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Beyond monitoring: After-effects of responding to prospective memory targets

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ABSTRACT

Responding to bivalent stimuli (i.e., stimuli with features relevant for different tasks) slows subsequent performance. In prospective memory research, prospective memory targets can be considered as bivalent stimuli because they typically involve features relevant for both the prospective memory task and the ongoing task. The purpose of this study was to investigate how responding to a prospective memory target slows subsequent performance. In two experiments, we embedded the prospective memory task in a task-switching paradigm and we manipulated the degree of task-set overlap between the prospective memory task and the ongoing task. The results showed consistent after-effects of responding to prospective memory targets. The specific trajectory of the slowing depended on the amount of task-set overlap. These results demonstrate that responding to prospective memory targets results in after-effects, a so far neglected cost on ongoing task performance.

1. Introduction

A current issue in cognitive psychology is the adjustment of cognitive control following a conflict. Cognitive control is the ability to maintain current goal representations in face of conflict. It enables us to flexibly select goal-relevant features while suppressing distracting ones. A conflict can be triggered by responding to stimuli with relevant features for two different tasks (i.e., bivalent stimuli). Typically, responding to conflict stimuli not only slows performance on these stimuli, but also on subsequent (non-conflict) stimuli (e.g., Botvinick, Braver, Barch, Carter, & Cohen, 2001; Meier, Woodward, Rey-Mermet, & Graf, 2009; Rey-Mermet & Meier, 2012a, 2012b; Woodward, Meier, Tipper, & Graf, 2003; Woodward, Metzak, Meier, & Holroyd, 2008). In prospective memory research, prospective memory targets can be considered as bivalent because they typically involve features relevant for both the prospective memory task and the ongoing task. The goal of the present study was to investigate how responding to a prospective memory target would affect subsequent ongoing task performance.

Prospective memory refers to the ability to remember to perform a particular task at some designated point in the future. In laboratory tasks, participants have to execute a particular action when a target event occurs in the course of an ongoing activity. For example, while participants perform a lexical decision task about letter strings (the ongoing task), they must press a particular key when they encounter a designated target word (i.e., the prospective memory task). Typically, prospective memory targets have relevant features for both the ongoing task and the prospective memory task, which turns them into bivalent stimuli.

A controversial issue in prospective memory research is the nature of memory retrieval (Einstein & McDaniel, 2010; Smith, 2010). One theory puts forward that prospective memory retrieval is the consequence of *strategic monitoring* for

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the prospective memory task and comes always along with a cost, expressed as a slowing in ongoing task performance (Smith, 2003; Smith & Bayen, 2004). Another theory posits that prospective memory retrieval can occur either spontaneously or as the consequence of monitoring. Whether one relies on spontaneous retrieval or monitoring depends on the features of the prospective memory task, the ongoing task, and the rememberer (McDaniel & Einstein, 2000).

Critically, spontaneous retrieval of the prospective memory task should not affect ongoing task performance. This seems to hold for some situations, particularly when prospective memory targets are well specified (e.g., Cohen, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; Hicks, Marsh, & Cook, 2005; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Meier, von Wartburg, Matter, Rothen, & Reber, 2011), when the processing operations required to identify a prospective memory target are similar to those required to perform the ongoing task (Marsh, Hicks, & Cook, 2005; Meiser & Schult, 2008; cf., Meier & Graf, 2000), and when cues are focal (e.g., Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, & Lee, 2010).

In contrast, strategic monitoring results in a cost that can be measured as a performance slowing in the ongoing task (Brandimonte, Ferrante, Feresin, & Delbello, 2001; Marsh et al., 2003; Smith, 2003, 2010; Smith, Hunt, McVay, & McConnell, 2007). This occurs for example, when the prospective memory task is important (Kliegel, Martin, McDaniel, & Einstein, 2004; Smith & Bayen, 2004), when the occurrence of the prospective memory task is expected to occur within a specific pre-defined time window (Marsh, Hicks, & Cook, 2006; Meier, Zimmermann, & Perrig, 2006), and when there are multiple targets (Cohen et al., 2008; Einstein et al., 2005). Moreover, the magnitude of this monitoring cost depends on the kind of ongoing task trials. For example, Marsh, Cook, and Hicks (2006) presented words and pictures for an ongoing naming task and they used words or pictures as prospective memory targets. They found slower ongoing task performance on words when the prospective memory target was also defined as a word, and conversely, slower performance on pictures when the prospective memory target was defined as a picture. Thus, the monitoring cost was larger for ongoing task trials that had overlapping features with the prospective memory targets than for those that had no overlapping features.

Most of the previous studies aimed at investigating the presence or absence of a monitoring cost. However, Loft, Kearney, and Remington (2008, Experiments 1 and 3) provided evidence that besides the expectancy-based monitoring cost, a second source of slowing exists, which is related to the after-effects of responding to prospective memory targets. They tested three groups of participants. In the first group, participants were instructed to perform the prospective memory task and later prospective memory targets were presented. In the second group, participants were instructed to perform the prospective memory task but no prospective memory targets were presented. In the third group, participants were not instructed for the prospective memory task (control group). The results showed a performance slowing in the ongoing task for both groups with prospective memory task instructions. Critically, the performance slowing was larger for the group in which participants responded to prospective memory targets. This suggests that responding to prospective memory targets resulted in an additional after-effect, expressed as a slowing in ongoing task performance similar to the usual, expectancy-based, monitoring cost. This finding is particularly interesting because it suggests that monitoring cost may be generally overestimated.

The purpose of the present study was to investigate the specific trajectory of the after-effects of target presentation on ongoing task performance. We present two experiments, in which we kept the expectancy-based monitoring costs constant. Specifically, we used a within-subjects design consisting of three blocks during which the prospective memory task was activated all the time, but prospective memory targets appeared only in the middle block. This allowed investigating the after-effects that are specific to the presentation of prospective memory targets by comparing performance in Block 2 to the average performance in Blocks 1 and 3.

This procedure is based on the assumption that expectancy-based costs follow a linear trajectory across blocks. This assumption is based on our previous task switching findings in which we administered only two blocks (one purely univalent, one with occasional bivalent stimuli) and counterbalanced block type across block order (Meier et al., 2009, Experiment 3). The results showed exactly the same pattern as when the design with three blocks was used (with purely univalent Blocks 1 and 3 and occasionally occurring bivalent stimuli in Block 2). Moreover, in the domain of prospective memory, Loft et al. (2008, Experiment 3) have explicitly investigated how attention allocation policies changes across three blocks. In one condition, prospective memory instructions were given and prospective memory targets occurred (but only in block 2). In another condition, prospective memory instructions were given, but no prospective memory targets occurred. They reasoned that Block 1 provides a robust baseline measure of attention allocation policy and that Block 3 provides a subsequent measure of policy after a period of time with or without target presentation. The most important result for the purpose of the present study is that although the RT reduction from Block1 to Block 3 was more pronounced when no prospective memory targets were presented, the difference between the means of Blocks 1 and 3 and Block 2 was very similar for both conditions, indicating a linear trajectory of change in expectancy-based monitoring, independent of whether or not cues were actually encountered.

We used three different ongoing tasks in order to manipulate the amount of task-set overlap between the prospective memory targets and the ongoing tasks. In Experiment 1, the ongoing task was to perform parity decisions (odd vs. even), colour decisions (red vs. blue), and case decisions (uppercase vs. lowercase). Stimuli were black numerals for the parity decision, coloured symbols for the colour decision, and black letters for the case decision, all displayed in triplicates (e.g., 777, &&&, and nnn, respectively; see Fig. 1). However, for some case decisions, stimuli were turned into prospective memory targets by presenting consonant–vowel–consonant triplicates (e.g., nen) and by requiring participants to press a designated key whenever they encountered them. In Experiment 2, we investigated the after-effects of target presentation when the task-set overlap between the prospective memory task and the ongoing task was increased. Accordingly, we created prospective