

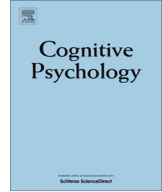


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# The Dynamic Multiprocess Framework: Evidence from prospective memory with contextual variability



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### ABSTRACT

The ability to remember to execute delayed intentions is referred to as prospective memory. Previous theoretical and empirical work has focused on isolating whether a particular prospective memory task is supported either by effortful monitoring processes or by cue-driven spontaneous processes. In the present work, we advance the Dynamic Multiprocess Framework, which contends that both monitoring and spontaneous retrieval may be utilized dynamically to support prospective remembering. To capture the dynamic interplay between monitoring and spontaneous retrieval, we had participants perform many ongoing tasks and told them that their prospective memory cue may occur in any context. Following either a 20-min or a 12-h retention interval, the prospective memory cues were presented infrequently across three separate ongoing tasks. The monitoring patterns (measured as ongoing task cost relative to a between-subjects control condition) were consistent and robust across the three contexts. There was no evidence for monitoring prior to the initial prospective memory cue; however, individuals who successfully spontaneously retrieved the prospective memory intention, thereby realizing that prospective memory cues could be expected within that context, subsequently monitored. These data support the Dynamic Multiprocess Framework, which contends that individuals will engage monitoring when prospective memory cues are expected, disengage monitoring when cues are not expected, and that when monitoring is disengaged, a probabilistic spontaneous retrieval mechanism can support prospective remembering.

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## 1. Introduction

Each day humans form intentions, or *prospective memories*, that must be executed following a delay interval, such as remembering to take medication with breakfast. Since the development of a laboratory paradigm to study prospective memory (Einstein & McDaniel, 1990; Kvavilashvili, 1987), researchers have identified many factors that are associated with prospective memory successes and failures (Brandimonte, Einstein, & McDaniel, 1996; Kliegel, McDaniel, & Einstein, 2008). Yet the processes underlying successful prospective remembering are still being debated (Einstein & McDaniel, 2010; Smith, 2010).

There are at least two general cognitive processes that have been posited to support prospective memory retrieval: monitoring and spontaneous retrieval (McDaniel & Einstein, 2007). Monitoring refers to maintaining the prospective memory intention in mind and searching the environment for cues that signal that the prospective memory action should be executed (for theories of monitoring see Guynn, 2003; Shallice & Burgess, 1996; Smith, 2003). Monitoring is dependent on the prefrontal cortex (e.g., Burgess, Quayle, & Frith, 2001) and working memory capacity (e.g., Brewer, Knight, Marsh, & Unsworth, 2010). Allocating attention toward monitoring results in fewer attentional resources being devoted to performing concomitant activities (i.e., the ongoing task), thereby leading to a performance cost (Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; Smith, 2003).

Spontaneous retrieval processes can also support prospective memory (McDaniel & Einstein, 2007). Spontaneous retrieval is a probabilistic process that delivers an intention to consciousness in response to processing a retrieval cue (for elaborated views of spontaneous retrieval, see Lee & McDaniel, 2013; McDaniel, Guynn, Einstein, & Breneiser, 2004). In contrast to monitoring, spontaneous retrieval does not require preparatory activation of the prefrontal cortex (McDaniel, LaMontagne, Beck, Scullin, & Braver, *in press*), but instead has been linked to the hippocampus (Gordon, Shelton, Bugg, McDaniel, & Head, 2011; Moscovitch, 1994). Introspectively, spontaneous retrieval is experienced as an intention “popping” into mind (e.g., Meier, Zimmermann, & Perrig, 2006). Reflexive-automatic processes might underlie spontaneous retrieval (McDaniel et al., 2004), but spontaneous processes should not be equated with automatized prospective memory responding (Einstein, Smith, McDaniel, & Shaw, 1997; McDaniel & Scullin, 2010).

The Multiprocess Framework (McDaniel & Einstein, 2000) was developed to predict the variables that are associated with either spontaneous retrieval or monitoring processes (e.g., cue focality; Einstein & McDaniel, 2005). Since the proposal of this framework, numerous studies have attempted to isolate spontaneous retrieval and monitoring processes (for review, see McDaniel & Einstein, 2007). A provocative possibility, however, that stems from observations of prospective memory in naturalistic settings (Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2010; Kalpouzos, Eriksson, Sjölie, Molin, & Nyberg, 2010; Kvavilashvili & Fisher, 2007; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010; Sellen, Louie, Harris, & Wilkins, 1997) is that reliance on spontaneous retrieval and monitoring is a dynamic process within individuals. In the present work, we advance the Dynamic Multiprocess Framework (Fig. 1) that suggests that spontaneous retrieval and monitoring may be interconnected processes that operate in a dynamic manner to support prospective remembering (Chen, Huang, & Yuan, 2010).

## 2. Dynamic interplay of retrieval processes in prospective memory

Our theoretical approach suggests that in prospective memory tasks there is often an interplay between spontaneous retrieval and monitoring that augments the functional value of these processes relative to what each alone enables (cf. Chen et al., 2010; Einstein et al., 1997; Gilbert, Hadjipavlou, & Raelison, 2013). In naturalistic prospective memory tasks in which the delay intervals between intention formation and the opportunity to execute the intention are long (hours) and may even include sleep (days, weeks), it is very unlikely that individuals will or can sustain monitoring over that time interval. This assertion is suggested by several findings in the laboratory. First, even when the retention interval is on the order of minutes, monitoring may wax and wane across an ongoing task block (DeWitt, Hicks, Ball, & Knight, 2012; Einstein et al., 2005; Scullin, McDaniel, & Einstein, 2010;

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