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Divided attention interferes with fulfilling activity-based intentions

Gene A. Brewer [a,*], B. Hunter Ball [b], Justin B. Knight [b], Michael R. Dewitt [b], Richard L. Marsh [b]

[a] Department of Psychology, Arizona State University, United States
[b] Department of Psychology, University of Georgia, United States

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ABSTRACT

Two experiments were conducted to examine the effects of divided attention on activity-based prospective memory. After establishing a goal to fulfill an intention upon completion of an ongoing activity, successful completion of the intention generally suffered when attention was being devoted to an additional task (Experiment 1). Forming an implementation intention at encoding ameliorated the negative effects of divided attention (Experiment 2). The results from the present experiments demonstrate that activity-based prospective memory is susceptible to distraction and that implementing encoding strategies that enhance prospective memory performance can reduce this interference. The current work raises interesting questions about the similarities and differences between event- and activity-based prospective memories.

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Prospective memory refers to the strategic use of memory and attention processes to complete intentions in the future. The planning, retention, and retrieval of a prospective memory is influenced by a host of contextual variables including an individual's metacognitive knowledge about the intention, the future context in which the intention can be fulfilled, and their ability to successfully complete the intention (Einstein & McDaniel, 2008). Put simply, there are various types of intentions and numerous ways in which people fulfill them (Kvavilashvili & Ellis, 1996). Importantly, certain intentions are prone to disruption via distraction and prospective memory researchers have investigated strategies that can ameliorate these deficits (Chasteen, Park, & Schwarz, 2001; Kleigel, Martin, McDaniel, Einstein, & Moor, 2007; McDaniel, Einstein, Graham, & Rall, 2004; Tobias, 2009). In the current work, we sought to investigate the attentional demands of completing an activity-based prospective memory and we also investigated a technique for improving intention completion rates (i.e., implementation intentions).

Individuals may establish their prospective memories differently depending on the nature of the intention, the cues they will encounter in the future, and their metacognitive assessment of the types of cues that work well for them. Imagine planning to deliver magnets to a local high school science fair after leaving work. What characteristics will most likely help you remember to interrupt your typical routine of going home from work? Perhaps you would leave the magnets in the seat of your car to serve as a reminder that you needed to take them to the high school. In this case, the magnets would serve as an event-based prospective memory cue. A different characteristic that could effectively cue the intention would be temporal information. If, when establishing the intention, you note that the high school closes before 5:00 pm then you should rely more heavily on time-based cues. Another useful characteristic for planning would be associating the intention with some activity that you will participate in later in the day. For example, say that you have a meeting scheduled in the afternoon and you plan to deliver the magnets immediately after the meeting. In this case, you would have formed an activity-based prospective memory. Whereas much research has investigated event- and time-based prospective memory, much less research has examined activity-based prospective memory. The current experiments will not focus on comparing these different types of intentions but will investigate the attentional demands of completing activity-based intentions directly. However, a discussion of the similarities and differences between these types of intentions, as well as a theoretical framework for thinking about differences between intentions, will be provided in the general discussion.

More formally, activity-based prospective memory refers to doing "…one thing before or after another" (Kvavilashvili & Ellis, 1996 pg. 36). In this regard activity-based prospective memory shares aspects with both event- and time-based intentions, but it also differs in important ways. In standard laboratory paradigms, completing both event- and time-based intentions typically requires interruption to an ongoing task whereas activity-based intentions must be completed between tasks. By interruption, we mean that activity-based intentions are retrieved and enacted in the absence of performing an ongoing task whereas event-based and time-based intentions are typically retrieved and enacted while performing an ongoing task. For

* Corresponding author at: Department of Psychology, Arizona State University, Tempe, AZ 85287-1104, United States. Tel.: +1 4809652155.
E-mail address: gene.brewer@asu.edu (G.A. Brewer).

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this reason, some researchers have suggested that activity-based prospective memory should be less susceptible to distraction (e.g., Shum, Ungvari, Tang, & Leung, 2004). Similarly, activity-based prospective memory could be considered analogous to a contextually linked intention (Marsh, Hicks, & Cook, 2006). Based on this theorizing, activity-based prospective memory would not be susceptible to distraction over an intervening context. However, an important difference between event-, time-, and activity-based intentions is the degree of support that the environment provides for completing them. For example, event-based prospective memories are typically associated with some type of environmental cue whereas time- and activity-based prospective memories require a greater degree of self-initiated retrieval in the absence of processing any such cue (Craik, 1986; but see Kvavilashvili & Fisher, 2007). To the degree that self-initiated retrieval is a capacity consuming process (Unsworth, 2009), this view suggests that divided attention should negatively influence activity-based prospective memories. Based on these hypotheses (i.e., interruption to ongoing tasks, context linking of intentions, and self-initiated retrieval) about the effects of divided attention on activity-based prospective memory, it is not clear exactly how divided attention will affect intention completion.

Generally, the effects of divided attention on memory have been studied in many paradigms including free recall, cued recall, recognition, and prospective memory (Marsh & Hicks, 1998; for a review of retrospective memory see Mulligan, 2008). In retrospective memory studies, divided attention at retrieval has the greatest effects on recall with little to no demonstrable effects on recognition (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; but see Hicks & Marsh, 2000). Similarly, dual-task paradigms have demonstrated that both event- and time-based prospective memories suffer from distraction (Einstein, McDaniel, Smith, & Shaw, 1998; Hicks, Marsh, & Cook, 2005). With regard to retrospective and prospective memories, divided attention has the greatest effects on retrieval when capacity-consuming processes are needed for accessing information from long-term memory and monitoring for intention-related cues, respectively. To date, no research has explicitly examined the effects of divided attention on activity-based prospective memory, although previous empirical research does suggest that distraction could be disrupting.

Brewer et al. (in press) examined the nature of activity-based prospective memory by having participants form an intention to say "now" after finishing two phases of lexical decision trials. After finishing the first phase, participants were given the additional event-based intention to respond to any word containing the syllable TOR (e.g., tornado) during the second phase of lexical decisions that had previously been associated to their intention to say "now". This manipulation simulated the prospective memory demands of everyday life in which some intentions have to be interrupted by other more demanding intentions. Introducing an additional intention significantly reduced the likelihood that participants remembered to say "now" at the end of the second phase of lexical decision trials. The results from this experiment were consistent with the notion that some degree of attentional processes was necessary for retrieving the intention to say "now" and that interleaving a demanding event-based intention interfered with these self-initiated retrieval processes. What is less clear is whether the interference resulted from the increased demands of the nonfocal intention *during* the task, or from some continued consideration or contemplation of the nonfocal intention *after* the task. To address this issue more formally, the current study investigated divided attention during and after a task that participants have planned to make an activity-based response upon completing.

1. The current study

To the degree that capacity-consuming processes are necessary for self-initiating retrieval we hypothesize that activity-based prospective memory will be negatively impacted by divided attention. As discussed earlier, this hypothesis is not the only prediction that can be derived from the prospective memory literature. If activity-based prospective memories reflect a contextually linked intention, they should not be sensitive to disruption over an intervening context (Marsh et al., 2006; cf. Brewer et al., in press). Also, activity-based prospective memory may not be susceptible to distraction because interrupting performance of the ongoing task is not necessary for successful completion of the intention (Shum et al., 2004). To test these competing hypotheses we had participants form the intention to say "now" after finishing a lexical decision task (LDT). In addition to completing the LDT, some participants simultaneously completed a random number generation (RNG) task. Previous research suggests that cue-triggered prospective memory processes from event-based intentions interfere with self-initiated retrieval processes (Brewer et al., in press), but it is unclear if any distraction in general is sufficient to disrupt self-initiated retrieval or whether this disruption is specific to increasing load on competing prospective memory processes by holding multiple intentions. If a general disruption to self-initiated planning and retrieval processes is sufficient to interfere with activity-based prospective memory, decreased performance should be seen when any demanding secondary task is introduced. What is less clear is whether the detrimental effects on prospective memory performance will be seen when this additional task is completed before the interval in which the activity-based intention is to be fulfilled, and perhaps more importantly, whether there are ways to buffer against the detrimental effects of dividing attention. In a second experiment we elaborated on the influence of divided attention by investigating alternative planning strategies (i.e., implementation intentions; Gollwitzer, 1999). Implementation intentions improve prospective memory by enhancing the encoding experience at intention formation. Implementation intentions are used to specify the situation in which future behavior can be achieved and to associate this situation to the intended future action (Gollwitzer, 1999). Implementation intentions have been shown to mitigate the influence of divided attention on event-based prospective memory but have yet to be applied to activity-based prospective memory (McDaniel, Howard, & Butler, 2008).

2. Experiment 1

2.1. Participants

University of Georgia undergraduates volunteered in exchange for credit toward a research requirement. Participants (N = 120) were randomly assigned to one of three between-subject conditions (40 in each). In the No Divided Attention (No DA) condition participants formed an intention to say "now" when they finished the LDT. In the Divided Attention End (DA End) condition participants generated random numbers while performing the LDT and both tasks ended simultaneously. This condition was included to investigate whether divided attention *during* the activity that participants had previously associated their intention to would reduce its likelihood of being completed. In the Divided Attention Continue (DA Continue) condition participants continued generating random numbers after finishing the LDT. In both the DA End and DA Continue conditions, participants had the same intention as in the No DA condition.

2.2. Materials and procedure

The ongoing LDT consisted of 210 trials, with equal numbers of valid English words and pronounceable nonwords that were randomly presented on a computer monitor (for a complete description of the LDT procedure see Marsh, Hicks, & Watson, 2002). Upon stimulus presentation, participants were instructed to press the "word" key with their right index finger or the "nonword" key with their left index finger as quickly as possible. Trials were separated by a "waiting" message. In the No DA condition, participants received instructions for the LDT