Applied Cognitive Psychology, Appl. Cognit. Psychol. **25**: 632–640 (2011)
Published online 22 July 2010 in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/acp.1733

A Comparison of Activity-Based to Event-Based Prospective Memory

GENE A. BREWER[1]*, RICHARD L. MARSH[2], ARLO CLARK-FOOS[2], J. THADEUS MEEKS[2], GABRIEL I. COOK[3] and JASON L. HICKS[4]

[1]*Department of Psychology, Arizona State University, Arizona, USA*
[2]*Department of Psychology, University of Georgia, Athens, USA*
[3]*Department of Psychology, Claremont McKenna College, Claremont, USA*
[4]*Department of Psychology, Louisiana State University, Louisiana, USA*

Summary: Four experiments were conducted that directly compared activity-based to event-based prospective memory. In general, when a goal is established to perform an activity at the conclusion of a different activity, successful completion suffers as compared with associating the same intention with a concrete environmental event. In this regard, activity-based performance was worse than comparable event-based conditions. However, certain conditions such as making transitional points salient between tasks and providing practice may ameliorate these differences between the two kinds of intentions. Other variables that may discriminate between these two kinds of intentions are considered; but the initial evidence favours the notion that ultimate goal completion covaries with the type of intention that is established initially at encoding and the degree of environmental support provided at retrieval. Copyright © 2010 John Wiley & Sons, Ltd.

Activities that cannot be completed at the current moment must be delayed to a future point in time when the conditions are more favourable for successful completion. Such tasks and goals are stored as declarative representations; and they are labelled prospective memories to highlight a distinction between them and retrospective memories which record events and experiences that have occurred in the past with no relevance to the future. Similar to the conclusions drawn from a century of research on retrospective memories, researchers in the newly burgeoning field of prospective memory have realized that a variety of different kinds of intentions exist. Our goal in this study was to examine activity-based prospective memory which has received very little empirical, and consequently theoretical, attention in the literature to date. Moreover, we empirically compared the nature of intentions associated with completing activities to intentions associated with detecting environmental cues in order to critically consider any theoretical and interpretative similarities and differences between them. Before detailing our goals and the relevant background to this endeavor, we briefly mention the three main varieties of prospective memories that have been identified to date.

First, most published work has analyzed the cognitive processes associated with storing and realizing *event-based* intentions. These intentions require that some external cue trigger an associated memory of the previously formed plan to complete a goal. For example, the sight of a grocery store may activate the intention to purchase several items needed for dinner. Second, a *time-based* prospective memory is recorded when a person intends to perform a task at a specific time or after some set period of time has elapsed. For example, one may plan to drive to the grocery store at 5:30 or one may plan to work for one-half hour before accomplishing this same task. In both cases time-related processing is critical to success whereas the same is not true of an event-based task. Time-based and event-based tasks have been directly compared, although not very extensively (e.g., Craik, 1986; Einstein & McDaniel, 1990, Kidder, Park, Hertzog, & Morrell, 1997). One consensus that has emerged from such analyses is that time-based tasks require more self-initiated processing to complete (and perhaps greater attentional demands), but this position is not without its critics (e.g., Hicks, Marsh & Cook, 2005). Third, the most understudied type of intention is an *activity-based* prospective task which requires that the intention be retrieved and executed upon completing some other task. In the grocery store example, an intention might be formed to complete the intention after a late-day meeting has been concluded. As these examples make quite clear, an intention can be formed under any one of the three broad formats just identified, and the probability of completion could depend on the manner in which the current context interacts with the type of intention formed (see Marsh, Hicks & Cook, 2007). Our goal in this study was to examine the somewhat neglected activity-based format of intention formation and compare it to event-based tasks in the hopes of advancing our understanding of the efficacy of such intentions and what their potential theoretical underpinnings might be.

Activity-based prospective memory is prevalent in everyday life and failing to fulfil these types of intentions can have severe, and sometimes fatal, consequences. For example, Dembitzer and Lai (2003) reported the case of a man displaying abdominal pain, anorexia and nausea. Abdominal scans showed that the patient had a 16-cm Mayo clamp in his abdomen which had been inadvertently forgotten during a surgery 1 year earlier. In additional work, Gawande and coworkers have demonstrated that a nontrivial amount of surgical errors arise due to failures of prospective memory and other human factors (e.g., Rogers et al., 2006). Another far too common failure of activity-based prospective memory occurs when an infant is

*Correspondence to: Gene A. Brewer, Department of Psychology, University of Georgia, Athens, GA 30602-3013, USA.
E-mail: gabrewer@uga.edu

placed in the backseat of the car by a parent who intends to take the child out after arriving at a destination. Many news reports have recently been published detailing tragic deaths of infant children due to hyperthermia (prolonged exposure to heat) from being forgotten in the backseat of the car. In addition to these extreme cases, more commonplace examples of failing to complete activity-based intentions exist such as failing to attach a document to an email after writing it. In all of these cases, failures of activity-based prospective memory seem to occur because people conceptualize their prospective memory demands in terms of the end of a task (Marsh, Hicks, & Landau, 1998). Thus, it is clear that activity-based prospective memory is an important part of day-to-day functioning and also an important area of human memory for researchers to investigate.

Activity-based intentions have been studied by only a small number of researchers; and these attempts can be summarized briefly as follows. Loftus (1971) required people to write their birth state after completing a questionnaire and performance declined with longer questionnaires as opposed to shorter ones. In these experiments, participants associated completing the intention to finishing the questionnaire. By contrast, event-based intentions may require an obligatory interruption to ongoing activities whenever an unexpected cue is noticed, but such interruptions are not planned in advance or otherwise expected as they are in activity-based tasks. Schaefer, Kozak, and Sagness (1998) examined the type of encoding processes, or ostensibly the degree of learning, of an activity-based task and surprisingly found worse memory after better learning. Such a finding contravenes established principles from the retrospective memory literature and it belies Mäntylä's (1994) idea that realization of prospective memories improves with elaboration and reprocessing, thereby increasing their retrieval sensitivity. In line with the notion of elaboration via reprocessing of intentions, Sellen et al. (1997) monitored Xerox employees' prospective memory habits by having them click an active badge anytime that they thought about completing one of two intentions for the future while at work. The clicker recorded the time and location of the clicks and provided the researchers with a great deal of valuable information about when intentions for the future are reflected upon and completed. Central to the current research, most thoughts about future intentions were reported when workers were in a place of transition (i.e., 'transitional locations' such as stairwells and corridors). This result indicates that the end of an ongoing activity can provide people with the opportunity to review their plans for the future. Of course, there have been several other studies that have mainly investigated people's ability to remember to return personal belongings at the end of an experiment (e.g., Cockburn & Smith, 1991) or write something such as the day of the week after completing one or another of some questionnaire (e.g., Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). These are essentially activity-based tasks but the inquiries were mainly concerned with whether older versus younger adults have differing levels of performance. To date, the results are mixed in this arena but may nevertheless bear on the question of whether, or to what degree, activity-based tasks require attentional resources.

As the foregoing considerations highlight, only meager amounts of information exist on both the theoretical and applied ramifications concerning activity-based intentions that we form everyday. Kvavilashvili and Ellis (1996) were perhaps the first to draw the theoretical link between activity-based and event-based intentions. They noted that the end of one task might serve as an environmental retrieval cue for the intended activity. However, they also observed that the end of one task may be a less salient cue than the typical event-based cue that often occurs in the focus of attention (but see Hicks, Cook & Marsh, 2005). We will be using this observation as the motivation for the current experiments, but before doing so we note that two related literatures do exist. In delay-execute prospective memory tasks, people are cued by a particular context (say, trivia questions in an experimental sequence) but they must withhold their response until the context has been concluded (e.g., Einstein, McDaniel, Manzi, Cochran, & Baker, 2000). Just as activity-based intentions must be maintained in some form over an intervening activity, information can be gleaned advantageously from such studies to inform the current endeavor. In addition, the small but growing task interruption literature may also provide some insights into activity-based intention completion (e.g., McDaniel, Einstein, Graham, & Rall, 2004; McDaniel, Einstein, Stout, & Morgan, 2003). For example, maintaining intentions over filled retention intervals impedes older adults as compared with younger adults; and unless they can continuously rehearse the intention over an empty interval older adults still perform more poorly. Similarly, when tasks are interrupted, one must form what is essentially an activity-based intention to restore the previous status quo of plan execution. The length of the interruption does not matter in these paradigms, but reminders greatly improve performance.

Against this backdrop, we conducted four experiments that were conceived from Kvavilashvili and Ellis's (1996) distinction between activity- and event-based prospective memory. Consequently, we directly compared the two kinds of intentions, which to our knowledge, has not hitherto been examined. The first two experiments constituted an initial critical comparison of event-based and activity-based performance controlling for extraneous influences. We also sought to understand if we could ameliorate the differences that we found. Based on these results, we altered our paradigm in the second two experiments to address the issue of cognitive load from the younger versus older adult literature, once again asking if observed differences could be reduced or eliminated.

EXPERIMENT 1

In this first experiment, our goal was to directly compare performance when people formed an activity-based versus an event-based prospective memory. The ongoing activity consisted of nine subtasks in order to allow transitions between tasks that would be necessary to test activity-based performance (see Einstein, McDaniel, Smith, & Shaw, 1998

for a similar procedure). We embedded two junctures among these tasks that should have elicited either an event-based or activity-based response (tested between-participants). The intention in both conditions required people to respond to subtasks that dealt with numbers. In the event-based task, people should respond immediately at the beginning of the subtasks involving numbers whereas in the activity-based condition they should respond after time was called on the task dealing with numbers (i.e., at the end of the task). Theoretically, if the end of a task is just as salient as the beginning of the task in terms of cueing prospective memory, the two conditions should perform equivalently. Such an outcome would suggest at a general level that activity-based performance is not much different from event-based performance. By contrast, an activity-based intention may be lost over an intervening interval pursuant to our discussion of delayed-intentions or that the end of a task may not be as salient a cue as the beginning of a task. Subsequent experiments attempted to tease apart these competing hypotheses.

Method

Participants

Volunteers were solicited from the University of Georgia in exchange for credit towards a research appreciation requirement. Each person was tested in sessions that lasted approximately 20–30 min. Based on their arrival at the laboratory, participants were assigned to either the activity-based or the event-based condition. Two participants were replaced because they did not complete the nine ongoing subtasks as originally instructed. The final sample size was $N = 30$ in each of the two conditions.

Materials and procedure

The ongoing activity was comprised of nine subtasks that we piloted with other undergraduate students participating in unrelated experiments in our laboratory. These nine tasks are listed in Appendix A. Each task lasted exactly 90 s as timed by the experimenter with a handheld stopwatch. There was a 15 s delay between each of the tasks in order to switch materials (also timed). Upon entering the experiment, participants read detailed written instructions of the nine tasks which were then verbally reiterated by the experimenter. When the experimenter was convinced that the participant understood what was required of them, a prospective memory intention was then given verbally. In the event-based task, people were asked to say *now* as soon as they arrived at the beginning of any task that involved numerical stimuli (i.e., the dice and Sudoku subtasks; see the appendix). In the activity-based condition, the intention was similar except people were asked to say *now* when time was over for a task involving numbers and they were transitioning to the next subtask. After the participants received their intention we administered a 5 min distractor task before commencing the ongoing activities that had been learned earlier.

A response was recorded by the experimenter on a score sheet and a liberal criterion was applied for correct responding insofar as participants were considered successful as long as the word was spoken within 30 s of their first opportunity to realize that a subtask dealt with numerical information.[1] The order of the nine tasks is listed in Appendix A with the exception that two task tasks associated with an intention always appeared in the fourth and eighth positions subject to counterbalancing them based on the participant's assigned number in our database.

Results and discussion

We found no ambiguity in scoring the data according to the experimenters who conducted this study. Participants had the opportunity to respond 0, 1, or 2 times to their pre-established intention. In debriefing sessions, all participants were able to restate their intention accurately to the experimenter. Participants responded 60% (SEM = 8.09) of the time to an event-based intention whereas they responded only 23% (SEM = 7.48) to an activity-based transitional intention. This large difference was statistically significant, $t(58) = 3.33$, $p < 0.01$, $d = 0.87$. Therefore, the outcome from this experiment is clear: an otherwise equivalent event-based activity may be completed more successfully than an activity-based task. To our ken, this comparison represents the first direct contrast between these two types of intentions.

Although the empirical outcomes are clear, the underlying cognitive reason for the difference is not fully elucidated by this experiment. As Kvavilashvili and Ellis (1996) have argued, the end of task may be a less salient cue than the beginning of the same task. By this account, an activity-based intention is nothing more than an event-based task with a less salient cue (for a discussion of cue salience see McDaniel & Einstein, 2000). Another possibility is that the two kinds of intentions differ with respect to holding an intention over a retention interval. The design of this experiment had participants responding 90 s later in the activity-based condition than in the event-based condition. In addition, this retention interval was filled in the activity-based condition which is known to decrease performance in some populations as compared with an unfilled interval. In the next experiment, we explored the issue of salience.

EXPERIMENT 2

Our intuition is that the short retention interval between being reminded about an intention concerning a numerical task and the opportunity to respond is not the underlying causal factor for the difference observed in Experiment 1. With an event-based task one can respond immediately, but with an activity-based intention, one must wait 90 s. The empirical and theoretical investigations regarding retention intervals with prospective memories are somewhat murky,

[1]The criterion to accept a prospective memory response (i.e., 30 seconds) was chosen arbitrarily and, although providing participants in the event-based condition with multiple numerical cues as opposed to the one task-ending cue in the activity based condition, did not reliably influence the pattern of results. Moreover, setting a stricter criterion (i.e., 10 seconds) did not exert any influence on the effects reported due to participants in the event-based condition typically saying now as soon as they turned the page to the numerical tasks.

and discrepant findings have been reported (e.g., Hicks, Marsh, & Russell, 2000). All participants formed their intention at the beginning of the experiment, but the main differences between the tasks seem to be delaying a response and the salience of the contextual cue to respond. Given the ambiguity associated with retention intervals, we focused on cue salience in this next experiment. We had participants generate exemplars for 20 categories and they had to respond to two specific category labels when they occurred (event-based) or after the time was called for the same two categories (activity-based). In addition, we made the end of the generation salient for half the participants. Thus, we orthogonally crossed salience with type of intention. Changing the paradigm also allowed us to eliminate the time difference between initial intention formation and the arrival of the relevant 'cues'.

Method

Participants

A total of 130 University of Georgia undergraduates were recruited in exchange for partial credit towards a research appreciation requirement. Sixty were assigned to two conditions that did not involve a salient ending of the category generation task (half in each of the activity vs. event-based prospective memory tasks). Seventy were assigned in the same manner with conditions that highlighted the end of generating from each category (i.e., more salient). The slightly unequal cell sizes were due to a miscommunication but the results do not hinge on this issue.

Materials and procedure

Twenty categories were chosen from the Battig and Montague (1969) category compendium. Booklets were made that had one category title per page and lines filled each page for participants to record their generated exemplars. Our cover story was that we were interested in what common examples people generated for each of the 20 categories. We strictly controlled the timing in this experiment, and the experimenter allowed exactly 30 s for generation per category. A 15 s unfilled interval was allowed between categories in order to allow participants in the activity-based conditions to get ready for the next category. Each category generation began with the experimenter saying *begin* and ended 30 s later with the spoken word *stop*. Participants were informed there would be a 15 s rest period before they could turn the page in their booklet. Written instructions for the conditions were issued at the beginning of the experiment and these were then verbally repeated by the experimenter. The instructions differed for the four conditions as follows. For those assigned to the two event-based conditions, they were asked to place a check mark by the category label when they encountered either of the categories of *fruits* or *insects*. For those assigned to the activity-based intention, they were asked to place a check mark by the last exemplar that they had generated when time was called for either of the same two categories. The manipulation of salience primarily applied to the activity-based condition but we ran the orthogonal design for scientific integrity. In the salient conditions, participants were instructed to draw a line underneath the last category member they had written when the experimenter spoke the word *stop*. They were also asked to count the number of exemplars they had generated and to write this to the left of their line. The event-based categories of fruits and insects occurred as categories 9 and 19 in the sequence whereas in the activity-based conditions they occurred as categories 8 and 18 in the entire 20 category sequence. This manipulation controls for the amount of time (i.e., retention interval) between original intention formation and the occurrence of the cues. The two prospective categories were counterbalanced but the remaining categories were presented in a fixed sequence.

Results and discussion

The results are displayed in Figure 1 with the left pair of bars depicting performance in the two event-based conditions and the right pair of bars depicting success in the two activity-based conditions. We conducted a two (form of intention) $\times$ 2 (salient vs. not) Analysis of Variance

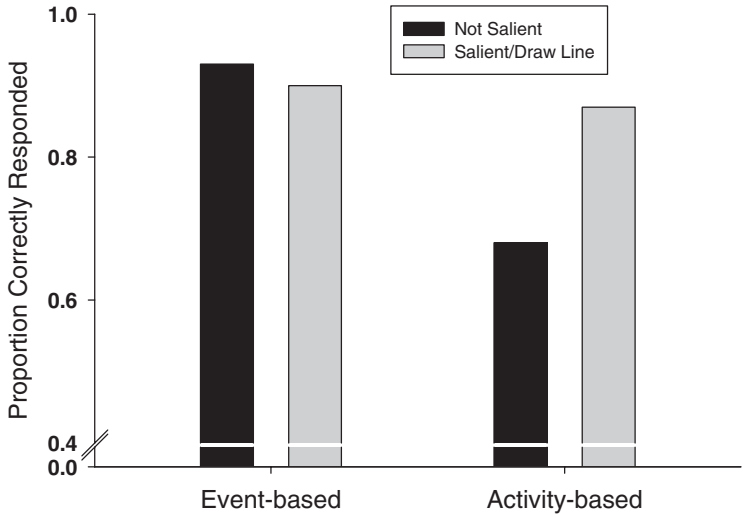

Figure 1. Proportion of participants who correctly responded in the salient and non-salient event-based and activity-based conditions in Experiment 2.

(ANOVA) which revealed a significant interaction between the two manipulated variables, $F(1, 126) = 3.94$, $MSE = 12.68$. The data in the figure clearly indicate that the salience manipulation of drawing a line had absolutely no effect on the event-based prospective memory task. This outcome makes sense because participants could respond immediately when they encountered the two relevant category labels. By contrast, the right-most two bars indicate that participants who held the activity-based intention were greatly aided by making the end of each category generation salient before moving on to the next category. There was no difference between the two salient conditions (event and activity) indicating that salient activity-based conditions more closely resemble event-based conditions when there is additional environmental support in the form of salient cues. Of course the main effects from this experiment replicated Experiment 1 insofar as activity-based intentions were performed less often, $F(1, 126) = 6.23$, but this outcome is qualified by the interaction just described.

The outcome of this experiment reaffirms that activity-based intentions are completed less frequently than event-based plans. However, the results also demonstrate that when an activity ends in a salient manner, that change can serve to better cue that a previously established intention should be completed. One important aspect of this experiment is that we controlled the retention interval from intention formation until the appropriate time to respond had arrived. This interval did not affect performance across Experiments 1 versus 2; consequently, we conclude in accord with Kvavilashvili and Ellis (1996) that the end of task may serve as a less salient cue for responding than the beginning of a new task. Ironically, these results are not completely consistent with Sellen, Louie, Harris, and Wilkins (1997) who claimed that the end of one task causes people to think about their other intentions and what activities to engage in next. The difference in the two outcomes might have a locus in the fact that finishing a task focuses attention on *future* intentions and not ones that are currently still active. This speculation awaits further scrutiny. Nevertheless, this notion does highlight the fact that attention is important to prospective memory (cf. Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Marsh & Hicks, 1998). Consequently, we decided to explore in the next two experiments the role of attention in comparing event-based versus activity-based prospective memory.

EXPERIMENT 3

Depending on the type of cue that is relevant to an intention, we know that attentional demands can reduce event-based prospective memory. For example, nonfocal cues that are nonsalient tend to go unnoticed as compared with focal ones that are salient; and this effect may be exacerbated under a cognitive load or otherwise compromised normal functioning (Einstein & McDaniel, 2005). To date, there has been no published research on whether activity-based intentions also suffer the same fate from a depletion of attentional resources. As discussed previously, there have been many applied anecdotes about failures of activity-based intentions in this regard. For example, a parent may fail to remove their child from a car seat or a surgeon may leave medical instruments inside a patient. These kinds of everyday mistakes can justifiably be called activity-based failures because a planned intention (retrieve child, remove clamp) was not carried out at the appropriate transition point between tasks. Perhaps these failures are due to attention being pulled away from the activity-based intention and towards other types of actions or intentions.

Our goal in the next two experiments was to assess whether the additional load of a different, competing intention would reduce the successful completion of an activity-based prospective goal. Consider the case of the forgotten child in the back seat of a car. From news briefs, most parents who have suffered this outcome have reported that their mind was redirected onto a different intention. Consequently, we wanted to know if we could experimentally demonstrate that having another intention would indeed reduce activity-based performance. In order to do so, we changed the ongoing task to making lexical decisions that we have used on many previous occasions. In this next experiment, people encoded the activity-based intention but we later stopped them partially through the lexical decision task and gave them an additional event-based task. Given the foregoing, the goal was to ascertain whether this additional load affected their success as compared with a comparable condition that did not have this additional event-based intention. If activity-based prospective memory, albeit worse in general than an event-based task, is immune from attentional depletion, then no differences should be observed between the two conditions. However, if anecdote and theory together suggest that such sensitivity exists, then we should be able to observe the first recorded decrement from attentional load in such a direct comparison.

Method

Participants

Sixty students from the University of Georgia volunteered in exchange for partial fulfilment of research appreciation requirement. They were randomly assigned to the two conditions depending on their arrival at the laboratory. An equal number of participants ($N = 30$) were tested in each condition.

Materials and procedure

Rather than discrete tasks as used in the previous two experiments, we used a single ongoing task in which lexical judgments had to be made concerning whether a letter string was a word or a nonword. We have used this task frequently in our studies examining event-based prospective memory (e.g., Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Marsh, Hicks, & Watson, 2002). The entire sequence was comprised of 136 trials, and half of these were valid English words and half were nonwords that were formed by replacing 1 or 2 consonants to yield a pronounceable nonword. Participants were instructed to press either one of two keys to make their judgment, and they were asked to respond as quickly but accurately as they could. After these instructions were understood and verbally reiterated by the experimenter, all

participants were instructed to say *now* when the entire experiment was over (i.e., the activity-based intention). People were warned that they would also be stopped partially through the experiment and that this was not the end of the experiment. All participants performed the lexical decision task for 40 trials. At this juncture, the computer stopped and a message appeared that they were to receive more instructions from the experimenter. In the control condition, the experimenter merely asked people to take a break before continuing on with a longer sequence of the same judgments. In the dual-intention condition, they were instructed that we were also interested in whether they could detect words containing the syllable *tor* such as in the word *motor*. The response was recorded by a/-key press. This event-based prospective memory task is a hallmark nonfocal task that ostensibly requires cue-focused processes that demand some attentional resources (Einstein & McDaniel, 2005). The time to deliver the rest/break versus event-based instructions in the two different conditions was equated by the experimenter with a handheld stopwatch. Participants in the dual-intention condition encountered words with a *tor* syllable four times over the succeeding 96 trials. In all other respects the two conditions were treated identically.

Results and discussion

The fundamental question of interest was whether adding an additional (event-based) intention ultimately affected activity-based remembering to say *now* at the conclusion of the lexical decision task. Indeed, those people in the control condition remembered to do so 90% of time (SEM = 5.60) whereas those who held the additional event-based intention did so only 57% of the time (SEM = 9.20). This difference is statistically significant, $t(58) = 3.10$, $p < 0.01$, $d = 0.81$. The implication of this outcome is that having additional intentions, or being under an additional cognitive load, can reduce activity-based prospective memory. There are a number of ways to operationalize being under load that have emanated from the event-based literature, but we reassure the reader that all of these measures are indicative that this was the case (see Einstein, McDaniel, Thomas, Mayfield, Shank, Morrisette, & Breneiser, 2005). To assuage concern in this regard, we note that the average lexical decision times were 715.10 msec (SEM = 23.74) in the control condition whereas they were 844.71 msec (SEM = 34.46) in the dual intention condition over the final 96 trials; and this difference is statistically significant, $t(58) = 3.09$, $p < 0.01$, $d = 0.81$.

The results from this experiment confirm both anecdote and theory. Concerning the former, parents or surgeons who have formed the intention to perform an activity at the conclusion of an ongoing activity can get distracted by competing demands and other intentions. If these demands are consequential then they have the potential to interfere with the ultimate completion of the original activity-based intention. Theoretically, we argue that the end of a task may not be a particularly strong cue to accomplishing a pre-established intention. We discovered in Experiment 2 that making the end of a task salient had the effect of improving activity-based prospective memory. Clearly, further work is needed to understand the exact attentional demands that will or will not affect activity-based performance, but we sought to understand in a final experiment whether we could ameliorate activity-based performance with a common, everyday variable as described next.

EXPERIMENT 4

The preceding three experiments suggest that activity-based intentions are more fragile or prone to disruption as compared with event-based intentions. However, there are probably variables in our environment that lead people to form intentions in this manner because past successes indicate that this form of memory can be efficacious. One of these variables is practice. If one has learned to perform the activity-based intention at critical junctures in a variety of different circumstances, then an additional cognitive load may not have the same deleterious consequences that were observed in the previous experiment. Using the analogy of retrieving a child from a car seat, if one has to check on the infant at every juncture along a multi-stage shopping trip and/or on the way to work, then one has had ample practice with the activity-based intention. Perhaps this practice raises the importance of the intention, or raises its activation level in memory (cf. Kleigel et al., 2004; Marsh & Hicks, 1998). The underlying cognitive mechanism may be unclear, but we wanted to know if this variable would nonetheless mitigate the losses in performance observed in the previous experiment.

To these ends, we used a variant on the lexical decision task that divided the entire experiment into three phases (see Marsh, Hicks, & Cook, 2006). The first and third phases were performing lexical decisions and the interceding second phase was a short demographic questionnaire. The experiment consisted of two conditions, both of which were instructed to respond *now* after the third and final phase of the experiment. Moreover, both conditions were given the dual task instruction to respond to words containing the *tor* syllable; and in both conditions this instruction occurred in between the second and third phases of the experiment. The important manipulation concerned an additional instruction. In the practice condition, we asked people to say now to the experimenter at every juncture or change of activities in the experiment. Thus, as compared with the control condition, these participants had the opportunity to practice or solidify their activity-based intention at least twice (after the first and second phases) in much the same way that Mäntylä (1994) has argued would increase retrieval sensitivity of an intention.

Method

Participants

University of Georgia undergraduates were recruited and rewarded in the same fashion as described for the previous experiments. Seventy people were tested and they were assigned to the control and practice conditions until an equal number was tested in each condition ($N = 35$).

Materials and procedure

The materials were essentially the same as those used in Experiment 3 except that more words and nonwords were

drawn from the pool used by Marsh et al. (2003; see also Marsh et al., 2006). The experiment was comprised of a 105 trial lexical decision task, followed by a 1 min questionnaire, and then an additional 105 lexical decisions. At the outset of the experiment, participants were informed of the three-sequence nature of the experiment and they were informed that upon conclusion of the third phase that they should say *now* to the experimenter. When these instructions had been verbally reinforced, the experimenter informed participants that an additional task would be added in the course of the experiment. In the control condition, people were given a 4 min distractor task before the first lexical decision stage was commenced. In the practice condition, the experimenter informed people that the additional task was also to say *now* at the end of each of the three distinct phases of the experiment (i.e., not just at the end of the third phase). Participants in this group also were given a distractor task before commencing the first phase lexical decision task but the distractor was reduced by 30 s to account for the additional instruction. Therefore, all participants understood the three phases of the paradigm, and they understood the activity-based intention of responding after the third phase. The only difference was that the practice condition had two additional opportunities to say *now* before the critical comparison.

To provide an important touchstone to Experiment 3, we also overlayed an event-based intention during the third phase. Once they had completed the 1 min demographic questionnaire, we asked people in both conditions to respond to words containing the syllable *tor* with a/-key response. Our instructions did not obviate the need to complete the activity-based intention (i.e., they began: *In addition to your other tasks. . .*) and it was clear that they should perform both intentions. There was a short retention interval before the third and final phase of the lexical decision task was commenced. In all other respects, the two conditions were treated identically.

Results and discussion

The important comparison concerns whether there was a difference between the no-practice control condition and the condition who had the opportunity to exercise the activity-based intention twice previously (after phases 1 and 2). Although not central to the current analysis, we report here the proportion of participants who said *now* after the first ($M = 89\%$) and second ($M = 53\%$) phases of the experiment. The difference in responding between the first and second phases may be due to participants associating their intention to lexical decision task, but this result awaits further scrutiny. Those who had practice responded accurately 91% (SEM = 4.80) of the time whereas those without the continual intention were successful only 69% (SEM = 8.0) at the end of phase 3. The difference between activity-based completion with and without an event-based intention overlayed upon it was reliable, $t(58) = 2.46$, $p < 0.05$, $d = 0.60$. A 22% difference in responding is hard to ignore and it strongly suggests that previous experience with an activity-based task influences performance when attention is distracted. More specifically, the parent who has the child in the back seat would be more likely to remember to retrieve the infant if he or she had to perform this activity on multiple and other varied occasions. The odd deviation of a parent not accustomed to taking a child to day care in his or her normal routine might make him or her more likely to forget this particular activity-based intention. In all other aspects of standard event-based tasks this experiment conforms to the outcomes that have been reported consistently in the arena of prospective memory. Additionally, the practice condition resulted in slower reaction times ($M = 835.64$) for the third phase than the no practice condition ($M = 785.31$), $t(58) = 4.48$, $p < 0.01$, $d = 1.09$. As McDaniel et al. (2004) suggest, participants were sensitive to the task requirements and were allocating their attention accordingly. We turn now to considering how these four experiments collectively inform us about the distinction between event-based and activity-based prospective memory.

GENERAL DISCUSSION

Collectively, the experiments in this study depict a consistent theme about the comparison between activity-based and event-based prospective memory. The general finding was that activity-based performance was worse than the forms of event-based prospective tasks that we tested here. In this sense, we conclude that intentions associated with transitions between tasks may go unfilled more often than intentions associated with more specific environmental cues when encoding conditions are matched. Earlier we noted that a transition between tasks could be considered as an event-based cue; and we tested variables known to affect event-based prospective memory that might have also changed activity-based remembering. We demonstrated that initially an activity-based intention was fulfilled less often than an event-based intention (Experiment 1) but that salience of the change in activities could dramatically decrease any differences between the two types of intentions (Experiment 2). Thus, salience increases remembering for both kinds of intentions and introducing a cognitive load decreases remembering for both types of intentions (Experiment 3). Moreover, practice with responding during activity changes also reduced these observed differences (Experiment 4). We do not wish to equate activity-based intentions with event-based intentions, but the two kinds of prospective memory seem amenable to the same variables, at least as tested here. In the current study, our distinction between activity- and event-based intentions revolves around the type of information the cognitive system is using to complete intentions. This view suggests that there should be much in common between activity- and event-based prospective memories but that there should also be important differences.

Both sorts of intentions require people to store in memory that an environmental event (cue vs. task change) will signal an appropriate time to fulfil the goal of responding. One possibility is that the salience of the cue is responsible for an activity-based intention appearing more fragile than an event-based task. A change in activities may involve offloading a current production rule in favour of loading a new one (Marsh, Hancock, & Hicks, 2002; McNerney &

West, 2007). By contrast, the current production rules in working memory do not change with an event-based intention. In this sense, cognitive changes between tasks may work against detecting that one should perform one task after finishing another (Rabbit, 1996). Ironically, this line of argumentation does not neatly mesh with theories proffered by Sellen et al. (1997). They argued quite cogently that people reflect on uncompleted intentions after completing one task and during downtime before commencing their next activity. If this were true, then activity-based performance might be expected to be much better than we observed empirically across the current experiments. One possible reconciliation with this theory is that participants might be reflecting on *future* intentions and not on goals that are more backward looking. Admittedly, this conjecture requires further scrutiny but the two sets of data sorely need to be reconciled with one another.

Another fundamental difference between the two types of intentions concerns an inherent context-linking component. By this we mean that an activity-based intention can be linked to a distal context at intention formation whereas an event-based intention is linked to the current, ongoing context. Very little work has examined the role that context plays in prospective memory and the work that has been done only begins to specify at rudimentary levels how context supports prospective memory (see Marsh et al., 2007; Marsh et al., 2006). We know that with event-based intentions, a goal linked to a distal context provides no interference at all until that context is reached. The implication here is that the intention is 'out of mind' and not receiving sustained activation during the intervening interval. To the extent that activity-based intentions are indeed context linked, the lack of sustained activation over the intervening context could theoretically explain the poorer performance as compared to an event-based intention that is refreshed or rehearsed during the same period of time. The level of activation of these two different kinds of intentions is hard to compare directly, but with additional work then perhaps comparable measures could be developed.

We specifically chose the event-based tasks in these experiments to be *nonfocal* ones (Einstein & McDaniel, 2005; Einstein et al., 2005). By this, the field has indicated that cue-focused resources would be required to detect these cues; and we did so specifically to provide the fairest comparison to activity-based intentions that we initially deemed to be nonfocal in nature. By contrast, we chose not to test extensively *focal* cues which are likely to draw an intention to mind spontaneously (and obligatorily) when they occur. Some of the variables that make an event-based cue a focal one include its discrepancy from the background information, its perceptual or semantic salience, and cognitive processing in the ongoing task that focuses people on the relevant features of the cue (McDaniel et al., 2004; Einstein et al., 2005). None of these variables appear to be particularly operative when one forms an activity-based intention, and this observation may account for why such intentions are completed less frequently without appropriate environmental support which was operationalized here as salience and practice at executing the intention.

One implication of these results is that, when activity-based intentions are associated with ending of a task (e.g., removing a surgical clamp after the last procedure), perhaps they should be associated with beginning the next task (e.g., removing a surgical clamp before closing the incision). This difference in encoding strategies should lead to higher levels of prospective memory fulfillment because the ending of a task will most likely be less specified than the beginning of a subsequent task. Based on this line of reasoning, the most apparent difference between activity- and event-based intentions seems to be found in the degree of environmental support for completing them. In future investigations, prospective memory researchers should investigate activity-based intentions in different populations (e.g., surgeons, air-traffic controllers, older adults, etc.) to further elaborate on our understanding of prospective memory in naturalistic settings. These investigations will undoubtedly shed light on the theoretical mechanisms underlying activity-based intentions and suggest interventions for situations where prospective memory failures have the most severe consequences.

Theoretically, we do believe that the conclusion of one task and the commencement of another task is a form of an environmental event that can effectively serve to remind a person that a goal can be accomplished at that moment. However, we also believe that the characteristics of that intention as established at encoding are different from those associated with specific events, albeit even nonfocal events. The main differences appear to include the role of associating the intention with a distal context, a degree of uncertainty when the context will change, a cognitive agenda that is in a stage of transition from one task to another (versus not), and the initial specificity of the intention as established at encoding. We acknowledge that this is not a complete list of variables that might be operative, but it is a strong foray into understanding what is an otherwise understudied form of prospective memory. Specifically, the nature of a prospective memory is fundamentally related to the characteristics which people associate their future behaviours. Our goal in the current study was to compare and contrast activity-based performance with event-based goal completion. As the field progresses, the three basic forms of intentions must be drawn into a larger theoretical framework; and this work is a first attempt to do so.

ACKNOWLEDGEMENTS

Gene A. Brewer, Richard L. Marsh, Arlo Clark-Foos, J. Thadeus Meeks, Department of Psychology, University of Georgia; Gabriel I. Cook, Department of Psychology, Claremont McKenna College; Jason L. Hicks, Department of Psychology, Louisiana State University.

We wish to thank Alex Diaz, Ariel Wilson, and Michael Hopkins for their dedicated help in collecting and scoring the data from these experiments.

REFERENCES

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monographs, 80(3, Pt. 2)*, 1–46.

Cockburn, J., & Smith, P. T. (1991). The relative influence of intelligence and age on everyday memory. *Journal of Gerontology: Psychological Sciences*, *46*, 31–36.

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. Klix, & H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performance* (pp. 409–422). New York: Elsevier Science.

Dembitzer, A., & Lai, E. J. (2003). Retained surgical instrument. *New England Journal of Medicine*, *348*, 228.

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

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

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*, *14*, 286–290.

Einstein, G. O., McDaniel, M. A., Manzi, M., Cochran, B., & Baker, M. (2000). Prospective memory and aging: Forgetting intentions over short delays. *Psychology and Aging*, *15*, 671–683.

Einstein, G. O., McDaniel, M. A., Smith, R. E., & Shaw, P. (1998). Habitual prospective memory and aging: Remembering intentions and forgetting actions. *Psychological Science*, *9*, 284–289.

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

Hicks, J. L., Cook, G. I., & Marsh, R. L. (2005). Detecting event-based prospective memory occurring within and outside the focus of attention. *American Journal of Psychology*, *118*, 1–11.

Hicks, J. L., Marsh, R. L., & Cook, G. I. (2005). Task interference in time-based, event-based, and dual intention prospective memory conditions. *Journal of Memory & Language*, *53*, 430–444.

Hicks, J. L., Marsh, R. L., & Russell, E. J. (2000). The properties of retention intervals and their affect on retaining prospective memories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 1160–1169.

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (1997). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition*, *4*, 93–112.

Kvavilashvili, L., & Ellis, J. (1996). Varieties of intentions: Some distinctions and classifications. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 23–52). Mahwah, NJ: Erlbaum.

Loftus, E. F. (1971). Memory for intentions: The effect of presence of a cue and interpolated activity. *Psychonomic Science*, *23*, 315–316.

Mäntylä, T. (1994). Remembering to remember: Adult age differences in prospective memory. *Journal of Gerontology*, *49*, 276–282.

Marsh, R. L., Hancock, T. W., & Hicks, J. L. (2002). The demands of an ongoing activity influence the success of event-based prospective memory. *Psychonomic Bulletin & Review*, *9*, 604–610.

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

Marsh, R. L., Hicks, J. L., & Watson, V. (2002). The dynamics of intention retrieval and coordination of action in event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *28*, 652–659.

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

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2006). Task interference from prospective memories covaries with contextual associations of fulfilling them. *Memory & Cognition*, *34*, 1037–1045.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2007). On beginning to understand the role of context in prospective memory. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective Memory: Cognitive, Neuroscience, Developmental, and Applied Perspectives* (pp. 77–100). Mahwah, NJ: Erlbaum.

Marsh, R. L., Hicks, J. L., Cook, G. I., Hansen, J. S., & Pallos, A. L. (2003). Interference to ongoing activities covaries with the characteristics of an event-based intention. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *29*, 861–870.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, *14*, 127–144.

McDaniel, M. A., Einstein, G. O., Graham, T., & Rall, E. (2004). Delaying execution of intentions: Overcoming the costs of interruptions. *Applied Cognitive Psychology*, *18*, 533–547.

McDaniel, M. A., Einstein, G. O., Stout, A. C., & Morgan, Z. (2003). Aging and maintaining intentions over delays: Do it or lose it. *Psychology and Aging*, *18*, 823–835.

McNerney, M. W., & West, R. (2007). An imperfect relationship between prospective memory and the prospective interference effect. *Memory and Cognition*, *35*, 275–282.

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

Rabbit, P. (1996). Commentary: Why are studies of 'prospective memory' planless?. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 239–248). Mahwah, NJ: Erlbaum.

Rogers, S. O., Gawande, A. A., Kwaan, M., Puopolo, A. L., Yoon, C., Brennan, T. A., et al. (2006). Analysis of surgical errors in closed malpractice claims at 4 liability insurers. *Surgery*, *140*, 25–33.

Schaefer, E. G., Kozak, M. V., & Sagness, K. (1998). The role of enactment in prospective remembering. *Memory & Cognition*, *26*, 644–650.

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

APPENDIX A:

Tasks used in Experiment 1

1. Hidden figures
2. Rubik's cube
3. Reading a NYT article
4. **Solving Sudoku puzzles**
5. Answering synonym questions
6. Solving Anagrams
7. Finding hidden words
8. **Rolling dice and adding/dividing numbers**
9. Stacking poker chips by color

Note: Tasks 4 and 8 (that are in bold print) involve numbers and they were the tasks associated with an intention. These two tasks were counterbalanced.