

On the Interaction of Ongoing Cognitive Activity and the Nature of an Event-Based Intention

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SUMMARY

Three experiments were conducted to explore the interaction between the nature of an event-based prospective intention and the ongoing activity in which it was embedded. Following the basic predictions of E. A. Maylor's (1996, 1998) task appropriate processing framework, we orthogonally crossed semantic and structural ongoing activities with intentions to respond to semantic and structural event-based cues. In Experiments 1 and 2, we found a cross-over interaction in which the match of the ongoing task and the nature of the intention resulted in better event-based performance than a mismatch between the two. Experiment 3 attempted to define boundary conditions for these effects by demonstrating that the task appropriate processing effect will not occur when event-based cues are particularly salient. The implications of the results and suggestions for further investigations are discussed. Copyright © 2000 John Wiley & Sons, Ltd.

In the course of everyday cognition objects and events often remind us of things that we have experienced or thought about in the past. For example, a particular piece of furniture may remind us of a city we lived in many years ago because we purchased it there. A reference to a college student's endeavours may evoke memories of one's own years spent at a university. To learning theorists there is no mystery here insofar as these objects or events merely serve as good retrieval cues for experiences that have been recorded in memory. In fact, Sir Francis Galton (1883) capitalized on such retrieval cues in his classic studies of autobiographical memory. Likewise, Tulving formalized the idea that the best retrieval cues are the ones that get associated with to-be-remembered material at the time of encoding (e.g. Tulving and Pearlstone, 1966; Tulving and Osler, 1968). But retrieval cues are not only useful in everyday life as a means of recalling episodic and semantic information that has been learned in the past. Rather, they can be very effective in drawing out of memory intentions to perform some action in the future. Cues that remind us of intentions to perform are cues that remind us of prospective memories (e.g. Ellis and Milne, 1996). Such cues do not necessarily remind us of the exact time or place that we formed the intention, just that the intention exists. For example, a person may have had the intention to have the eaves troughs cleaned on their house for over a year but may have no recollection of when or where the intention was formed. Nevertheless, leaves falling in the

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garden, rain pattering on the roof, and debris sticking out of them all serve as good retrieval cues for the unfulfilled intention.

A number of experimental studies exist that have investigated the characteristics of retrieval cues in prospective memory. In what has been labelled event-based prospective memory, participants are asked to respond with a unique action when a particular target event or class of items appears during some ongoing activity (e.g. Einstein and McDaniel, 1990; McDaniel and Einstein, 1993). The ongoing activity keeps participants busily engaged as they might be in everyday activities. For example, participants might be asked to respond when an animal word appears during a long series of pleasantness ratings or when a particular word appears in a sentence verification task (e.g. Ellis *et al.*, 1999). Noticing the cue and responding appropriately is then recorded as an instance of successful prospective memory. Prospective cues that are distinctive against the background activity have increased prospective performance, as did prospective cues that were less familiar (McDaniel and Einstein, 1993). Also, more specific cues (e.g. tiger) have elicited better performance than did more general cues (e.g. *animal*; Einstein *et al.*, 1995; Elish and Milne, 1996).

Findings such as these are important in their own right because they have allowed us to formulate theories about how retrieval cues might subservise prospective memory in the real world. For example, a simple model of the findings in the previous paragraph led to the hypothesis that an automatic noticing component based on the familiarity of a cue leads to a more conscious and strategic search for what the cue might signify (i.e. the noticing plus search model; Einstein and McDaniel, 1996; see also McDaniel and Einstein, 2000). In our previous work on event-based prospective memory, we have demonstrated that ongoing activities that require more attention (i.e. executive processes) tend to reduce event-based prospective memory (Marsh and Hicks, 1998). Although it is clear from the existing literature that both the characteristics of the cue and the nature of ongoing activity are both important to event-based prospective memory, only recently has their joint influence been investigated. Likewise, the nature of the intention itself should also interact with the ongoing task in a principled fashion to produce either higher or lower levels of prospective remembering. These two factors are the focus of the study reported here.

More specifically, we were interested in pursuing speculations that derived from Maylor's work with older adults (Maylor, 1993, 1996, 1998). Maylor's event-based task consisted of participants identifying the names of famous faces in the ongoing task. The prospective memory task was to respond by marking response sheets uniquely when faces had a particular structural attribute (e.g. glasses or a beard). She found that older adults performed more poorly on the event-based task than did younger adults. She hypothesized that her ongoing task was semantic in nature (identifying faces) whereas the prospective task was structural (search for specific facial features). Older adults might have more difficulty switching from the semantic ongoing activity to analysing the structural features of a face in order to respond (Maylor, 1996, 1998). Extrapolating this logic, people should identify a prospective cue more readily when the demands of the ongoing cognitive activity highlight features of the cue that are related to the intention itself. In other words, prospective cues that are encountered when the cognitive processing is oriented toward features of the cue that overlap with the intention should evoke the previously established intention more readily. By contrast, if the cognitive processing of the ongoing activity were oriented otherwise then prospective memory may be worse. In Maylor's paradigm, performance of the older adults may have been much better if the prospective task was semantic in nature (e.g. respond to politicians) because the ongoing cognitive activity was

semantic as well (i.e. identifying faces). If the structural prospective task were to be retained, then responding might have been facilitated with a different ongoing activity that was also structural in nature (e.g. rating the age or beauty of the photograph).

The overarching point here is that overlap between the cognitive components of the ongoing task and the cognitive processing needed to identify an item as a prospective cue might facilitate performance. Likewise, a mismatch between them might hamper identification of the prospective cue. Maylor (1996, 1998) has set forth these predictions under the label of *task appropriate* processing. Darby and Maylor's (1998, presentation at the Seventh Cognitive Aging Conference, Atlanta, GA) demonstration of limited support for these predictions will be considered in the General Discussion section. The present study was conducted to provide additional information concerning the conditions under which the nature of the intention and the type of ongoing activity would interact in principled ways. To this end, we gave some participants a semantic ongoing task (rate items for how pleasant they were) whereas other participants were given an orthographic task (identify whether words had repeated letters). We also gave some participants a semantic intention to identify any animal words that they encountered whereas others were given an orthographic intention to respond to words that were palindromes (i.e. spelled the same way forward and backward). From the task appropriate processing framework, we predicted that a cue that had to be identified semantically (respond to animals) would benefit from an ongoing task that required access to semantic features of the items (pleasantness ratings). Likewise, if the cue had to be analysed structurally in order to retrieve the intention (respond to palindromes), then an ongoing cognitive activity that oriented participants toward structural aspects of items (identify repeated letters) should lead to better prospective memory. Obviously, those conditions constituting a mismatch in the two types of processing should lead to worse prospective performance than when they match.

There are several theoretical frameworks that would support these predictions. For example, an animal prospective cue may evoke more familiarity when it is being analysed semantically as opposed to when it is being analysed structurally. That heightened familiarity would have a higher probability of evoking a search for the source of the familiarity as specified in the noticing plus search model (Einstein and McDaniel, 1996). In our work, we have specified that production rule accounts based on Anderson's (1983) ACT* model can be used to illuminate aspects of event-based prospective memory (see Marsh and Hicks, 1998). By this account the intention can be thought of as a condition-action rule (e.g. if animal then press key). Ongoing activities that orient cognitive processing toward features that would specify that the conditions of the rule had been met would increase the probability that the production rule would fire, and therefore, that a prospective response would be made. At this early stage, however, our goal in this study was not to provide evidence that would disambiguate among different theoretical accounts of event-based prospective memory. Rather, our goal was to provide some needed empirical evidence for the task appropriate processing hypothesis.

EXPERIMENT 1

In this experiment, different groups of participants were asked to rate a series of words for their perceived pleasantness or were asked to identify whether words contained repeated letters. These were the two ongoing tasks. Prior to beginning the ongoing activity, some

participants were asked to press a key when animal words occurred in the ongoing activity and others were asked to do the same when palindromes appeared. Because rating the pleasantness of words is essentially a semantic task, as is identifying a word as an instance of the category of animals, we predicted that event-based prospective memory would be better under these matching conditions as compared to when either the ongoing task or cue identification task was related to structural processing. By the same token, we predicted that a structural ongoing task (identifying repeated letters in words) would lead to better prospective memory if the intention involved identifying a structural cue (palindromes). In brief, the predictions from a task appropriate processing framework is that a semantic ongoing task and semantic cues or a structural ongoing task and an intention involving structural cues should lead to the best prospective memory. A mismatch between the cognitive processing of the ongoing activity and that processing required to identify the cue should lead to worse prospective memory. In essence, a cross-over interaction between the type of ongoing activity and the nature of the intention was predicted.

Method

Participants

In exchange for partial credit toward a course research requirement, 100 University of Georgia undergraduates volunteered. Each participant was tested individually in sessions that lasted approximately 25 minutes. Participants were randomly assigned to one of four between-subjects conditions. Therefore, each condition contained 25 participants.

Materials and design

The procedures in this experiment closely matched those that we have used in other investigations of event-based prospective memory (e.g. Hicks *et al.*, 2000). One hundred and four medium frequency words were chosen from the Kučera and Francis (1967) compendium. These were the words that would be rated for pleasantness or for whether they contained a repeated letter during the ongoing task. Approximately half of the words contained repeated letters and half did not. Four animal words were chosen as were four palindromes that were roughly equated for word frequency, number of syllables, and number of letters. Palindromes were selected from the Chism (1992) compendium. The animal words all had repeated letters as did the palindromes. In this fashion, the two classes of prospective targets were roughly equated on those dimensions that could have affected performance. When the prospective memory task was to identify animals, the four animal words replaced words at trials 25, 50, 75, and 100 in the 104-trial sequence. When the intention was to respond to palindromes, the palindromes replaced words on the same trials. Assignment of prospective cues to trials within the experimental sequence was determined randomly anew for each participant tested. In a 2×2 orthogonal design, half the participants were asked to identify animals and half were asked to identify palindromes as the prospective memory task. Within each group, half of the participants were rating pleasantness of words as the ongoing cognitive activity and half were judging whether a word contained repeated letters.

Procedure

Participants read instructions from a computer monitor that were appropriate to their assigned condition. In the pleasantness rating condition, participants were asked to rate how pleasant words were on a 5-point Likert scale. By contrast, participants assigned to

the repeated letters ongoing task were asked to classify words as to whether or not they contained a repeated letter (e.g. *CLEVER*). The experimenter reviewed these instructions and additionally told participants that we were interested in their ability to perform an action in the future. If participants were assigned to the animal prospective task, they were told to press the '/' key before making their ongoing task judgement when they found an animal word. If they were assigned to the palindrome condition, they were told to press the same key before the ongoing task judgement when they found a word that was spelled the same way forward and backward (e.g. *ROTOR*). In order to ensure they understood the intention, all participants received an example of the animal or palindrome prospective cue that did not appear in the 104 trial experimental sequence.

Following these instructions, participants were asked to work on a distractor task for 4 min that involved mental paper-folding. The purpose of this distractor task was simply to introduce a delay between the prospective instruction and the commencement of the ongoing task (see Hicks *et al.*, 2000). During the ongoing task, a query was placed in the center of the screen reminding participants of the judgment that they were making (i.e. *pleasantness?* and *repeated letters?*). The word to be processed on that trial appeared 500 ms after the query appeared and both stayed on the screen until the participant made the appropriate response to the ongoing task. All words were presented in upper-case letters in this and the experiments that follow. The software controlling the experiment recorded participants responses and recorded when a prospective response was made. The purpose of the four trials following trial 100 was to capture late responses but these rarely occurred (less than 2% of the time) perhaps as a consequence of our instruction to respond to cues before making the ongoing task response. Consistent with our previous work, those few late responses that were made are considered to be missed prospective trials in this study.

Results and discussion

The data are summarized in Table 1 as the average proportion of cues that elicited a prospective response. A 2(pleasantness rating versus repeated letters) \times 2(animal versus palindrome cues) between-subjects analysis of variance (ANOVA) model was tested. On average, both ongoing tasks resulted in the same overall prospective performance, $F(1, 96) < 1.0$, n.s. The same was true of the two types of prospective cues, $F(1, 96) < 1.0$, n.s. Although neither main effect was significant, the interaction between type of cue and ongoing task was, $F(1, 96) = 5.83$, $p < 0.05$. As can be seen in Table 1, there was an orderly cross-over interaction. The cognitive processing in the ongoing task resulted in better identification of the cues when it matched structurally or semantically with the particular analysis that would be needed to identify the cue as relevant to the intention to respond. When participants were asked to rate the pleasantness of words, they fulfilled the intention to respond to animal cues numerically more often than they identified palindrome cues (see first row of Table 1). The opposite was true with the repeated letters ongoing task (see second row of Table 1). For the pleasant ratings ongoing task, the simple effects analysis of the type of intention (animals versus palindromes) was not statistically significant, $t(48) = 1.16$, n.s., whereas for the repeated letters ongoing task it was significant, $t(48) = 2.25$, $p < 0.05$. We are not sure why the semantic ongoing task led to a slightly attenuated difference as compared with the structural ongoing activity. One possibility is that the two ongoing activities require different overall allocations of attention. We will return to this idea later in this article.

Table 1. Prospective memory performance as the proportion of responses made to the prospective cues. Standard errors are also provided in parantheses

Experiment and ongoing Task	Prospective cues	
	Animals	Palindromes
Experiment 1:		
Pleasantness Rating	0.66 (0.05)	0.55 (0.07)
Repeated Letters	0.56 (0.07)	0.75 (0.06)
Experiment 2:		
Pleasantness Rating	0.61 (0.04)	0.51 (0.06)
Repeated Letters	0.51 (0.05)	0.72 (0.04)
Experiment 3:		
Pleasantness Rating	0.70 (0.07)	0.73 (0.06)
Repeated Letters	0.73 (0.06)	0.78 (0.06)

Overall performance was not extremely low when the ongoing task and the processing required to identify the cue did not match. In other words, identification of prospective cues is occurring fairly often even when the cognitive processing may be orienting participants away from those features of the cue that need to be recognized in order to respond. For this reason, we are assuming that the semantic or structural match between intention and ongoing task has a facilitatory effect, as opposed to a mismatch between them having a deleterious effect. We admit that this interpretation is speculative and also acknowledge that it would be difficult to specify whether the task appropriate processing effects found here represent facilitation of match, inhibition of mismatch, or some combination of two. The important point is that identification of a prospective target can occur quite readily in the adverse or suboptimal situation in which ongoing task processing is being oriented away from the relevant properties of the cue.

EXPERIMENT 2

In Experiment 1, each participant had only one ongoing task to perform and one intention to keep in mind. Therefore, prospective memory was being measured under a sort of 'best case' scenario. By contrast, in everyday life people switch between tasks and are sometimes forced to keep track of multiple activities that are going on around them. Some of the activities may heighten people's sensitivity to event-based cues not because they are currently performing an activity that maps on to the matching conditions of Experiment 1, but rather, because they had recently performed such an activity. In Experiment 2 we tested conditions that might be less conducive to finding the cross-over interaction that was obtained in Experiment 1. In this experiment, participants performed both the semantic and the structural ongoing tasks on different trials throughout the experiment. The type of intention (animal versus palindrome) was kept a between-subject variable. Thus, two prospective cues occurred on trials performed with one

ongoing task judgement and two occurred on trials performed with the other judgement. By having participants perform both a types of ongoing activity we made them aware of the type of processing that could be beneficial to identifying a cue in their assigned condition. Our hypothesis was that if all participants had exposure to the necessary cognitive processing that would benefit cue identification then perhaps the interaction found in Experiment 1 would be eliminated or greatly attenuated. If the interaction persists, then this would be valuable evidence in favor of the generalizability of conditions under which the task appropriate processing effect could be obtained.

Method

Participants

Ninety-six volunteers who had not participated in Experiment 1 were recruited. They were awarded course credit toward fulfilling a research requirement. Half of the participants were tested with the intention to respond to animals and the other half were asked to respond to palindromes.

Procedure

The procedure was a within-subjects variant of Experiment 1. Participants read instructions for the two types of ongoing task judgments from a computer monitor. They learned that on any given trial a query would appear telling them which kind of judgment to make. Following the instruction, the word on that trial would appear for either the semantic or structural judgement. Judgements were assigned to trials randomly anew for each participant under the constraint that 50 non-prospective trials were performed under each task. For the prospective trials, two cues were randomly chosen to be rated for pleasantness and two were chosen to be judged for repeated letters. After the participants understood the ongoing tasks, they were informed that we were interested in their ability to perform an action in the future. Half of the participants were asked to respond to animals and half were asked to respond to palindromes. As in Experiment 1, they were asked to make their prospective response before the ongoing task judgment and the 4 min distractor task intervened between the prospective instruction and the commencement of the ongoing task.

Results and discussion

By having all participants exposed to the cognitive processing that would be beneficial to identifying a cue in their assigned condition, we expected that the task appropriate processing interaction might be attenuated or absent. This hypothesis turned out to be wrong. Semantic processing continued to facilitate identification of the semantic cues and a structural judgements continued to facilitate identification of the structural cues. As can be seen in Table 1, the overall prospective performance was neither a function of the particular ongoing task judgement alone, $F(1, 94) = 1.12$, n.s., nor the type of intention alone, $F(1, 94) = 1.10$, n.s. Rather, the cross-over interaction pattern persisted even when participants had been exposed to both types of cognitive processing in the ongoing task, $F(1, 94) = 10.06$, $p < 0.01$. As in Experiment 1, the simple effects analysis for the pleasantness rating judgement showed a numerical advantage for the animal intention over the palindrome intention, but this did not reach statistical significance, $t(48) = 1.44$,

n.s. By contrast, when the performing the repeated letter judgement, more palindrome cues were identified as compared to animal cues, $t(48) = 3.10$.

The results from this experiment suggest that the cognitive activities that are taking place at the time an event-based cue appears will influence how likely it is to be identified and responded to. The fact that participants were using cognitive processes on other trials that would increase identification of the prospective cues did not matter; processing was specific to the trial on which the event-based cue appeared. In other words, we found no evidence of 'overspill processing' in which recently performing the ongoing activity that might benefit cue identification actually did benefit performance. We had believed that even though participants were making, say, a semantic judgement on a given trial that the fact that they had recently made a series of structural judgments might heighten their awareness to the orthography of the words. In some ways the results from this experiment are rather unfortunate because they suggest that event-based cues will not benefit from recent cognitive activities to which they might be related or their identification facilitated. We had hoped to find conditions that might weaken the task appropriate processing finding because doing so would provide a better understanding of when it does and does not operate. Experiment 3 was conducted with this objective.

EXPERIMENT 3

Our goal was to find a condition that would mitigate or eliminate the task appropriate processing effect. The working hypothesis has been that the cognitive processing of the ongoing task judgments highlight those aspects of the prospective cues that leads to the retrieval of the intention. Einstein *et al.* (in press) have recently shown that particularly salient cues will evoke consistent and high levels of event-based prospective memory. In their paradigm, they used upper-case cues against a background of lower-case words. The goal in this experiment was not to place prospective memory on ceiling, but rather to demonstrate that salient targets might remove the task appropriate processing pattern of results that was so strongly observed in Experiments 1 and 2. Our logic was that when cues are salient for reasons other than the nature of the intention or the type of processing in the ongoing task then the interaction would disappear. Conditions such as these are important to find in order to place boundary conditions on when the intention and the ongoing task will and will not interact. In the present experiment we predicted that the manner of presentation of the cue, if it were salient, would eliminate the intention and ongoing task interaction because saliency would confer a benefit to noticing the prospective cues. If the cue is already highly salient and identifiable, then little additional benefit would occur from matching processing in the ongoing task and that required to identify the cue.

Method

Participants

Sixty University of Georgia undergraduates volunteered in exchange for partial credit toward a course research requirement. Each participant was tested individually in sessions that lasted approximately 25 minutes. None had participated previously. Half were assigned the intention to respond to animals and half were assigned to respond to palindromes.

Procedures

The procedure was virtually identical to the one used in Experiment 2. Participants randomly alternated between judgments throughout the experimental sequence but they were assigned either the semantic or the structural intention. To make prospective cues somewhat salient from the remaining trials in the ongoing activity we enclosed the prospective words in angle brackets (e.g. >CIVIC<). Because we believed that such a manipulation might result in near-perfect responding which would not allow the task appropriate processing interaction to appear, we diluted it. The dilution technique was to include two other non-prospective words in angle brackets as well somewhere in the 24 trials that led up to each prospective cue. In this fashion, the cue would appear to be special (i.e. salient) but not be perfectly correlated with the prospective memory task.

Results and discussion

The results are summarized at the bottom of Table 1. The first thing to notice is that the overall performance is generally better than in Experiments 1 and 2, but the averages are not on ceiling which would allow the interaction between the ongoing task and cue identification to emerge if the saliency manipulation did not have its intended effect. However, as is evident from the means, neither main effect of ongoing task nor type of intention was statistically significant and there was no interaction between them, all three $F(1, 58)$'s < 1.0 . Although there is a small numerical advantage for identifying palindromes over animals under the structural processing judgement, that advantage is also present for the semantic processing judgement that should have favoured detecting animal cues. The saliency manipulation increased performance in general but particularly when there was a mismatch between the cognitive processing in the ongoing task and the type of cue to be identified. In other words, saliency of the prospective cue has appeared to trump the task appropriate processing effect.

Results such as these are important because they place boundary conditions on when the ongoing task and type of intention might interact. For example, the results highlight the fact that it is generally inappropriate to conclude that the interaction will always materialize. A third variable appears to be the saliency of the cues, and a fourth is likely to be individual differences in certain populations like older adults (Maylor, 1996, 1998). The contrast between Experiments 1 and 2 on the one hand and this experiment on the other demonstrate the incredible complexity of event-based prospective memory. Whereas previously we believed that it was primarily the nature of the cue that mattered (e.g. McDaniel and Einstein, 1993), now we know that in addition, the ongoing task demands matter in terms of absolute amounts of resources (Marsh and Hicks, 1998), as well as processing specific components that interact with the type of intention. We turn now to considering what these results imply about event-based prospective memory more generally.

GENERAL DISCUSSION

Our goal in these experiments was to explore the task appropriate processing predictions originally made by Maylor (1996, 1998) for event-based prospective memory. Part of the thesis was that different ongoing activities require different basic cognitive processes.

Depending on the nature of a previously established intention, some ongoing activities will make aspects of an event-based cue salient and draw to mind the intention more readily. We found evidence for this in Experiments 1 and 2. When the ongoing activity engaged cognitive processes dealing with the semantic aspects of words, a semantic intention to respond to animal cues was achieved numerically more often than an intention that required structural analysis of the words. The reverse was true with a structural ongoing task. This general pattern of results was removed when the prospective cues were made salient by altering their perceptual appearance relative to other words in the ongoing activity. Thus, the interaction of ongoing task and the requirements of cue identification may only show a beneficial (or detrimental) effect when the event-based cues are not particularly salient. Alternatively, the task appropriate processing effect may only appear in a lower range of the response scale in event-based prospective memory experiments such as those conducted here.

In Darby and Maylor's (1998) test of the current hypothesis, they also orthogonally crossed semantic and structural intentions with semantic and structural ongoing task demands. Their semantic task was to choose a synonym for a target word from a series of six words whereas the structural task was to choose the word from the same series that followed alphabetically. The semantic intention was to identify color words and the structural intention was to respond to words with double letters. Their design allowed them to use the exact same prospective cue words (*green*, *maroon*, and *yellow*) for both intentions because these colour words had repeated letters. This approach is somewhat more elegant than our use of four different words (palindromes versus animals) in the two intention conditions that we tested. Our ongoing tasks were also slightly different from one another insofar as the semantic task required a rating on a 5-point scale whereas the repeated letter condition required essentially a yes–no answer. In Darby and Maylor's two ongoing tasks the participant was always choosing one word out of an array of six. In these respects, Darby and Maylor's paradigm may have been slightly cleaner than the procedures that we adopted.

However, they did not find the orderly cross-over interaction that we found here because responding to color cues far surpassed responding to cues with double letters regardless of the ongoing task. Nevertheless, they showed that the reduction in prospective memory in the mismatch conditions was greater for older than for younger adults (as they predicted). Therefore, researchers who are interested in comparisons across particular populations (e.g. older adults, brain impairment, anxiety disorder, etc.) or who are interested in particular manipulations (e.g. divided attention, frequency of the prospective cue, etc.) might be interested in the *relative* impairment caused by the mismatch condition across populations or manipulations as a means of exploring important theoretical and practical questions about event-based prospective memory.

In a related vein and from a methodological standpoint, the cross-over interaction is not always necessary to make use of the task appropriate processing effect. A researcher might want to use the present findings as a means of placing prospective memory either higher or lower in the overall range of the response scale. In other words, the findings reported here can be used to manipulate overall event-based performance by judiciously choosing the type of ongoing activity and the type of cue that is to be identified. If a researcher wants to raise performance, an ongoing task and an intention that share semantic or structural properties may be one way to achieve this. By contrast, if the goal is to lower performance, then a mismatch in the requirements of the ongoing task and the nature of the intention may lead to the desired result. We have in our work had occasions when we were interested

both in the fate of successful and failed prospective trials. In order to get sufficient numbers of each, the present results suggest one means of manipulating overall performance (see also Hicks *et al.*, 2000). Thus, the task appropriate processing effect can be used in a variety of practical ways to study event-based prospective memory.

From a theoretical standpoint, the present results may support our contention that event-based prospective memory requires attention (Marsh and Hicks, 1998). Ongoing activities require the deployment of attention in order to successfully respond. We have demonstrated that when those cognitive resources match the types of cognitive resources needed to identify a cue then prospective memory is improved. However, we do not mean to claim that all forms of event-based memory demand high levels of monitoring in order to respond. McDaniel and Einstein (2000) have claimed that when the cue and action are highly associated then the event-based intention may come to mind relatively automatically. By contrast, when the cue and the action are relatively novel, then attention may be required in order to identify that the contingencies have been met to fulfil a previously established intention. By this multi-process view of event-based memory, perhaps we have tested only those conditions that might require attention. After all, there is no strong or pre-existing association between seeing a type of word and responding with a key press. One important theoretical implication of this view would be that the task appropriate processing effect should not be found when the cue and the response are highly associated because the intention is delivered relatively automatically, much as it was in Experiment 3 herein.

Of course, the present results have a number of practical ramifications for prospective memory in everyday life. Cues that are encountered in the course of performing a particular activity may not bring to mind an intention whereas if they are encountered within the context of a different activity they may serve as a much better reminder. For example, if one has an intention to give a student or a colleague a message, the person might serve as better reminder when one is at work and thinking about work-related matters as compared to encountering the person in the grocery store when one's mind is occupied with shopping for household goods. Similarly, the intention to purchase postage stamps may occur more readily when one is picking up mail at the post office than when one is in the check-out aisle of the grocery store despite the fact that both venues sell postage stamps and each provides an equally good opportunity to fulfil the intention. In this later case, of course, the context of ongoing activity may also aid in fulfilling the intention. However, we know that ongoing cognitive activity is strongly influenced by context and the experiments reported here may be a simpler form of manipulating ongoing cognitive processes that would naturally vary across a variety of contexts (e.g. the first example in this paragraph).

When viewed in this way, there are interesting questions to be asked about cues that are related to intentions. For example, will habitual intentions like taking vitamins be more likely to be forgotten when one's morning routine has been changed by the circumstances of a particular day (e.g. having to take children to school when that is one's spouse's normal routine)? Similarly, will cues about novel intentions (e.g. taking medication for a week) be overlooked more readily in context of a habitual routine as compared to when they are encountered in a place that may be less associated with a habitual routine (see Ellis, 1998; Park and Kidder, 1996)? In seeking answers to such questions it may be difficult to separate the saliency of the cue against its background context from its saliency due to particular cognitive processes. Although challenging, Experiment 3 demonstrated that these influences can be teased apart successfully in the laboratory. Of course, the real challenge will be generalizing such laboratory demonstrations to everyday issues of

prospective memory in order to improve prospective performance in those populations where it appears to be most problematic.

The present results also raise some interesting questions for recently reported findings. For example, Einstein *et al.* (in press) have found very rapid forgetting for event-based intentions if they must be maintained over relatively short delays. Will the nature of the ongoing activity that precedes or occurs during the delay affect such forgetting rates? If the intention is semantic and the processing during the short retention interval is structurally oriented (i.e. requires a change in cognitive processing) the intention may be more likely to be lost from working memory. The same may be true in Hicks *et al.*'s (2000) manipulation of retention intervals that span longer time frames. In a similar vein, West and Craik (1999) have recently reported that older adults are more susceptible to momentary lapses of intention (MLI) in which prospective lures that meet some, but not all, of the characteristics of an appropriate cue to respond will sometimes evoke an incorrect prospective response.

Perhaps with appropriate ongoing cognitive activity these MLIs could be reduced; and similarly, perhaps with a suboptimal ongoing activity it could be shown that people are more prone to these MLIs. Gedanken experiments such as these highlight potentially important extensions of Maylor's (1996, 1998) original task appropriate processing hypothesis. The overall demands of ongoing activity such as those explored by Marsh and Hicks (1998) and others who have divided attention during the ongoing task (e.g. McDaniel *et al.*, 1998) were informative manipulations when they were reported. However, in addition to the overall demands that are required by an ongoing task we must now give some very serious consideration to how those processing manipulations interact with the processing that would be required to identify a prospective cue. Observations such as this one only reinforce the fact that the terrain of event-based prospective memory is rockier and more complex than many of us originally imagined.

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