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Journal of Memory and Language 53 (2005) 430–444
Journal of Memory and Language
www.elsevier.com/locate/jml

Task interference in time-based, event-based, and dual intention prospective memory conditions ☆

Jason L. Hicks [a], Richard L. Marsh [b,*], Gabriel I. Cook [b]

[a] Department of Psychology, Louisiana State University, USA
[b] Department of Psychology, University of Georgia, Athens, GA 30602-3013, USA

Received 2 December 2004; revision received 4 April 2005
Available online 1 June 2005

Abstract

Forming the intention to complete an activity later is the standard definition of a prospective memory task. Recently, a debate has arisen concerning the degree to which near-term intentions usurp resources away from other ongoing activities. In four experiments the authors tested how much interference was caused by holding a variety of different intentions. In all but one case, possessing an intention to perform an activity later resulted in slowed decision latencies to a different, ongoing activity. Intentions that were well-specified interfered less than intentions that were more ill-specified. In dual intention conditions, evidence for subadditivity of interference was obtained, although not uniformly. In considering potential mechanisms that cause this interference, the explanation favored here is that people establish resource allocation policies based on their predictions of being able to successfully complete both the ongoing and prospective memory tasks.

Keywords: Prospective memory; Intentions; Task interference

Perhaps dating as far back to Aristotle's treatise *On Memory and Reminiscence*, the primary function of memory is often cited to be reminiscence. However, memory actually subserves a multitude of daily human activities such as comprehending or producing language, preparing a meal, or appreciating the aesthetics of an evening at the theater. Among these many, often overlooked functions of memory, one is to record activities and plans that cannot be carried out immediately. This particular use of memory has been labeled prospective memory because hypothetical actions are recorded that will (hopefully) take place in some future spatiotemporal context that is frequently different from the context in which the intention is formed. Later, when an appropriate opportunity arises such as sufficient time, adequate funds, appropriate objects, or the correct people are present to complete a task; recollection of the previously stored intention allows it to be fulfilled. Therefore, other than spontaneous decisions about action such as retrieving a piece of fruit from the refrigerator because one is hungry, memory is integral to completing the vast majority of activities in which humans engage. From this perspective, there are important theoretical and applied ramifications for understanding how prospective memory operates and for delineating the cognitive

☆ We thank Benjamin Martin, Eric Grissino, Chris Burns, Sarah Perpich, and Gene Brewer for their invaluable assistance in collecting the data.
* Corresponding author. Fax: +1 706 542 3275.
E-mail addresses: jhicks@lsu.edu (J.L. Hicks), rlmarsh@uga.edu (R.L. Marsh).

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doi:10.1016/j.jml.2005.04.001

processing that supports it. The present study was conducted to seek some clarification about the degree to which possessing near-term intentions can interfere with other ongoing activities.

Before describing the theoretical motivations for this study, a brief synopsis of laboratory-based experiments on prospective study is provided. Although many types of intentions exist, event-based and time-based intentions have proven to be the most amenable to laboratory control. Therefore, most studies use one or both of these types of intentions. In event-based tasks, participants are busily engaged in an ongoing task such as making word or picture ratings, reading, answering questions, making lexical decisions, or taking a video tour of a town. When an intention-related cue appears (e.g., a face, word, concept, or category of items), participants must make some overt, recordable response to indicate that they have remembered the intention (Brunfaut, Vanoverberghe, & d'Ydewalle, 2000; Einstein, Holland, McDaniel, & Guynn, 1992; Ellis, Kvavilashvili, & Milne, 1999; Maylor, 1996, 1998; McDaniel, Robinson-Riegler, & Einstein, 1998). Therefore, event-based prospective memory tasks are characterized by the rememberer identifying a cue in the environment that reminds them to fulfill an intention. In contrast, time-based intentions must be completed after some duration has elapsed, such as remembering to perform an action after 8 min or at a specific clock time (Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). Within time-based tasks, the distinction has been drawn between intentions that must be carried out at a specific time (called pulse intentions) versus those that can be completed within a window of time (called step intentions, see Ellis, 1988). For reasons that are not entirely clear, the vast majority of research has investigated event-based prospective memory whereas only a handful of articles have appeared on time-based prospective memory.

As it relates to event-based intentions, one issue that has arisen recently in this literature concerns whether detecting a cue requires processing resources or can be done relatively automatically. According to the multiprocess view theory, cue detection will be automatic when one or more of the following conditions are met: when the cue and the to-be-performed target action are highly associated, when the cue is salient, and when the ongoing processing focuses attention on the relevant features of the cue (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004). Otherwise, cue detection can require significant processing resources. By contrast, the preparatory attention and memory (PAM) model argues that even under those conditions where cue detection should be automatic according to the multiprocess view, possessing an intention creates a processing cost manifested in the ongoing activity itself (Smith, 2003; Smith & Bayen, 2004). More specifically, Smith (2003) found that lexical decisions as an ongoing task were slowed when participants possessed an event-based intention relative to not having an intention. Although Einstein et al. (in press) prefers the term *monitoring* for the slowed latencies, we advocate calling this effect *task interference* because this label is neutral on the cognitive mechanisms that give rise to it (Marsh, Hicks, & Cook, 2005; Marsh, Hicks, Cook, Hansen, & Pallos, 2003). Regardless of its label, the PAM theory argues that fulfilling event-based intentions always requires significant and measurable capacity.

The present study was not designed to adjudicate between the PAM and multiprocess theories because we have obtained significant task interference with some event-based intentions and not with other event-based intentions (Marsh et al., 2003). Rather, the opposing views highlight the fact that insufficient empirical evidence currently exists to disambiguate between the two theoretical positions. The lack of empirical evidence concerning task interference also makes it difficult to specify with any confidence the underlying cognitive mechanisms that give rise to it when it does occur, or to provide a complementary rationale for when it does not occur. Therefore, the approach taken in this study was to assess task interference effects with a vastly expanded set of intentions than has hitherto been explored. Not only did we test event-based intentions which are the only ones known to date to produce interference, but we also tested time-based intentions and situations in which participants held both types of intentions simultaneously. In all cases, the primary interest concerned how latencies to the ongoing task were affected by possessing these different kinds of intentions.[1]

The data from the present study will allow us to speculate in General discussion on the opposing points made by PAM versus the multiprocess views, as well as offer some specific hypotheses about what cognitive mechanisms give rise to task interference when it occurs. The reader will note that we have conspicuously refrained from speculating on the theoretical mechanisms until General discussion. However, in the remainder of this introductory section, we use the existing theoretical frameworks in the prospective memory literature to

[1] Our focus in this article is on task interference. However, the reader should not construe this to mean that we are stating that performing well on an ongoing task is necessarily antagonistic to finding event-based cues. As Maylor (1996) pointed out, when the ongoing activity focuses a person on the correct features of an event-based cue, prospective memory is better than when it does not (also see Marsh, Hicks, & Hancock, 2000). Recently, we have shown this effect (dubbed task appropriate processing by Maylor) actually requires cognitive capacity (Marsh et al., 2005).

highlight the potential importance of directly comparing task interference in time-based versus event-based tasks.

Task interference as manifested in slower ongoing task latencies can indicate that resources were devoted to the prospective memory task that otherwise would have been allocated to the ongoing task. Advocates of either the PAM theory or the multiprocess view theory would agree on that basic point. What appear to be debated are the conditions under which this occurs. Time-based intentions have been claimed to require more self-initiated processing than event-based tasks (Craik, 1986; Einstein et al., 1995). If this is true, then task interference should be greater when participants possess a time-based intention as compared with an event-based intention. There are at least three findings that converge on this prediction. First, age differences have been found in a time-based task when participants were asked to respond either every 10 min (Einstein et al., 1995) or every 2 min (Park et al., 1997). Moreover, the effect of age on event-based tasks was smaller (or absent) in both of these studies. If deficits in self-initiated processing occur in aging because of compromised resources, these results suggest that time-based tasks require more processing resources. Second, when participants were asked to record self-initiated reminders about event-based and time-based intentions by pressing electronic badges that they were wearing, more thoughts occurred about time-based intentions than event-based ones (Sellen, Louie, Harris, & Wilkins, 1997). This finding suggests that time-based intentions come to mind more, and therefore, are more intrusive of the demands on an ongoing task. Third, directly manipulating the importance of the prospective memory task can affect time-based intentions more than event-based intentions which suggests that they require (or benefit more from) strategic allocations of attention (Kliegel, Martin, McDaniel, & Einstein, 2001; Kliegel, Martin, McDaniel, & Einstein, 2004).

Thus, the prevailing view of time-based prospective memory clearly predicts that more task interference in the form of slower latencies to the ongoing task should be obtained when participants possess a time-based intention as compared with an event-based intention (but see Park et al., 1997). However, our analysis of potential differences in the two types of prospective memory tasks led us to consider the following alternative prediction. Event-based cues are always embedded in the ongoing tasks in order to fulfill the requirement that participants be busily engaged in an activity simulating the demands of everyday life when a cue occurs. Task interference could represent a natural tradeoff of the attentional allocation policy of processing the same set of stimuli for two different purposes (to make the ongoing task judgment and to fulfill the intention). The same is not true when participants possess a time-based intention. In this case, the stimuli only need to be processed to make an ongoing task response. If the locus of the task interference that has been observed to date is a function of processing the stimuli for dual purposes, task interference could be absent with a time-based intention. On the other hand, if both time-based and event-based intentions result in task interference, a parsimonious account concerning the locus of the effect on the ongoing task cannot be linked to processing the stimuli. Rather, task interference must be mediated at some other, perhaps more central level. As mentioned before, we hold in abeyance any further speculation on why possessing an intention may cause task interference until the results from all four experiments have been reported.

Experiment 1

Three conditions were tested in this first experiment. One condition was given the intention to respond to words denoting an animal (e.g., *tiger*). Another condition was asked to respond after 4 and 8 min had elapsed in the ongoing task. To assess the amount of task interference that was caused by possessing these event-based category and time-based pulse intentions, respectively, a no intention control condition performed only the ongoing task. As just mentioned, the prevailing theories of prospective memory predict that more task interference should be obtained with the time-based as compared with the event-based intention (but see Park et al., 1997). Any other outcome (equal interference or less interference) could call into question whether time-based intentions are really more resource demanding.

Method

Participants

Undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a course research requirement. Each participant was tested individually in sessions that lasted approximately 30 min. Based on their arrival time at the laboratory, 105 participants were randomly assigned to one of the three between-subjects conditions (with $N = 35$ in each condition).

Materials and procedure

As in many prospective memory experiments where we have been concerned mainly with reaction times, the ongoing task was making lexical decisions. To accommodate both the time-based and event-based intentions, the details of this task had to be changed slightly from previous instantiations reported from our laboratory (Marsh et al., 2003; Marsh, Hicks, & Watson, 2002). There were 210 trials, with equal numbers of valid English words and pronounceable nonwords.

The 105 valid words were chosen from the Kučera and Francis (1967) corpus. Nonwords were constructed by taking 105 different words and replacing one or two letters (e.g., *wook*). Assignment of words and nonwords to trials was randomized anew by the software each time a participant was tested. Only two event-based cues appeared in the 210 trial sequence, and these occurred on trials numbered 80 and 160. The cues were *dog* and *horse* in this experiment. These cues occurred in all three conditions, but participants in the time-based and control conditions were not informed of their special relevance.

Each trial in the lexical decision task was fixed at 3 s to ensure that the time-based intention to respond at 4 min and again at 8 min exactly corresponded to trials 80 and 160 when the animal words appeared. Each trial commenced with a warning tone and fixation point for 250 ms followed by the letter string to be judged. As soon as a word or nonword response was made with one of the two home keys, the screen went blank and participants waited for some variable amount of time until 3 s had elapsed from the appearance of the fixation point. The software calculated this intertrial interval by subtracting the response time on that trial (plus 250 ms for fixation) from 3 s in order to preserve the exact temporal sequence of events. The succeeding trial commenced automatically with the next fixation point, and so forth through the entire experimental sequence. We chose to keep the fixation duration constant and the blank interval as variable because had the fixation point been made variable then participants would not be able to anticipate the onset of each letter string. We believe that doing so would add unnecessary variability in response latencies and chose the current approach to maximize finding differences in the conditions of interest.

After learning what was required to perform the lexical decision task, participants in the two prospective memory conditions were told that we were also interested in their memory to perform an action in the future. In the event-based condition, participants were asked to press the / key whenever they encountered a word denoting an animal. The nontested example *monkey* was given. Participants were told to press the / key during the blank interval after making their word response (after Marsh et al., 2002). In the time-based condition, participants were asked to press the / key after 4 min had elapsed in the ongoing task, and to do so again after another 4 min had elapsed (i.e., 8 min total). They were informed that the clock would begin at the moment the fixation point appeared for the first trial, and that they could check the computer's clock at any time by pressing the Z key. Doing so brought up a small clock of the form 6:20 in the upper right-hand corner of the monitor which, in this example, would indicate that 6 min and 20 s had elapsed. The clock appeared for 1 s and then disappeared automatically. The software recorded all key presses. To avoid any external reminders, the / and Z keys were not specially labeled and all participants in all conditions were asked to remove from their person all external time keeping devices such as watches and cellular phones.

Participants initially read all of the instructions relevant to their assigned condition from the computer monitor. After doing so, the monitor was cleared and the experimenter reiterated all of the instructions again, and answered any questions. Participants in the two prospective memory conditions were then given a 5 min paper and pencil distractor activity to avoid the prospective memory task becoming a vigilance task. This task was timed with a stopwatch; and at the appropriate time the experimenter initiated the lexical decision task without any mention of the prospective memory task.

Results and discussion

Unless otherwise specified with a p value, the probability of a Type I error does not exceed 5% in any statistical analysis in this article. We begin by dispensing with several data analytic issues. First, the primary dependent variable in all experiments is the average reaction time to words in the lexical decision task, excluding trials that contained an event-based cue. For a variety of reasons, task interference effects are only obtained consistently on words and only intermittently on nonwords which have much longer and more variable latencies anyway.[2] Nevertheless, latencies for both words and nonwords are reported in the table of results, but analysis has been confined to words. Second, errors in lexical decision tasks are infrequent, and we have never found errors to significantly vary across tasks and conditions in a prospective memory experiment (cf., Marsh et al., 2003; Smith, 2003). The same was true of the experiments in this study; and consequently, we have streamlined the results by omitting the accuracy data which is uninformative to the issues at hand. Nonetheless, average latencies do not include the small number of trials on which errors were made (2.4%).

[2] All other factors being equal, the reader might assume that nonword latencies would show some evidence of monitoring just like the words in a lexical decision task. One problem in making this prediction is that nonword/negative decisions in a lexical decision task may be a function of extra cognitive processes using extralexical information (e.g., Grainger & Jacobs, 1996). These extralexical processes are a function of task demands, speed accuracy tradeoffs, metacognitive variables, and a host of other factors that we did not attempt to control in this study. Although interesting predictions can be made about the appearance or absence of monitoring effects on nonwords, we will not be considering this issue further because our main interest in this article is in controlling for monitoring differences rather than studying characteristics of this process.

Third, as we have found before, trimming outlying responses at 2.5 standard deviations beyond a participant's grand mean changes neither the pattern of results nor statistical significance, but the data have been so trimmed (see Marsh et al., 2002). Fourth, late responses in the event-based condition were rare (1.6%), and including them does not alter the results in any experiment in this article. To be consistent with our previous reports, late responses were counted as incorrect (i.e., misses). Fifth, in the time-based condition, how close to the 4 and 8 min times a response had to be made for it to count as correct did not significantly affect performance, in part, because performance was quite good. A variety of windows around these two times were examined, and we settled arbitrarily on a 20 s window centered on the 4 and 8 min times to respond. Sixth, data from our laboratory suggest that after a time-based intention is completed, task interference gradually dissipates (see Marsh, Hicks, & Cook, submitted). Consequently, latencies after trial 175 were not included from any condition in this experiment. Finally, the issue that task interference from time-based based intentions might only be observed in the 10 or 15 trials prior to the response window was raised during the review process. We analyzed the data in this and the three subsequent experiments and found that average latencies just prior to a time-based response were the same as latencies after, say, the first time-based response. We even took this sort of analysis one step further by examining the 10 latencies preceding and following the actual time-based response, and still these latencies did not differ. Thus, the task interference effects that we will report for time-based intentions appear to be stable across the ongoing task.

The data are summarized in Table 1. The first two columns report the average proportion of times that the event-based and time-based intention was successfully fulfilled, respectively. The remaining two columns report the average latency to identify correctly words and nonwords, respectively. In this experiment, participants more often remembered to fulfill their time-based intention than their event-based intention, $t(68) = 2.80$, $SEM = .07$. Einstein et al. (1995) found the opposite effect with younger adults, but their event-based task was to respond to a single event-based cue (the word *president*) and it occurred six times in the ongoing task. In

Table 1
Average prospective memory performance and average latency to respond to the ongoing task as a function of types of intention in Experiments 1–4

Experiment and condition	Prospective memory				Latencies			
	Event-based		Time-based		Words		Nonwords	
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Experiment 1								
No intention control	—	—	—	—	619	(17)	814	(38)
Event-based category	.69	(.06)	—	—	696	(20)	844	(34)
Time-based pulse	—	—	.89	(.04)	672	(13)	816	(27)
Experiment 2								
No intention control	—	—	—	—	625	(15)	811	(39)
Well-specified								
Event-based specific	.76	(.06)	—	—	630	(16)	778	(28)
Time-based pulse	—	—	.93	(.04)	668	(15)	827	(33)
Ill-specified								
Event-based category	.71	(.06)	—	—	686	(18)	817	(27)
Time-based step	—	—	.97	(.03)	695	(16)	829	(33)
Experiment 3								
Event-based specific								
With time-based pulse	.71	(.07)	.90	(.04)	678	(19)	807	(26)
With time-based step	.66	(.06)	.69	(.07)	685	(21)	806	(29)
Event-based category								
With time-based pulse	.77	(.06)	.86	(.05)	704	(17)	812	(22)
With time-based step	.59	(.08)	.89	(.04)	744	(22)	856	(34)
Experiment 4								
No intention control	—	—	—		626	(16)	757	(25)
3 s fixed trial length	—	—	.83	(.06)	681	(16)	821	(27)
Self-paced (continuous)	—	—	.69	(.08)	672	(16)	782	(25)

Note. The — indicates the data are not available by design.

general, specific cues known at intention formation result in better cue detection than the categorical intention tested here (Einstein et al., 1995). Moreover, participants were answering general knowledge questions that may have had additional semantic indicants related to the event-based cue. Park et al. (1997) found similar completion rates for younger adults in their time-based and event-based experiments, but their event-based cue was a perceptual pattern and the number of times participants had to make either a time-based or an event-based response was either 6 or12 times, thereby increasing the importance of the prospective memory task (but see Ellis et al., 1999). Therefore, the divergence in the pattern of results across the studies (including this one) is understandable. To reiterate, we are not as concerned with overall prospective memory as we are with the interference that is caused by holding an intention, and it is this aspect of performance that we consider next.

A one-way Analysis of Variance (ANOVA) model was tested on the average word latencies from the three conditions. A significant omnibus result was obtained, $F(2,102) = 5.63$, $MSE = 9833.88$. Visual inspection of the latencies indicated that task interference was present in both intention conditions, but contrary to the prevailing views about prospective memory, its magnitude was not any greater for participants possessing the time-based intention as compared with the event-based one. These impressions were confirmed with simple effects analyses that demonstrated longer word latencies were obtained in both intention conditions as compared with the control condition, smaller of the two $t(68)$'s = 2.48. Moreover, average latencies to the ongoing task in the two intention conditions were not statistically different from one another, $t(68) = 1.05$, ns. Therefore, these results potentially contravene the notion that time-based tasks require more self-initiated processing resources, or if they do, this greater cost is not being expressed as a cost on the ongoing activity itself. In fact, task interference was numerically smaller in the time-based condition than in the event-based condition.

We followed the convention used by Einstein et al. (1995) in examining clock checking in the time-based condition. Those authors also asked people to respond at two specific times and their approach was to average the number of clock checks over intervals of two minutes. These data are reported in Table 2. In the present case, the intention to respond fell at the end of the second and fourth two-minute intervals. Consistent with previous research, participants increase their clock checks as the time to respond grows near (e.g., Ceci

Table 2
Average number of clock checks in the time-based conditions by two minute intervals in Experiments 1–4

Experiment and condition	Average number by interval				Total
	1 and 2	3 and 4	5 and 6	7 and 8	
Experiment 1					
Time-based pulse	.54	2.89	1.14	3.71	8.29
	(.21)	(.37)	(.16)	(.32)	(.78)
Experiment 2					
Time-based pulse	.89	2.94	1.31	3.83	8.97
	(.27)	(.38)	(.16)	(.33)	(.83)
Time-based step	1.00	2.31	1.40	1.86	6.57
	(.20)	(.28)	(.28)	(.16)	(.67)
Experiment 3					
Event-based specific					
With time-based pulse	.86	3.46	1.46	4.26	10.03
	(.18)	(.37)	(.19)	(.44)	(.98)
With time-based step	.37	1.66	.89	1.69	4.60
	(.12)	(.18)	(.13)	(.21)	(.44)
Event-based category					
With time-based pulse	1.23	4.46	1.29	4.97	11.94
	(.22)	(.52)	(.18)	(.40)	(1.07)
With time-based step	.69	2.00	1.11	1.83	5.63
	(.14)	(.21)	(.20)	(.22)	(.48)
Experiment 4					
3 s fixed trial length	.75	3.64	1.50	4.25	9.39
	(.22)	(.45)	(.19)	(.39)	(.96)
Self-paced (continuous)	.44	1.89	.85	2.37	5.07
	(.15)	(.27)	(.22)	(.26)	(.62)

Note. SE appear in parentheses.

& Bronfenbrenner, 1985; Einstein et al., 1995). To confirm the pattern obvious in the data, we averaged the two initial intervals (i.e., min 1, 2, 5, and 6) and compared clock checking to the final intervals just preceding a requested response (i.e., min 3, 4, 7, and 8). More clock checking occurred just prior to the response, $t(34) = 9.05$, $SEM = .27$. Although numbers of clock checks could be correlated with time-based responding, the severe restriction of range in the latter variable would invalidate such an analysis.

In sum, no evidence was found that possessing a time-based intention caused more task interference to the ongoing task than possessing an event-based intention. In fact, the effect was nominally in the opposite direction. Of course there is an implicit assumption in making this comparison, namely, that whatever task interference is present in the two intention conditions is caused by the same mechanism (e.g., attentional allocation policies that are established at the outset of the entire task set). This assumption need not be correct, and later we return to considering this question more deeply. For now, another factor is considered that may have influenced the results, namely, the specificity of the intention. These considerations lead to Experiment 2.

Experiment 2

The event-based intention used in Experiment 1 was categorical insofar as participants had to detect animal exemplars. This intention is less well-specified during intention formation than telling people the specific cues that they will encounter later (e.g., *hit* and *nice*). As noted earlier, Einstein et al. (1995) found better event-based prospective memory performance with a specific intention as compared with a categorical intention (also see Ellis & Milne, 1996). By contrast, the time-based pulse intention used in Experiment 1 may have been more specific than the event-based intention because the exact times to respond were specified during intention formation (i.e., 4 and 8 min). A less well-specified time-based intention would be to ask people to respond sometime during a window of time (i.e., a step intention). In this sense, Experiment 1 may have compared an ill-specified event-based intention to a well-specified time-based intention. But, in our defense, these two intentions were chosen because they are the ones most commonly used in the literature. That is, many event-based prospective memory studies use categorical cues, and all time-based studies of which we are aware have used time-based pulses to respond at specific times.

Nevertheless, we sought in this next experiment to expand the range of intentions in order to assess whether different types of intentions produce different amounts of task interference. Using specificity as an operational variable, we tested both a well-specified and an ill-specified intention for each of the time-based and event-based prospective memory tasks. As such, the basic design of the experiment was a 2 (intention: time vs. event) by 2 (specificity: well vs. ill) factorial. From the pattern of results obtained in Experiment 1, we predicted that well-specified intentions may cause less task interference than ill-specified intentions. If this is true, then more task interference should occur with a categorical event-based intention than when specific cues are provided, and similarly, more interference to the ongoing task should occur when participants are requested to respond in a window of time as compared with when exact times are given. This experiment also serves as a much-needed replication of Experiment 1 insofar as no published studies to date have examined task interference in time-based tasks (but see Marsh et al., submitted). For purposes of planned comparisons, a no intention control condition was tested in this experiment as well.

Method

Participants

Undergraduates from the University of Georgia volunteered in exchange for partial credit toward a course requirement. Each participant was tested individually in sessions that lasted approximately 30 min. Participants were randomly assigned to four experimental conditions created by crossing type of intention (time- vs. event-based) with the specificity of that intention (well- vs. ill-specified). A fifth condition was not provided with any intention at all as a control. Thirty-five volunteers were tested in each condition (for a total of 175 participants).

Procedure

The ongoing lexical decision task was identical to that used in Experiment 1, and the only thing that varied in this experiment was the nature of the intentions provided at the outset. In all conditions except the control, after the lexical decision instructions were delivered we informed participants that we were also interested in their ability to remember to perform an activity in the future. For the event-based intentions, we asked participants to respond either to animal words (ill-specified) or whenever they encountered the words *hit* or *nice* (well-specified). These words were matched in word frequency to the two animal words used in the event-based category condition.[3] As before, participants were asked to

[3] A different approach for the well-specified condition would have been to use the same two animal words (dog and horse) as in the ill-specified condition. However, our experience has been that sometimes participants spontaneously change the intention to be categorical in nature (i.e., recode the intention as being about animals). To avoid any possibility that they would do so, we chose the current approach.

indicate that they had remembered by pressing the / key after making their word response. For the time-based intentions, the well-specified intention (i.e., a pulse) requested that participants respond at 4 and 8 min whereas the ill-specified intention (i.e., a step) requested that they respond anywhere within the windows of 3–5 min and 7–9 min. These windows straddle the specific times named in the time-based pulse condition. Consistent with Experiment 1, participants in these time-based conditions could check the computer's clock by pressing the Z key, and they responded with the / key. In all other procedural respects, including a 5 min distractor activity after intention formation, this experiment was identical to the previous experiment.

Results and discussion

The data are summarized in Table 1. A 2 (intention) by 2 (specificity) ANOVA was conducted on the average proportion of prospective memory responses. As obtained in Experiment 1, time-based prospective memory was better than event-based $F(1, 136) = 19.22$, $MSE = .08$. There was neither a main effect of specificity nor an interaction, both Fs < 1. Consistent with the Einstein et al. (1995) report, specific event-based cues were detected nominally more often than categorical cues.

The average latencies to words in the ongoing task were analyzed with an identical 2 by 2 ANOVA model. There was a main effect of intention specificity reflecting the fact that ill-specified intentions caused more task interference than well-specified intentions, $F(1, 136) = 6.24$, $MSE = 9464.38$. There was neither a significant effect of type of intention (time- vs. event-based), nor an interaction, both $F(1, 136)$'s < 1.99, ns. The absence of a main effect of time-based versus event-based intentions conceptually replicated the results from Experiment 1, albeit under more varied conditions in this experiment. The purpose of the no intention control condition was to identify which intentions gave rise to significant task interference. In four planned comparisons, all intentions caused slowing in the ongoing task relative to the control condition, smallest of 3 $t(68)$'s $= 2.01$, except the well-specified event-based condition where the two cues were known during intention formation, $t(68) < 1$, ns. The omnibus result for ill- versus well-specified intentions suggests that more resources are being allocated away from the ongoing activity when the prospective memory task is less well defined as is the case with a categorical event-based intention or a step time-based intention.

Marsh et al. (2003) reported a dissociation between the amount of task interference and successful prospective memory performance. That outcome has been obtained again in this experiment. Event-based performance was nominally greater with a specific intention than a categorical one, but that condition resulted in significantly less task interference relative to the control condition (actually none). By contrast, time-based performance was nominally better in the step (ill-specified) condition that was associated with more task interference. These dissociations between interference and successful intention completion will be relevant when considering what mechanism(s) cause task interference.

The difference in task interference in the two time-based intentions does not appear to be explained by the patterns of clock checking behavior. If more interference were generated by the time-based intention coming to mind more often, then participants should check the time more often in the step condition as compared with the pulse, but the opposite can be found in Table 2. The same interval analyses were conducted as reported in Experiment 1, except that the additional factor of type of time-based intention was included. In that analysis, there was a significant interaction between first interval (min 1, 2, 5, and 6) versus second interval (min 2, 4, 7, and 8) and the type of intention, $F(1, 68) = 18.34$, $MSE = .94$. As is apparent from the data in Table 2, the ill-specified step intention did not result in as much clock checking during the second interval as compared with the well-defined pulse intention, $t(68) = 3.56$, $SEM = .36$. However, this difference was likely due to the fact that many participants had already responded before the second interval had expired (i.e., the step intention could be fulfilled during min 3 and 7). Given the differences in opportunity to respond in these two types of intentions, the intention should have come to mind less often in the step condition as compared with the pulse, and consequently, the intention should have caused less interference. But, it caused more interference as measured by the reaction time cost to the ongoing task.

The absence of any significant task interference in the specific event-based condition despite a high rate of intention fulfillment suggests that the cognitive mechanism(s) causing interference are not always functionally necessary for completing all types of prospective tasks. Although the conditions of the event-based task with specific cues does not meet the requirements for automatic cue detection as specified in the multiprocess view theory, proponents of that theory might claim that detection was automatic in that case (Einstein et al., in press). Those same proponents would also have to argue that all three other types of intentions require some sort of resource allocation to the prospective memory task. However, time-based intentions do not require cue-focused processes because there are no cues to consult in the ongoing task that are relevant to the time-based intentions. Therefore, if the mechanism(s) causing interference are similar in time-based and event-based tasks, then the multiprocess view will need to specify that costs to all event-based prospective memory tasks, when they are present, are more centrally mediated and do not reflect a cue-checking process as seems to be implied in that theory. Further discussion of the theoretical implications of these results will occur after the results from the next two experiments are presented.

Experiment 3

The previous experiment discovered that the specificity of, rather than the type of, intention mediated the amount of slowing in the ongoing task. The goal of the next experiment was to assess whether multiple intentions would have an additive effect on task interference. For example, possessing a categorical event-based intention produced slowing in both Experiments 1 and 2, but we wanted to determine whether also asking participants to complete a time-based step or time-based pulse intention would produce even more task interference. And if so, would the interference be additive insofar as adding a time-based step (ill-specified) to an event-based category intention produce more interference than adding a time-based pulse (well-specified)? Additivity or its absence may be one good indicator as to what is causing task interference. Consequently, four conditions were tested in which all participants were given one event-based intention and one time-based intention. The conditions were created by orthogonally crossing the specificity factor (well- versus ill-specified) with the type of intention (time vs. event). This design resulted in the following four conditions: event-based specific cues (EBS) with time-based pulse (TBP), event-based specific cues (EBS) with time-based step (TBS), event-based category (EBC) with time-based pulse (TBP), and event-based category (EBC) with time-based step (TBS).

Method

Participants

One-hundred forty 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 30 min. Thirty-five participants were assigned quasi-randomly to each of the four conditions.

Procedure

This experiment was virtually identical to the lexical decision experiments already reported herein. The main difference was that participants were given two intentions. One of these was event-based and the other was time-based. In addition to informing participants that we were interested in their ability to perform actions in the future, we also told them that we would be asking them to fulfill two separate intentions. The subsequent instructions for intention formation always described the event-based task first and then described the time-based task. The actual instructions for each of the four intentions were identical to those used in Experiment 2. All participants performed a 5 min distractor task after intention formation and before commencing the ongoing task.

The only other required modification was placement of the event-based cues relative to when the time-based intentions should have been fulfilled. Recall that in Experiments 1 and 2, the conditions were timed identically so that an event-based cue always appeared exactly at 4 and 8 min. Under dual intention conditions, the possibility of interference or facilitation to completing the prospective memory tasks at the same time (or nearly so) had to be avoided. We piloted several different instantiations of the following experiment that placed the event-based cues within and outside of the step intention's window for responding. As best as we could ascertain, cue placement had no effect on performance (cf. Experiment 3, Cook, Marsh, & Hicks, 2005). Consequently, we settled on presenting the event-based cues on trials 50 and 130 which corresponded to 1.5 min before the 4 and 8 min time to respond with an event-based pulse intention and 0.5 min before the window opened for a time-based step intention.

Results and discussion

The data are summarized in Table 1 and were analyzed with 2 by 2 ANOVA models with specificity of the event-based task as the first factor and specificity of the time-based task as the second factor. In terms of event-based prospective memory performance, there were no differences among the four conditions that met the standard convention for significance. However, when the event-based task was paired with the well-specified time-based task (pulse) cue detection was marginally higher as compared to when it was paired with ill-specified time-based task (step), $F(1, 136) = 3.27$, $MSE = .16$, $p = .07$. Therefore, there was some evidence that the ill-specified time-based task may have created an impediment to cue detection. We do note that by comparison to Experiment 2, event-based performance under dual intention conditions was approximately the same as possessing a single event-based intention. By contrast, time-based performance was different among the four conditions as verified by a significant interaction between the specificity of the time-based and event-based tasks, $F(1, 136) = 5.96$, $MSE = .09$. The nature of this interaction also led to a marginal main effect in which the time-based step performance was worse than the time-based pulse, $F(1, 136) = 3.49$, $MSE = .09$, $p = .06$. Performance on the time-based step intention (ill-specified) suffered when it was required in conjunction with the well-specified event-based task as compared with the ill-specified event-based task,

$t(68) = 2.7$. The latency data to the ongoing task may be informative as to why this outcome may have occurred.

In the 2 by 2 ANOVA model on lexical decision latencies, there was only a main effect in which possessing an ill-specified event-based intention caused more task interference than possessing a well-specified event-based task, $F(1, 136) = 4.51$, $MSE = 13985.77$. That outcome replicates the results from Experiment 2. As can be seen in Table 1, possessing both the time-based step and event-based categorical intentions resulted in the slowest ongoing task latencies as compared with the remaining three conditions. Thus, the condition with the two ill-specified intentions resulted in the greatest numerical task interference to the ongoing task. Based on the results from Experiment 2, one might have expected that that the other time-based step condition would have resulted in slower latencies than was observed, but this outcome was not obtained. However, that condition was the one in which time-based performance was significantly lower than the remaining three conditions. Consequently, accuracy may have been sacrificed on the time-based step task because more resources were devoted to the ongoing task.

To assess whether dual intentions produced additive task interference some preliminary assumptions needed to be made. First, we did not test a no-intention control condition because the data from Experiments 1 and 2 were so stable in those conditions. Second, we did not test single intention conditions because that was the purpose of Experiment 2 herein. For the present purposes we assume that we would have obtained comparable results for the no-intention control and the single intention conditions had they been re-tested. Therefore, we took the cost over baseline from Experiment 2 for each of tasks individually and added them together to obtain a prediction for each of the dual intention conditions. These are represented as the first column of data in Table 3. The obtained slowing over baseline in Experiment 2 was then calculated and is displayed in the second column of data in Table 3. In all but the first condition, the overarching message is that the dual-task conditions tested in this experiment are subadditive. That is, possessing two intentions does not exert the same costs as each would exact individually. Consequently that outcome suggests that there is some central cost to holding any intention. That cost could be an initial allocation of attention at the outset when participants realize that they are essentially in a dual-task situation (i.e., Marsh et al., 2005). In this sense, the cost may be something akin to the cost of concurrence that Norman and Bobrow (1975) described to be true of any dual-task situation.

Table 3
Predicted and obtained slowing (in ms) for the dual-task conditions of Experiment 3 based on the single task conditions of Experiment 2

Condition	Predicted	Obtained
Event-based specific		
With time-based pulse	48	53
With time-based step	75	60
Event-based category		
With time-based pulse	104	79
With time-based step	131	119

The clock checking data for the time-based intentions are presented in Table 2. The data for the pulse intentions to respond at 4 and 8 min show that participants check frequently during the second interval right before they must respond. By contrast, recall that participants with a step intention can complete the intention during min 3 and 7, and as in Experiment 2, there were fewer clock checks in the second interval with step intentions. Statistical analyses confirmed these impressions insofar as pooling over the two step intentions, and likewise pooling over the two pulse intentions, lead to a significant interaction between interval and type of intention, $F(1, 136) = 73.54$, $MSE = 1.00$. The more interesting result appears to be that more total clock checking occurs, regardless of the type of time-based intention, when it is combined with the ill-specified event-based intention as compared with the well-specified event-based task, $F(1, 136) = 3.64$, $MSE = 2.76$, $p = .06$. Therefore, lacking specificity about the event-based task increased checking behavior on both of the time-based tasks. Perhaps the ill-specified nature of the event-based task created some overall feeling of increased difficulty of the entire task set thereby causing participants to check more frequently. The less frequent checking behavior when the step intention was combined with well-specified event-based task may also have contributed to the lower time-based prospective memory performance in that dual intention condition.

The overall latencies in this experiment, except one condition, are consistent with an underadditive effect of task interference. Moreover, there was no evidence for a supra-additive effect in which two intentions produced more interference than would be expected from the single intention conditions tested in Experiment 2. The dual intention condition with two ill-specified prospective tasks produced the largest numerical slowing to the ongoing task. Ironically, that condition was the one with nominally worst event-based performance. So, the slowed latencies in the ongoing task did not necessarily preserve prospective memory performance and did not necessarily affect both prospective memory tasks in the same way. Once again, this outcome highlights that task interference does not always functionally contribute to fulfilling an intention [the same conclusion was drawn by Marsh et al. (2003)].

Experiment 4

One residual issue with the foregoing experiments is that participants could be using the time after the offset of a letter string differently in the time-based and event-based conditions. More specifically, the time after the offset of a letter string and prior to the next trial could be functionally useful when holding a time-based intention whereas it would not be so with an event-based task. If the time-based intention comes to mind after a response is made, the interference effect with a time-based intention could be a residual carry-over effect on the next trial. To evaluate this proposition, we conducted this next experiment that compared a time-based pulse intention (respond at 4 and 8 min) using the fixed trial duration of the previous experiments versus a new, more continuous, self-paced task that drastically reduced the time between the response and the onset of the next trial. If the time between the decision and the next trial is affecting task interference in a time-based task, then the overall latencies should be different between the two conditions. If, however, the task interference effect is caused by some cognitive process determined at the outset of the experiment, then the latencies from these two conditions should be equivalent.[4]

Method

Participants

The volunteers were 84 undergraduates from the University of Georgia who participated in exchange for credit toward a research requirement. The three conditions tested were a self-paced, no intention control, a fixed-paced pulse, and a self-paced pulse condition, each of which had 28 people randomly assigned to them. The clock checking data for one participant in the self-paced intention condition was accidentally deleted.

Procedure

The baseline control condition in this experiment was self-paced because the fixed-paced control has been tested twice previously. Thus, the control and self-paced pulse conditions were modified to be a maximum of 400 trials long, with half being valid English words and half being nonwords constructed in the same manner as described for Experiment 1. The software was modified to keep a running total elapsed time and the experiment ended automatically after 8.5 min. The inter-trial interval from the response time on one trial to the fixation point on the next trial was reduced to 400 ms in the control and self-paced conditions. Thus, there was an average 80% reduction in the intervening time between trials for the self-paced as compared to the fixed-paced conditions. The fixed-paced condition was essentially the time-based pulse condition from the previous experiments. The two conditions who were given time-based intentions were asked to respond at 4 and 8 min, as described previously. All other facets of this experiment were identical to the previous ones.

Results and discussion

Time-based performance is given in Table 1. The extra time available in the fixed-paced condition nominally raised performance over the self-paced condition, but the difference was not statistically significant, $t(54) = 1.61$, ns. The omnibus ANOVA on the word latencies demonstrated that task interference was present in the fixed-pace and self-paced conditions over the no intention baseline control, $F(2, 81) = 3.13$. However, the task interference effect was comparable in the fixed-pace and self-paced conditions, $t(54) < 1.0$. We also note that the fixed-pace baseline condition was virtually indistinguishable from the previous fixed-pace control conditions tested in Experiments 1 and 2. Together, all of these results suggest that although the extra time available between trials may have been functionally useful for increasing time-based performance (although not statistically so in this experiment), it certainly did not affect the magnitude of the task interference effect. Consequently, the current results do not favor a theory in which the time-based intention is coming to mind during the extra time available after a judgment is made in the fixed-paced condition and that processing spills over to the next trial. Rather, the results favor a mechanism determined at the outset of the experiment.

For the sake of completeness we have summarized clock-checking behavior at the bottom of Table 2 in the same manner as before. There was less clock checking in the self-paced condition as compared to the fixed, $F(1, 53) = 5.66$. The faster pace of this condition (or increased density of trials per unit of time) may have led to fewer clock checks which in turn accounts for the nominally lower time-based performance. A visual comparison of the data to the time-based pulse conditions tested in Experiments 2 and 3 show that the identical pattern was obtained in both conditions of the present experiment. Namely, clock checking increases just prior to when a response needs to be made, $F(1, 53) = 147.23$. We now turn to consider more generally what the results from all four experiments contribute to our current understanding of the potential mechanism(s) that cause task interference.

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[4] We thank Gil Einstein for raising this issue and working with us to devise the best approach for the current experiment.

General discussion

We begin by summarizing the results from this study. First, all intentions caused task interference except the event-based intention with specific cues. Second, contrary to the prevailing claims that time-based intentions necessarily involve more self-initiated processing, time-based intentions did not generally result in greater interference to the ongoing task. Third, the specificity of the intention appears to drive, in part, the amount of task interference that is produced rather than the type of intention (time-based vs. event-based). Fourth, dual intentions of the type studied in Experiment 3 can exhibit increased costs on the ongoing task, although subadditivity was the general rule in Experiment 3. Fifth, the magnitude of task interference is not necessarily related to the probability of intention completion, although in some cases we readily admit that it could be. Finally, slower paced ongoing activities may affect clock checking which may in turn have some nominal influence on performance, but the pace of the task does not influence the magnitude of the interference effect to the ongoing task, at least as tested in the current experiments.

There are at least five tentative theories for what causes the task interference effect, and all of them hail from the basic idea that possessing an intention usurps resources from the ongoing task which is manifested in slower average decision latencies. To date, no article has summarized these theories, and therefore, we do so now. One mechanism could be that each stimulus receives a quick check prior to the ongoing task response being issued to verify whether it is related to an unfulfilled intention. A variant on this idea is that two production rules are kept in working memory, one for the ongoing task and one for the prospective memory task (see Marsh & Hicks, 1998). The stimuli in the ongoing task are matched to both production rules, which takes some extra processing time. Although such a theory might be plausible for event-based prospective memory tasks, there are no environmental stimuli related to the time-based tasks studied here which weakens the appeal of such an explanation. Moreover, the absence of task interference for an event-based task with specific cues further detracts from this explanation. Consequently, a mechanism that operates at the level of individual trials is not favored by the present results.

Another explanation could be that an intention fades in and out of conscious working memory in much the way that material waxes and wanes out of focal attention in Cowan's (1995) theory of working memory and attention (the same is argued by McDaniel, Einstein, Stout, & Morgan, 2003). When it is outside of focal attention it uses little or no capacity, but when it reaches the level of conscious awareness it has usurped some measurable resources. Such a theory is broadly consistent with the idea that possessing a time-based intention causes that intention to come to mind from time to time, and may be responsible for certain patterns of clock checking behavior. Although our intuition is that such drifting does indeed occur, one problem for arguing that this mechanism causes task interference is that Reese and Cherry (2002) interrupted participants and asked them what they were thinking about and only 2% of the time do people report thinking about the prospective memory task. Thus, although intentions do come to mind, the data do not support this as the primary mechanism for task interference.

Smith's (2003) explanation, as we discussed earlier when describing her PAM theory, is that attention is allocated toward any event-based task; and, that allocation usurps resources from the ongoing task. Clearly, Smith's theory could be extended to time-based tasks, but the only underlying mechanisms that have been specified are nonautomatic monitoring and rehearsal of the intention (see Smith & Bayen, 2004, p. 757). One issue with rehearsal is that it predicts a conscious monitoring process, but participants do not report in post-experimental debriefings that they constantly thought about either the time-based or the event-based intentions (cf. Einstein & McDaniel, 1996; see also Reese & Cherry, 2002, as discussed in the previous paragraph). In addition, there is no reason to believe that participants would differentially rehearse a categorical event-based intention versus one that specifies two specific cues (when no task interference was found). Moreover, we conducted an unpublished experiment in which we reminded participants on every trial about a categorical event-based intention. We did so by replacing a intertrial *waiting* message with the word *animals*. On the assumption this manipulation should cause the intention to be present in working memory most (if not all) of the time, we should have observed dramatic task interference similar to when the importance of the prospective memory task is experimentally heightened relative to the ongoing task (see Smith & Bayen). Contrary to predictions from this rehearsal account, significantly less task interference was obtained with a constant reminder even though event-based performance was quite high (91%). Simple rehearsal does not appear adequate as a mechanism for task interference.

A more subtle and perhaps more viable alternative mechanism to rehearsal can be derived from the intention superiority literature (Freeman & Ellis, 2003; Goschke & Kuhl, 1993; Marsh, Hicks, & Bink, 1998; Marsh, Hicks, & Bryan, 1999). In those studies, intention-related material was processed faster than equivalent material that had no associated intentionality. The standard explanation for this finding is that unfilled intentions (at least near-term ones) are represented as goal nodes in working memory as specified by Anderson's (1993; Anderson & Lebiere, 1998) ACT-R model. In that theory, goal nodes sustain independent activationthereby leaving less activation (i.e., capacity) for other cognitive processing. By this explanation, the intention need not be rehearsed for there to be a relatively constant drain on the available processing resources. The idea that activation usurps capacity fits well with Smith's (2003) work that people with smaller working memory capacity show greater task interference effects, and this can also detrimentally affect cue detection in an event-based task. However, we are unclear how this theory would predict that the specificity of the intention (ill- vs. well-specified) would change the magnitude of task interference as we found in the present study. In a similar vein, our reading of Anderson's model does not easily predict mechanisms by which possessing two intentions will produce either additive or subadditive effects on the magnitude of task interference that may depend on intention specificity as was found in Experiment 3. Nevertheless, perhaps with some additional assumptions this theory would provide an adequate account of task interference effects.

Our preferred explanation is that task interference is driven by attentional allocation policies stored in memory at the time instructions are delivered for the ongoing and prospective memory tasks (Marsh et al., 2005). We assert that people make predictions at intention formation about how much difficulty they will have completing the two tasks together, and accordingly, represent in memory information about how they plan to cope with the entire task set. This explanation is consistent with ill-specified intentions causing more task interference than well-specified ones if participants believe the former intentions will be more difficult to fulfill. If participants believe that it will be easy to find the two specific event-based cues, they may allocate little or no attention to the prospective memory task as we found here. This explanation is also consistent with manipulations of the relative importance of the ongoing versus prospective memory tasks in which stressing the importance of the prospective memory task increases task interference. The setting of an initial attentional allocation policy need not be conscious, but may represent a metacognitive strategy about how to approach the entire task set, and therefore, not necessarily be accessible to conscious awareness (for an elaboration of this theory see Marsh et al., 2005). In our approach task interference covaries not with ultimate prospective memory, but rather with people's predictions about how easy it will be to fulfill the intention in the context of the ongoing activity.

Nevertheless, the finding of no more task interference for a time-based task than an event-based task will probably not be replicated under all circumstances. For example, searching for a very nonsalient cue such as the phoneme *tor* in a word like *dormitory* or searching for word with double letters from the set t, l, and o could produce extraordinary interference in an event-based task as compared with a time-based task (see Einstein et al., in press). Or, very demanding ongoing tasks that focus participants on the correct feature of the prospective memory cues could produce more interference in a time-based task than an event-based task. However, the mechanisms of rehearsal, quick stimulus checks on each trial, and wafting of the intention in and out of consciousness are not viable based on the foregoing discussion if the task interference effect has the same locus in both time-based versus event-based tasks. Moreover, the absence of any task interference with specific cues (but good cue detection) argues very strongly that preparatory attention is not a necessary precondition to successful prospective memory; and, that finding supports the multiprocess view (McDaniel et al., 2004).[5] Our theory that people predict the difficulty of the dual tasks they face and allocate attention to the entire task set as well as make an allocation between the ongoing and prospective memory tasks handles both kinds of intentions. Of course, as more is learned about the understudied topic of time-based prospective memory, perhaps our intuition that task interference is caused by the same mechanisms in event-based and time-based tasks will be disproved.

We are not wed to the idea that the attentional allocation policy must be set at encoding because it could be established at the outset of the ongoing task. We also are not wed to the idea that the policy is fixed, but could be influenced by experience with the ongoing and prospective memory tasks which changes the policy over time. Highly salient cues in an event-based task, or ever-present reminders about an intention as manipulated in our unpublished experiment, may foster a change in the policy favoring the ongoing task which speeds responses. By our account, interference is a by-product of how people feel they can best cope with succeeding at both intention completion and the ongoing activity. If this is the sense in which Smith (2003) intends preparatory attention to contribute to prospective memory, then perhaps her theory is correct. However, preparatory attention is flexible in the attentional allocation policies we are arguing cause task interference. Sometimes the policies produce

[5] One aspect of the current design does challenge this claim. Namely, we used an entirely between-subject design which means that our measure of baseline performance was from different people than those given an intention. Consequently, if those baseline participants were somehow very slow, then our claim that specific cues cause no task interference is in jeopardy. However, the two control conditions in the present report are virtually identical to the control condition in Experiment 3 of the Marsh et al. (2003) report and faster than a comparable condition in Experiment 1 of that same report. Thus, although an aberrantly slow no-intention control condition is theoretically possible, our data and past experience do not favor it. We thank Rebekah Smith for raising this issue.

no task interference when people correctly predict that intention completion will be easy to accomplish.

Based on the foregoing, McDaniel and his colleagues are correct in their multiprocess view that prospective memory sometimes requires resources and sometimes does not (McDaniel & Einstein, 2000; McDaniel et al., 2004). However, that theory may need some modification. Intentions with highly salient event-based cues, highly associated cue-target pairings, and processing that focuses one on the features of cue are claimed to cause automatic detection and retrieval of the intention. Although this may be so, participants might also factor these features of the entire task set into their predictions about how easily the ongoing and prospective memory tasks will be to complete. Therefore, task interference and automatic cue detection will only be inversely correlated to the extent that when an attentional allocation policy is initially established people correctly predict how easily each task will be able to complete in the context of the other task. According to this analysis, we would predict that task interference can be present when cues are subsequently easily detected and that it can be absent even when none of the features of the entire task set correspond to those specified in the multiprocess view as causing automaticity (as was found in Experiment 2).

In sum, our belief is that task interference is caused by a metacognitive assessment of a person's ability to handle the cognitive demands of the entire task set (i.e., both tasks together). This theory predicts that task interference will be highly variable in its manifestation across different types of intentions, their specificity, and across individuals as well. Regarding the last item, Einstein et al. (in press) have identified subpopulations who either exhibited task interference or did not. Both populations performed well on an event-based prospective memory task, and so by our account, the subpopulation with no task interference must have felt confident about succeeding on the prospective memory task when performed concurrently with the ongoing task. Their confidence may be due, in part, to individual difference variables such as having larger working memory capacity, or as we suggested before, because they adjusted their attentional allocation policies after some experience with the entire task set. The results from the present study do constrain what mechanisms give rise to the task interference effect, but discovering what variables modulate the accuracy of people's predictions about how successful they will be in fulfilling an intention promises to be an interesting avenue of exploration.

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