to read each word aloud while memorising the object for immediate recall (see Figure 1). This cognitively demanding ongoing task was used in order to reduce the likelihood of participants engaging in systematic strategic monitoring. This was necessary because pilot work had revealed that with less demanding tasks many student participants were consistently monitoring for the prospective memory cues.

The prospective memory task was to perform a certain action when a word representing a musical instrument appeared on the screen. The prime was either "music stand" or "conductor". We varied whether the prime was presented as a word or as a line drawing. As encoding the line drawings for immediate recall was the primary ongoing task, we expected that a processing overlap would occur between processing the prime as a line drawing and the ongoing task (*overlap prime condition*), but no processing overlap would occur between processing the prime as a word and the ongoing task (*non-overlap prime condition*, see Meier & Graf, 2000, for a discussion of processing overlaps in prospective memory). In the control condition, no prime was presented at all (*no prime condition*). The hypothesis was that a performance benefit should occur for the prime conditions and that this benefit would be accompanied by an increase in *pop up* rather than *search* experiences. We also expected an additional performance benefit for the overlap prime condition and again, this benefit was hypothesised to be accompanied by an increase in *pop up* rather than *search* experiences.

Method

Participants. A total of 72 undergraduate students from the University of Bern (54 women and 18 men, $M = 22.9$ years, $SD = 5.9$) participated in this study for course credit.

Apparatus. Presentation of stimuli was controlled by E-Prime 1.1 software (Schneider, Eschman, & Zuccolotto, 2002) running on an IBM-compatible computer. Experimental materials were presented in black against a white background at the centre of a 15" VGA-monitor.

Materials. A total of 222 words and line drawings were used for the complex STM task. Four- to eight-letter German nouns with medium frequency and medium to high concreteness were selected from two different sources (Hager & Hasselhorn, 1994; Ruoff, 1981). Line drawings of easy-to-name objects were taken from the material of Snodgrass and Vanderwart (1980) and one other source.[1] These materials were pseudo-randomly grouped into different sets of lists. Each list consisted of three, four, five, six, or seven word–object pairs. Composition of word–object pair list followed two restrictions. First each word–object pair was conceptually different, and second within each list the same object did not occur as a word and an object. In addition, the sets were composed such that the means for name and image agreement, familiarity, and complexity of the objects did not differ across sets of lists according to the norms of Snodgrass and Vanderwart (1980).

Three different names of musical instruments were used as prospective memory targets (i.e., "piano", "guitar", and "trumpet"). In addition, two associated cues were used as primes in a pilot study the strength of the association between the primes *conductor* ("Dirigent" in German) and

[1] A line drawing of a music stand was required. It was drawn by a local artist in the same style as the materials provided by Snodgrass and Vanderwart (1980).

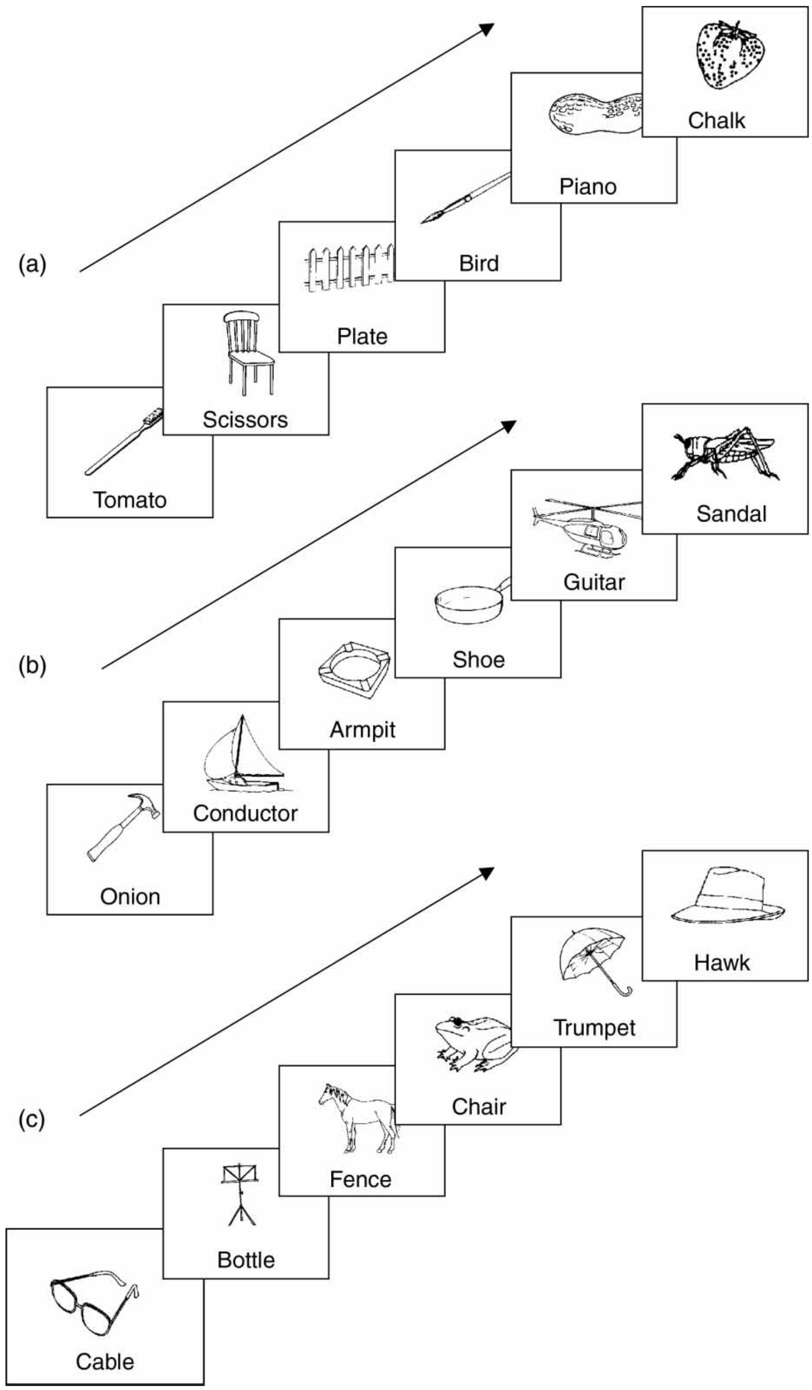

Figure 1. STM lists with embedded prospective memory tasks: (a) no prime condition, (b) non-overlap prime condition, (c) overlap prime condition. Overlap refers to the shared requirements for processing the prime as a picture and processing pictures for the ongoing STM task. The materials were originally presented in German.

music stand (''Notenständer'' in German) and the category *musical instrument* (''Musikinstrument'' in German) was assessed in a sample of 46 undergraduates. Mean ratings on a 5-point rating scale (between 1 = ''not associated at all'' and 5 = ''very strongly associated'') were 4.2 for *music stand* and 3.8 for *conductor* and did not differ statistically.

For practice, four lists of word–object pairs were used (i.e., one list comprising three, four, five, and six word–object pairs). For the experimental trials, a total of 42 lists were required.

Trials were arranged such that there were six sets of lists containing three, four, five, six, or seven word–object pairs, and three sets of lists containing three, four, five, and six word–object pairs (but not seven items).[2] For these latter three sets, the lists comprising six word–objects were modified, by replacing the fifth (i.e., penultimate) word with one of the prospective memory targets. We presented the prospective memory target at the fifth position rather than at the beginning or at the very end of the list, because pilot work had revealed that this arrangement provided for an appropriate memory load. Prospective memory targets were assigned randomly without replacement. In addition, two of the three six-element lists just mentioned were modified by presenting an associated prime at the second position of the list. The position of prime-type condition was counterbalanced across participants, resulting in six different counterbalancing conditions (i.e., overlap – non-overlap – no cue, overlap – no cue – non-overlap, non-overlap – overlap – no cue, etc.).

Procedure. Participants were tested individually. They were seated in front of a computer and informed that the experiment consisted of a variety of tasks. Then each participant completed a sequence of activities as shown in Table 1.

First the STM task was explained. Participants were told that they would be presented with a series of words and line drawings, which would appear simultaneously on the screen. They were instructed to read each word aloud and memorise the line drawing on each trial. They were also told that after a few pairs of words and line drawings, the instruction to recall the line drawings would appear on the screen. They were instructed to recall all of the line drawings —or as many as possible—in any order. They were told that the length of the lists varied and that we were interested in measuring their memory span. The real reason for having lists of different lengths was to maintain participants' interest and motivation. Then four practice trials were given, which consisted of one series of lists comprising different-length lists of word–object pairs. The lists, with lengths of three, four, five, and six word–object pairs, were presented in ascending order (i.e., shorter lists first). For all trials of the STM task the procedure was the same. Participants started the presentation of each list of word–object pairs by pressing the return key. Each word–object pair was presented for 1500 ms. The object was centred vertically and horizontally within a 7 cm $\times$ 7 cm square; the word was horizontally centred and was printed in a 18-point font. After each list of word–object pairs the instruction to recall was shown on the screen. The experimenter wrote down participants' responses on a separate answer sheet.

TABLE 1
Ordering of activities and use of materials in Experiment 1

Activity type	*Trials and materials*
(1) Short-term (STM) task practice	Four trials were given, which included one three-, four-, five-, and six-element list
(2) Prospective memory instructions	
(3) Retention interval	Filled by completing an unrelated questionnaire
(4) Test phase: STM task with embedded prospective memory task	42 trials were given, which consisted of the triplicate presentation of the following structure: two sets of three-, four-, five-, six-, and seven-item lists, and one set of three-, four-, five-, and six-item lists with the prospective memory target embedded at the fifth position.

Then instructions for the prospective memory task were given. Participants were informed that whenever they came across a word that was the name of a musical instrument, they should give a short description of that particular musical instrument. They were given an example of what kind of description was considered appropriate. Specifically they were told that if the prospective memory cue was, for example, "saxophone", an appropriate description would be "an instrument that is typically made of metal and has a silvery or golden colour". The reason for asking the participants to notify the experimenter when they saw a musical instrument rather than pressing a specific key on the keyboard was that with this set-up it was possible to introduce the interactive situation necessary for asking the questions about the phenomenological retrieval experience in a rather naturalistic manner. To exclude the possibility that the STM task could interfere with remembering the prospective memory task in the critical list, participants were informed that they were not required to recall a list that contained a prospective memory cue. Then, to ensure they had understood the instructions correctly,

[2] For practical reasons no seven-element list was presented after the list containing the prospective memory target.

participants were asked to repeat the instructions in their own words.

Subsequently, a paper-and-pencil personality questionnaire was given, requiring about 10 minutes. The purpose was to create a filled retention interval before assessing prospective memory performance (cf. Einstein & McDaniel, 1990). After the personality questionnaire, participants were reminded of the STM task, but no mention was made of the prospective memory task.

Next, a total of 42 word lists were presented for the STM test. On each trial a different list was presented. Presentation of lists was in ascending order. These consisted of two sets of lists containing three, four, five, six or seven object–word pairs, followed by a different set of lists containing three, four, five, and six object–word pairs (see Table 1). The prospective memory task was embedded in lists number 14, 28, and 42. Selection of a prospective memory target (out of three) was random without replacement. The order of the prime condition was completely counterbalanced across participants (i.e., overlap – non-overlap – no cue, overlap – no cue – non-overlap, non-overlap – overlap – no cue, etc.). In the overlap prime condition the prime was presented in pictorial format, and in the non-overlap prime condition the prime was presented as a word. One trial was administered for each prime condition. An example for the STM task with embedded prospective memory target for each of the three conditions is presented in Figure 1.

Prospective memory performance was scored as correct when a participant recognised the prospective memory target and described the musical instrument. Whenever participants carried out the prospective memory task correctly, they were immediately questioned about their retrieval experience with a short questionnaire. The first two questions asked about any strategies used to remember the prospective memory task and the specific experience encountered when recognising the prospective memory target. These questions were open-ended. They were intended as warm-up questions, and were not analysed further. The third question asked when the participant had last thought about the prospective memory task. The fourth question asked whether the participant had noticed something peculiar (i.e., the prime) during the presentation of the list. The fifth question asked how frequently participants had thought about the prospective memory task (during the experiment/since the occurrence of the last prospective memory target). The next question was critical regarding retrieval experience. It explicitly asked whether the participant remembered the prospective memory task "because you were continuously searching for a musical instrument" or "because it just popped into your mind". Collecting the answers to all these questions took approximately 20 to 50 seconds. The reason for including the warm-up questions was that pilot work revealed that participants were rather confused when the specific *pop up/search* question was asked immediately without introduction. People are not used to thinking about their retrieval experience in general, and it was found that gradually reaching the core of retrieval experience led to faster understanding. As answering the first few questions took little time, any memory distortion affecting the final answer is unlikely to have occurred.

After these questions the ongoing task continued until participants responded to the next prospective memory target or until all of the 42 STM test lists were completed. Participants who completely failed to remember the prospective memory task were given a short questionnaire at the end of the experiment. It consisted of questions on whether or not they remembered that they were asked to do something under specific conditions and what it was. As all participants who failed to perform the prospective memory task completely reported remembering exactly what had been required of them, these data are not reported further.

Design. The design was a 3×6 mixed factorial, with prime condition (overlap prime, non-overlap prime, no prime) varied within participants and order of prime condition varied between participants. In addition, only the first prospective memory cue was analysed in a one-factorial between-participant design, because practice effects can occur across trials (see Maylor, 1998).

Results

An alpha level of 0.05 was used for all statistical tests. Overall, proportion of successful prospective memory performance was .75, .53, and .44 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively. A two-way analysis of variance (ANOVA) with prime condition and presentation order as factors revealed that the three conditions differed significantly, $F(2, 132) = 10.58$, $MSe = 0.17$, $p < .01$, while presentation order and the interaction between prime condition and presentation order were not significant, $F(5, 66) = .34$, $MSe = 0.37$ and $F(10, 132) = .85$, $MSe = 0.15$, respectively (ps $> .05$). For further analyses prospective memory performance was collapsed across presentation order. Tukey's LSD post-hoc tests located the source of significance in the difference between overlap prime condition and no prime condition and in the difference between overlap prime condition and non-overlap prime condition, both $p < .01$, while the difference between non-overlap prime and no prime condition was not significant.

The proportion of successful performance on the first cue only was .64, .39, and .29 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively. A one-way ANOVA revealed that the three conditions differed significantly, $F(2, 69) = 3.37$, $MSe = 0.23$, $p < .05$. Again, Tukey's LSD post-hoc tests located the source of significance in the difference between overlap prime condition and both the no prime condition and non-overlap prime condition, ps $< .05$, replicating the results from the repeated measures design.

Proportions of participants who reported that remembering was accompanied by a *search* and a *pop up* experience are shown in Figure 2. Overall, proportions of *search* experiences were .24, .19, and .19 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively, and .20, .26, and .13 for the first cue only. Overall, proportions of *pop up* experiences were .51, .33, and .25 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively and .44, .13, and .17 for the first cue only. Two sets of separate ANOVAs were conducted for *pop up* and *search* responses, for all prospective memory cues and for the first cue only, respectively. Overall, the analysis of *pop up* responses revealed a main effect of prime condition, $F(2, 142) = 6.33$, $MSe = 0.207$, $p < .01$. In contrast, the analysis of *search* responses revealed no difference between conditions, $F(2, 142) = 0.38$, $MSe = 0.107$, $p > .05$. Similarly, for the first cue only the analysis of *pop up* responses was significant, $F(2, 69) = 3.98$, $MSe = 0.175$, $p < .05$, while the analysis of *search* responses was not significant, $F(2, 69) = 0.68$, $MSe = 0.16$, $p > .05$. In both analyses post-hoc tests located the source of the effect in *pop up* experience between the overlap prime condition and both the non-overlap prime condition and the no prime condition.

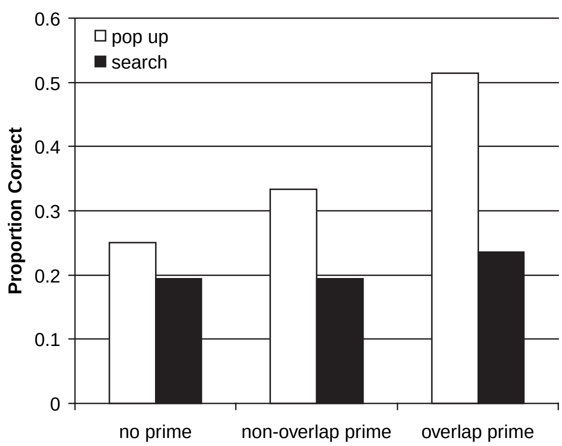

Figure 2. Prospective memory performance and retrieval experience as a function of prime condition in Experiment 1.

Further analyses of the experiential reports revealed that out of the participants who performed the prospective memory task in response to primed prospective memory targets, 30% reported noticing the primes (31% in the overlap condition and 29% in the non-overlap condition). To see whether the proportion of *pop up* and *search* responses was different for participants who detected the prime compared to those who did not, we conducted a follow-up analysis. In the overlap prime condition, splitting the sample into aware and unaware participants resulted in a 69% *pop up* to 31% *search* ratio for participants who were aware of the prime, compared to a 68% *pop up* to 32% *search* ratio for those who were not. Similarly, for the non-overlap prime condition splitting the sample resulted in a 64% *pop up* to 36% *search* ratio for participants who were aware of the prime, compared to a 63% *pop up* to 37% *search* ration for those who were not. Therefore, whether or not participants were aware of the prime did not alter the retrieval experience. However, the presentation of a prime seemed to have affected participants' reports of when they had last thought about the prospective memory task. Compared to the no prime conditions, more participants in the prime conditions reported that the last time they thought about the prospective memory task was immediately before the occurrence of the prospective memory target (33% and 34% in the overlap and the non-overlap conditions respectively and 6% in the no prime condition).

Next, we compared the rehearsal ratings (i.e., frequency of thinking about the prospective memory task) of participants who reported *pop up* and *search* experiences in the different conditions. The ratings were assessed on a 5-point scale (between 1 = never and 5 = all the time). For participants who reported a *pop up* experience mean ratings were 2.65, 2.75, and 2.78 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively. For participants who reported a *search* experience mean ratings were 3.58, 3.43, and 3.57 for the overlap prime condition, the non-overlap prime condition, and the no prime condition, respectively. Separate t-tests for each experimental condition confirmed that participants who reported a *search* experience also indicated that they thought more frequently about the prospective memory task: $t(52) = 3.55$, $p < .01$ for the overlap prime condition, $t(36) = 2.02$, $p = .05$ for the non-overlap prime condition, and $t(30) = 2.57$, $p < .05$ for the no prime condition, respectively. An additional analysis of participants who never reported thinking about the prospective memory task revealed that all participants who reported that they did not think about the prospective memory task, but nevertheless performed it successfully, did so as a result of a *pop up* experience.

Finally, the influence of retrieval experience on ongoing task performance was analysed. Overall, the proportion of remembered objects in the STM memory task was .60. The sample was split into two groups. One group was composed of those individuals whose successful retrieval of the prospective memory task was at least once accompanied by a *search* experience. The other group was composed of all the other participants. Performance of the 32 participants (44% of the sample) who belonged to the *search* group was .59. Performance of the 40 participants (56% of the sample) who belonged to the *no search* group was .61. The difference between the two groups was not statistically significant.

Discussion

The goal of Experiment 1 was to investigate whether priming improves prospective memory performance and whether the expected performance increase is accompanied by an increase in *pop up* experiences. The results confirmed these expectations. There was a performance benefit when prime processing and ongoing task processing overlapped compared to both other conditions; that is, when prime processing and ongoing task processing did not overlap or when no prime was presented at all. These results indicate that associated primes enhance the accessibility of the prospective memory task by lowering the threshold for recognising the prospective memory target. In general, this outcome is consistent with the spontaneous retrieval notion of prospective memory and the multi-process framework (Einstein & McDaniel, 1996; Einstein et al., 2005; McDaniel & Einstein, 2000).

There was also a numerical performance advantage for the non-overlap prime condition compared to the no prime condition, indicating that the absence of this effect may be due simply to a lack of power. It may also be that in general pictorial primes have stronger effects on activation levels of an intention than word primes. Another possibility is that despite similar association ratings, the concept of "musical stand" is a better cue for a musical instrument than the concept of "conductor". To exclude the latter interpretation it would have been necessary to counterbalance the specific prime and the prime condition.

Overall, our results support the predictions that priming enhances prospective memory and that the expected performance benefit is accompanied by an increase in *pop up* responses. Following the literature on priming effects, we have argued that primes affect performance automatically. However, an alternative explanation is that participants may start to search for a prospective memory cue once they noticed a prime. This is very likely possible, as we have not tried to present primes subliminally. However, due to the high resource demands of the ongoing STM task, noticing the prime word may not have been sufficient to induce a search strategy. More likely, participants may have remembered the intention when they came across the prospective memory cue or even when they tried to remember the objects for the STM task. Similarly, they may not have realised that a related prime had occurred during the list until the specific target event itself occurred. This interpretation is supported by the result that awareness of primes did not change the pattern of phenomenological experience. Therefore, it seems that prime processing had a more subtle influence on performance by lowering the activation threshold of the concept of a "musical instrument'' and as a consequence it increased the probability of detecting the prospective memory target.

We also found a relationship between rehearsal frequency and retrieval experience. Participants with a *search* experience reported more rehearsal than participants with a *pop up* experience. In addition, all participants who reported not having thought at all about the prospective memory task during the experiment consistently reported *pop up* experiences. This result is consistent with expectations.

According to a strategic monitoring approach, and consistent with the multi-process theory, participants who frequently rehearsed the prospective memory task and whose retrieval was accompanied by a *search* experience should display a cost in ongoing task performance. Experiment 1 was not designed to test this prediction. Experiment 2 was set up to test this additional hypothesis.

EXPERIMENT 2

The goal of Experiment 2 was to investigate a variable assumed to increase strategic monitoring. We informed half of the participants in which context (that is, in which particular ongoing task) the prospective memory task would occur, while the other half did not receive this specific information. We expected a performance increase in the specific context condition, which would be accompanied by an increase in *search* experiences. This expectation is empirically supported by two recent studies.

Nowinski and Dismukes (2005) used two different ongoing tasks and one prospective memory task. Prospective memory instructions were given in the context of one of the two ongoing tasks, while the instruction for the other ongoing task was given later in the experiment. Subsequently the ongoing tasks were alternated. Prospective memory cues (i.e., names of fruit) appeared in both tasks. The results showed that prospective memory performance was higher when the cues appeared in the context of the ongoing task that was initially associated with the prospective memory task instructions. This result suggests that associating a prospective memory task with a specific retrieval context improves prospective memory performance. Marsh, Hicks, and Cook (in press) showed that when specific instructions were given about the ongoing task context in which the prospective memory task would occur, no performance cost emerged in the ongoing task until that specific context was reached.

An additional goal of Experiment 2 was to further investigate the influence of retention intervals in prospective memory. The question of how the length of the retention interval might influence prospective memory performance is controversial. Some previous studies have reported a decrease of prospective memory performance when the length of the retention interval was increased (Brandimonte & Passolunghi, 1994; Loftus, 1971; Meier & Graf, 2001), other studies have found no influence at all (Einstein et al., 1992; Guynn, McDaniel, & Einstein, 1998), or even a performance increase when the length of the retention interval was increased (Hicks, Marsh, & Russell, 2000). As across studies the methods used to assess prospective memory differed considerably, these inconsistent results may have materialised as a result of different mixes of strategic monitoring and spontaneous retrieval processes across the experiments and conditions. We expected that by combining the context-specificity manipulation and the retention interval manipulation we should be able to clarify the influence of the retention interval in prospective memory.

In general, we used the same procedure as in Experiment 1. In addition we tested whether the presence of a prospective memory task would result in a cost in the ongoing STM task. To this end, the same number of STM trials was administered in a baseline measure without prospective memory instructions as later on in the ongoing task. In addition, only one single prospective memory cue was administered. Therefore any carryover effects in prospective memory task performance, ongoing task performance, or retrieval experience can be excluded a priori. According to the multi-process view a cost in ongoing task performance should occur only for participants whose retrieval of the intention was accompanied by *search*, but not for participants whose retrieval was accompanied by *pop up* or for those who completely forgot to carry out the prospective memory task.

Method

Participants. A total of 240 undergraduate students from the University of Bern (183 women and 57 men, $M = 22.85$ years, $SD = 5.55$) participated for course credit. They were assigned randomly to one of six experimental conditions. These were defined by the factorial combination of context (general vs specific) and retention interval (5, 15, 45 minutes).

Material. A total of 72 words and line drawings were selected from the same sources as in Experiment 1. These stimuli were pseudo-randomly grouped into four sets of lists. As in Experiment 1, each set consisted of lists of word–object pairs. The lists contained three, four, five, and six items (i.e., word–object pairs). In contrast to Experiment 1 no seven-item lists were used. Two sets were used for baseline and experimental trials, respectively.

As in Experiment 1, in the fourth set of lists, the final six-stimuli-pair list was modified such that the word on the fifth position was replaced by a prospective memory cue. The prospective memory cue words were defined as words representing a musical instrument. For each participant, the specific word was selected randomly from a pool of four different instruments (i.e., "piano", "guitar", "violin" and "trumpet").

Two distractor tasks were used. One was a lexical discrimination task, with word material taken from the WST (Schmidt & Metzler, 1992) and the MWT-B (Lehrl, 1989) vocabulary tests. A total of 108 foreign words and 498 nonsense words, which resembled existing foreign words, were selected. For a concreteness judgement task a total of 400 nouns from different sources was used. Approximately half of these items were abstract nouns, the other half were concrete nouns.

Procedure. Participants completed the sequence of activities summarised in Table 2. First, the baseline measure of the short-term memory task, consisting of eight trials (i.e., two sets with four lists each), was administered. The procedure of presenting the ongoing STM trials was identical to Experiment 1.

Immediately after assessing STM baseline, prospective memory test instructions were given. Half of the participants received a general type of instruction (i.e., "*whenever you see a word that is the name of a music instrument you have to inform the experimenter and give a brief description of the instrument*") and half of the participants received a specific instruction (i.e., "*later in this experiment you will perform the STM test again. Whenever you see a word that is the name of a musical instrument during this task you have to inform the experimenter and give a brief description of the instrument*"). To ensure that the participant understood the instruction s/he was given, s/he was required to repeat it to the experimenter and was corrected if necessary.

Then a lexical discrimination task and a concreteness judgement task were administered as distractor tasks. The order of these tasks was counterbalanced across experimental conditions. For the lexical discrimination task, a foreign word or non-word was presented on each trial in a random order and the participants had to indicate whether or not they thought this was a word. For the concreteness judgement task, a word was presented on each trial in a random order and the participant had to rate the word on a 5-point rating-scale between 1 (concrete) and 5 (abstract). For both tasks, a word was presented on the screen until the participant responded by a key press. The length of the task was determined by the experimental condition. The software was programmed in such a way that the tasks were finished automatically as appropriate. In order to manipulate the length of the retention interval, each task lasted 2, 7, or 22 minutes, respectively, depending on the experimental condition. Given that the instructions for the distractor tasks lasted another half minute each, the total retention interval was 5 minutes for the short, 15 minutes for the medium, and 45 minutes for the long interval condition.

Then the ongoing task consisting of the other eight word lists of the STM test was administered. The procedure was exactly the same as for the baseline task with one exception: A prospective memory cue was embedded in the last list. To assess phenomenological experience a similar questionnaire was used as in Experiment 1. The only difference was that rehearsal ratings (i.e., how frequent participants were thinking about the prospective memory task) were assessed for the different phases of the experiment (i.e., during the lexical discrimination task, the concreteness-rating task, and the STM task). Participants who failed to remember the prospective memory task were given the same short version of the questionnaire as in Experiment 1. As all these participants remembered what they had been asked to do, these data are not reported further. The questionnaire also contained frequency ratings, which are included in the results section.

TABLE 2
Ordering of activities across interval conditions

	Retention interval (minutes)		
	Short	*Medium*	*Long*
(1) Short-term memory (STM) task: Baseline measure	1	1	1
(2) Planning: Prospective memory task instruction	about 2	about 2	about 2
(3) Retention interval: Distractor task 1 Distractor task 2	5	15	45
(4) Test: Ongoing task (STM task) with embedded prospective memory task	1	1	1
(5) Assessment of phenomenological experience	about 5	about 5	about 5

The order of distractor tasks (concreteness judgement task and lexical discrimination task) was counterbalanced within conditions.

Results

Prospective memory performance was measured as the proportion of correct responses. Because only one prospective memory cue was administered, proportion of correct responses was equal to the proportion of successful participants. In the short interval condition performance was .65 in the specific context and .55 in the general context condition; in the medium interval condition performance was .53 in the specific context and .38 in the general context condition; and in the long interval condition performance was .53 in the specific context and .30 in the general context condition. A first data inspection suggests that prospective memory performance was higher in the specific context condition, and that across the length of the retention interval a stronger performance decrease seemed to occur in the general context than in the specific context condition. A two-factorial ANOVA with context specificity and retention interval as between-participant factors confirmed a significant main effect of context specificity, $F(1, 234) = 6.21$, $p < .05$, $MSe = 0.242$, and of retention interval, $F(2, 234) = 3.25$, $p < .05$, $MSe = 0.242$. However, the interaction failed to reach significance, $F(2, 234) = 0.327$, $p > .05$, $MSe = 0.242$. Tukey's LSD post hoc tests located the source for the significant interval effect in the difference between the short and the long interval condition, $p > .05$. In addition, the difference between short and medium interval conditions was marginally significant, $p = .055$, but the difference between medium and long intervals was not, $p = .63$.

The proportions of *pop up* and *search* responses across experimental conditions are shown in Figure 3. To investigate whether context specificity and retention interval affected retrieval experience differentially, separate ANOVAs were conducted. For *pop up* responses, a two-factorial ANOVA with context specificity and retention interval as between-participant factors revealed no significant effects, all Fs < 1. In contrast, for *search* responses, a significant main effect of context specificity, $F(1, 234) = 11.46$, $p < .01$, $MSe = 1.83$ materialised. No other effect reached significance, Fs < 1.5. To specifically locate the source of the significant main effect of retention interval in the overall analysis, separate contrast analyses were conducted for both *pop up* and *search* experiences and specific and general context conditions. In brief, the only significant result was a linear decline with increasing length of retention interval for *search* experiences in the general context condition ($p < .05$), while all other contrast analyses did not reach significance, all ps $> .30$.

We also analysed rehearsal frequency as a function of retrieval experience and context condition. Mean ratings are shown in Figure 4. Two separate sets of analyses were conducted. First,

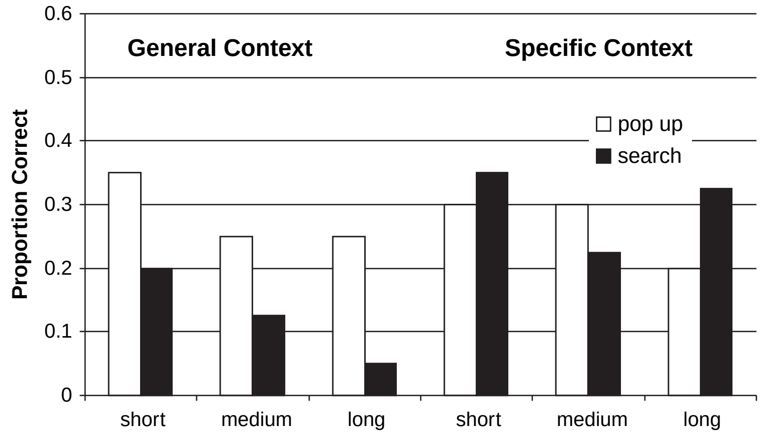

Figure 3. Prospective memory performance and retrieval experience as a function of specificity of retrieval context and retention interval in Experiment 2.

rehearsal during the distractor tasks was analysed. A three-way ANOVA with retrieval experience (*pop up*, *search*, missed) and context condition (general vs specific) as between-participants factor and rehearsal ratings in the two distractor tasks as repeated measure revealed a main effect of context condition, $F(1,\ 234) = 94.99$, $p < .01$, $MSe = 1.487$, indicating that participants in the specific context condition rehearsed less than in the participants in the general context condition. There was also a repeated measures effect, $F(2, 230) = 10.54$, $p < .01$, $MSe = 0.99$, indicating that across distractor tasks the amount of rehearsal decreased. No other effect was significant (all Fs <2.3, ps $>.05$). Second, rehearsal during Distractor Task 2 and Ongoing Task was analysed. Again, we conducted a three-way ANOVA with retrieval experience and context condition as between-participants factor and rehearsal ratings as repeated measure. All main effects were significant (all Fs >6, ps $<.05$). More importantly there were two significant two-way interactions, repeated measure $\times$ context condition, $F(1,\ 234) = 71.72$, $MSe = 0.98$, and repeated measure $\times$ retrieval experience, $F(2,\ 234) = 14.18$, $MSe = 0.98$. The former interaction implies that between Distractor Task 2 and Ongoing Task there was a higher increase in rehearsal frequency in the specific than in the general context condition. The latter interaction implies that there was a differential course of rehearsal frequency for participants with a *pop up* experience, a *search* experiences and those who missed the prospective memory task. The three-way interaction was marginally significant, $F(2,\ 234) = 2.11$, $MSe = 0.98$, $p = 0.065$. To locate the source of this interaction difference scores between rehearsal ratings in Distractor Task 2 and Ongoing Task were calculated and separate post-hoc comparisons were conducted. For the general context condition the increase in rehearsal was similar for *pop up* and *search* (ps $>.05$), and both were different from missed ($p < .05$). In contrast, for the specific context condition a larger increase materialised for *search* compared to both *pop up* and missed (ps $<.05$), while the latter two did not differ ($p > .05$).

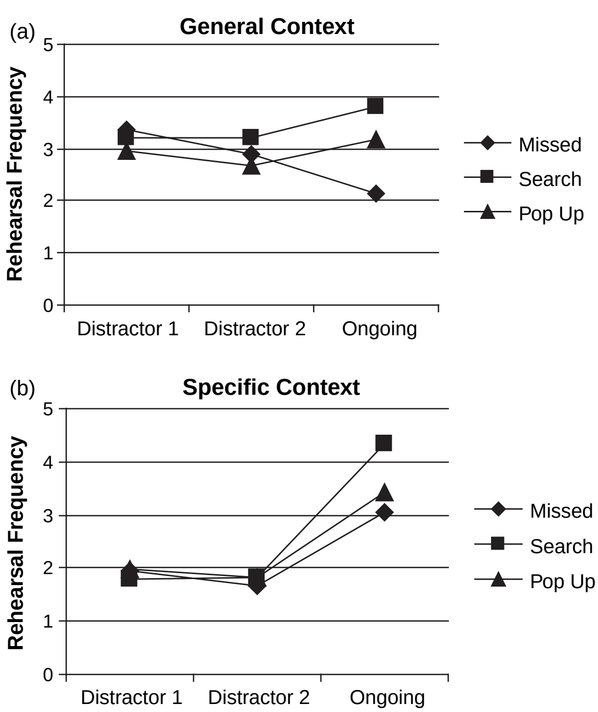

Figure 4. Rehearsal frequency as a function of retrieval experience and type of task in Experiment 2: (a) general context (b) specific context.

Finally, STM task performance was calculated as the proportion of correctly recalled items for the lists presented during baseline and ongoing task separately. To allow for a fair comparison, the final six-item list of word–object pairs (i.e., the list that contained the prospective memory cue in the ongoing task condition) was not included in both baseline and ongoing task scores. Overall, the number of correctly recalled items was 20.3 (out of 30) in the baseline condition and 19.5 in the ongoing task condition. This difference was significant, $t(239) = 4.79$, $p < .01$. More interesting, however, is whether retrieval experience was reflected in ongoing task performance. To analyse the effect of prospective memory retrieval experience on ongoing performance, we calculated a difference score (i.e., the difference between baseline and ongoing task STM performance). This score was .49 for missed, 2.08 for *search*, and .62 for *pop up*. A one-way ANOVA with retrieval experience (*pop up*, *search*, missed) as independent variable revealed a significant difference, $F(2, 237) = 6.49$, $p < .05$, $MSe = 7.43$. Tukey's LSD post-hoc tests showed that the significant differences between groups pertained to the *search* condition compared to each of the two other conditions (all ps $< .05$). Similar analyses were conducted for the lexical discrimination task and for the concreteness ratings. However, two-factorial ANOVAs with retrieval experience (*pop up*, *search*, missed) and task order (lexical discrimination first vs concreteness judgement first) as independent variables revealed no significant effects for either proportions correct or reaction times (all Fs < 1.2).

Discussion

The results indicate that specificity of retrieval context affects prospective memory performance. They also indicate that this effect is based on an increase in strategic monitoring as expressed by *search* experiences, while the amount of spontaneous retrieval as expressed by *pop up* experiences was not affected. At first glance, these results seem to contrast the theoretical explanation put forward by Nowinski and Dismukes (2005). They claimed that automatic processes facilitated prospective memory performance when the ongoing task context was reintroduced at retrieval. However, there is an important difference between the design of their study and the present experiment: In their study the experimenter did not inform participants that the prospective memory task would occur in a specific ongoing task. In fact, the prospective memory task occurred in the context in which the prospective memory task instruction was given, as well as in a different context. So, incidentally associating the prospective memory task with a particular context may effectively trigger automatic rather than strategic processes. In contrast, participants in the specific context condition of the present study were explicitly informed that the prospective memory task would occur later in a specific context. Therefore a legitimate anticipation of the prospective memory task was possible and this anticipation gave rise to a monitoring strategy, which resulted in an increase in *search* experiences. This interpretation is consistent with a recent study by Marsh et al. (in press). They demonstrated that when specific instruction about the context information was provided, no monitoring costs were obtained until the specific context was reached. Once the specific context occurred, however, ongoing lexical decision task performance was significantly affected, as was STM task performance in the current study.

Our findings complement previous results on the effects of cue specificity and suggest that, in general, factors that specify elements of the retrieval situation have a beneficial impact on prospective memory performance (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Ellis & Milne, 1996). Moreover, specificity effects may also be involved in the efficiency of implementation intentions (Chasteen, Park, & Schwarz, 2001; Gollwitzer, 1999). This manipulation includes the formation of specific "if-then" rules. Therefore, the exact specification of the retrieval context also plays an important role. Interestingly, in this field it is assumed that performance benefit is due to automatic rather than strategic processing. Further research may directly test this assumption using a *pop up/search* paradigm.

Experiment 2 also revealed important results regarding the effect of retention intervals. Overall there was a decrease in prospective memory performance. However, as indicated by the post-hoc analyses, this result was mainly due to a decrease in *search* experiences in the general context condition. It should be noted that in most of the previous studies the effect of retention interval was investigated under specific context conditions. Our findings suggest that under specific context conditions prospective memory declines are less likely than under general context conditions.

Replicating findings from Experiment 1, in Experiment 2 there was again a direct relation between rehearsal frequency and retrieval experience. Those participants who reported a *search* experience also reported more rehearsal compared to those who reported a *pop up* experience and those who completely forgot. In addition, as predicted by a strategic monitoring account of prospective memory, there was a cost in ongoing task performance for participants who searched for the prospective memory task.

GENERAL DISCUSSION

The goal of this study was to investigate whether the retrieval experience varies systematically with experimental conditions and whether therefore phenomenological experience can provide useful insights into the processes underlying prospective remembering. We considered that this approach would be convincing if we can demonstrate that specific variables affect one route towards prospective memory but not the other. Towards this goal we reported two experiments in which an experimental variable influenced one experience, but not the other. In Experiment 1 reports of *pop up* experiences varied as a function of prime presentation, while reports of *search* experiences did not. In Experiment 2 reports of *search* experiences varied as a function of context specificity, while reports of *pop up* experiences did not. The combined results from the experiential reports and the experimental manipulations support the multi-process framework of prospective memory (cf. McDaniel & Einstein, 2000; McDaniel et al., 2004). In both experiments spontaneous retrieval and strategic monitoring occurred, but their relative contribution was differentially affected by the experimental variables. Our results only partially support the theory put forward by Smith (2003); Smith & Bayen, 2004). According to this theory prospective memory retrieval is always accompanied by a cost and consequently there is no automatic, resource-free route towards prospective remembering. However, we have found clear evidence that prospective memory performance is only costly when participants report strategic monitoring, but not when they experience spontaneous retrieval. These results indicate that subjective experience can be used to measure these processes very appropriately (cf. Smith & Bayen, 2004).

Our results show that participants do not necessarily have to be aware of the source of their experience. In Experiment 1 the presentation of associated primes specifically affected *pop up* experiences, independently of whether the participants were aware of them. However, in Experiment 2, providing specific context information led to more rehearsal of the prospective memory task during the specified context compared to the distractor tasks. Participants seemed to be able to flexibly allocate resources to the prospective memory task when they believed it appropriate (cf. Marsh et al., in press). This change of task orientation (i.e., attention allocation policy) was most likely due to a conscious decision, which occurred even for those participants who did not remember the prospective memory task. This interpretation is supported by the finding that even participants who failed to perform the prospective memory task showed an increase in rehearsal frequency during the specified ongoing task.

The findings of this study show that assessing retrieval experience is a straightforward method to disentangle strategic *search* and spontaneous retrieval. However, we do not claim that this is the only way towards this goal. We believe that this approach complements the assessment of ongoing task interference and of rehearsal frequency. The specific advantage of the *pop up/search* paradigm is that information can be gathered about retrieval experience when retrieval occurs. Neither frequency ratings nor ongoing task costs can provide specific information about the critical retrieval episode. They provide rather more general information about a participant's attention allocation strategy or task orientation.

We also want to point out some disadvantages of our approach. Procedurally, probably only few prospective memory cues can be used, because it seems very likely that assessing retrieval experience can itself change the attention allocation strategy of a person. This may be especially problematic when a less demanding ongoing task is used than in the current study. As a consequence a larger number of participants may be mandatory in order to obtain similar statistical power as to when multiple prospective memory cues are used. Further, as is self-evident, retrieval experience can be measured only if retrieval takes place.

It has been suggested that phenomenological reports must be treated cautiously (e.g., Smith & Bayen, 2004). As many psychological processes operate outside awareness responses may reflect judgements of other variables that co-vary with the retrieval experience. For example, one could argue that because the *pop up/search* responses occurred at the end of the questionnaire in this study, the ratings may have been influenced by the previous rehearsal ratings. Rather than indicating a particular retrieval experience the *pop up/search* response may simply reflect participants' perception of how often they thought about the prospective memory task. Even though we cannot exclude this possibility, our results and evidence from other domains indicate that phenomenological reports can yield meaningful and valid information (e.g., Hertzog, Park, Morrell, & Martin, 2000; Tulving, 1985).

It is important to note that the specific combination of the characteristics of the prospective memory task and the ongoing task, and their relationship, may have a large influence on the specific amounts of spontaneous retrieval and strategic monitoring. For example, in this study a categorical intention was used in both experiments. It is very likely that a different combination of retrieval experience would have emerged if we had used specific instances instead. There is evidence that, with specific cues, costs in ongoing task performance are lower (Marsh et al., in press; 2003). A straightforward prediction would be that under these conditions the proportion of *search* responses is lower as well.

To conclude, the distinction between strategic monitoring and spontaneous retrieval is important because it demonstrates two different routes to successful prospective remembering (cf. McDaniel & Einstein, 2000). It may also indicate the involvement of different memory systems with different underlying cognitive mechanisms. For strategic monitoring, the prospective memory task may be represented actively in working memory. This implies that detecting the specific prospective memory target does not necessarily require its retrieval from long-term memory. In contrast, when the target event occurs but the person is not engaged in strategic monitoring at that moment, the prospective memory task may not be currently held in working memory. In that situation, retrieval of the task is triggered by the prospective memory target and the prospective memory task must then be retrieved from long-term memory. Our results suggest that asking participants about their retrieval experience is a meaningful way to disentangle these routes towards prospective remembering.

Manuscript received 26 January 2005
Manuscript accepted 18 March 2006
First published online 20 June 2006

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