ARTICLE IN PRESS

Acta Psychologica xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

After-effects without monitoring costs: The impact of prospective memory instructions on task switching performance☆

Beat Meier*[,1], Alodie Rey-Mermet[1]

University of Bern, Switzerland

ARTICLE INFO

Keywords:
Intention memory
Cognitive control
Task-set overlap

ABSTRACT

In a prospective memory task, verbal instructions are used to define an appropriate target event as retrieval cue. This target event is typically part of an ongoing activity and is thus bivalent as it involves features relevant for both the prospective memory task and the ongoing task. Task switching research has demonstrated that responding to bivalent stimuli is costly and can slow down even subsequent performance. Thus, responding to prospective memory targets may also result in after-effects, expressed as slowed subsequent ongoing task performance. So far, ongoing task slowing has been mainly considered as a measure of strategic monitoring for the prospective memory cues. The purpose of this study was to investigate whether after-effects of responding to prospective memory targets contribute to this slowing. In four experiments, a prospective memory task was embedded 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 in each experiment. Increasing task-set overlap increased the amount and longevity of the after-effects. Surprisingly, prospective memory retrieval was not accompanied by strategic monitoring. Thus, this study demonstrates that ongoing task slowing can occur in the absence of monitoring costs.

1. Instructions can turn univalent stimuli into bivalent ones: the case of prospective memory

For prospective memory, that is, the ability to form an intention, retain it in memory, and retrieve it at the appropriate occasion, instructions are highly relevant. Being able to make plans and to keep promises, be it by external instructions or self-instructions, is important for self-efficacy and for leading a successful life. In laboratory studies, a prospective memory task is created via verbal instructions. For example, participants are instructed to press a particular key on the keyboard when a target stimulus appears during an ongoing computerized decision task. Importantly, by instructions, these target stimuli become bivalent stimuli (i.e., stimuli with relevant features for two different tasks), because not only can they be used to perform the prospective memory task, they can also be used to perform the ongoing task. From task switching research, it is evident that processing bivalent stimuli is costly and can result in slowed performance even for subsequent univalent stimuli (Meier, Woodward, Rey-Mermet, & Graf, 2009; Rogers & Monsell, 1995; Woodward, Meier, Tipper, & Graf, 2003). The purpose of this study was to investigate the after-effects of responding to prospective memory targets.

Responding to a prospective memory task requires the detection of the target events which can happen either spontaneously or due to strategic monitoring for the target events (McDaniel & Einstein, 2000). Spontaneous retrieval occurs 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), or when the processing operations required to identify a prospective memory target are similar to those required to perform the ongoing task (Marsh, Cook, & Hicks, 2006; Marsh, Hicks, & Cook, 2005; Meiser & Schult, 2008; cf., Meier & Graf, 2000), that is, when the prospective memory target cues are focal (e.g., Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, & Lee, 2010). In situations in which retrieval is spontaneous, ongoing task performance is thus not affected by prospective memory task instructions.

In contrast, when the detection of prospective memory targets occurs as a consequence of strategic monitoring, for example, when the prospective memory task is important (Kliegel, Martin, McDaniel, & Einstein, 2004; Smith & Bayen, 2004, see Walter & Meier,

☆ This work was supported by the Center for Cognition, Learning, and Memory, University of Bern and by a grant from the Janggen-Pöhn Foundation to A. Rey-Mermet.
* Corresponding author at: Institute of Psychology, University of Bern, Fabrikstr. 8, 3000 Bern 9, Switzerland.
E-mail address: beat.meier@psy.unibe.ch (B. Meier).
[1] Beat Meier and Alodie Rey-Mermet, Institute of Psychology and Center for Cognition, Learning, and Memory, University of Bern, Switzerland. Alodie Rey-Mermet is now at the Catholic University of Eichstätt-Ingolstadt, General Psychology, Ostenstr. 27, 85072 Eichstätt.

http://dx.doi.org/10.1016/j.actpsy.2017.04.010
Received 30 November 2016; Received in revised form 18 March 2017; Accepted 26 April 2017

2014, 2016, for a recent review), 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), or when there are multiple target events (Cohen et al., 2008; Einstein et al., 2005), retrieval comes along with a cost, expressed as a slowing in ongoing task performance. In fact, according to the preparatory attentional and memory (PAM) theory, prospective memory retrieval is always the consequence of strategic monitoring for the prospective memory task (Smith, 2003; Smith & Bayen, 2004).

Operationally, monitoring costs are usually measured as the difference between ongoing task reaction times in a condition with vs. without the prospective memory task (i.e., prospective memory load; cf. Meier & Zimmermann, 2015). This calculation of monitoring costs does not take into account the possibility that responding to prospective memory target stimuli can also contribute to ongoing task slowing due to the bivalent nature of the prospective memory targets. Specifically, if responding to prospective memory targets leads to a lingering slowing similar to responding to bivalent stimuli in task switching, "monitoring cost" cannot be considered as a pure measure of strategic monitoring. This possibility, which is the focus of the present article, is supported by recent studies that have demonstrated that responding to prospective memory targets slows subsequent ongoing task performance and must thus be considered as an additional source of costs (Loft, Kearney, & Remington, 2008; Meier & Rey-Mermet, 2012).

Loft et al. (2008, Experiments 1 and 3) provided first evidence that besides the expectancy-based monitoring cost, another source of slowing exists which is probably 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 compared to the control group. Critically, the performance slowing was larger for the group in which participants responded to prospective memory targets. Therefore, responding to prospective memory targets resulted in an additional cost, likely due to after-effects of responding to prospective memory targets. This suggests that monitoring cost may be generally overestimated.

In a more recent study, we have investigated the specific trajectory of the after-effects of responding to prospective memory targets on ongoing task performance (Meier & Rey-Mermet, 2012). In two experiments, we used a within-subjects design consisting of three blocks in which we kept the expectancy-based monitoring costs constant. The prospective memory task was activated all the time, but prospective memory targets appeared only in the second block. This allowed investigating the after-effects that were specific to the presentation of prospective memory targets by comparing performance in block 2 to blocks 1 and 3 in which no prospective memory targets were presented. In both experiments, the results revealed a performance slowing on ongoing task trials that appeared immediately after responding to a prospective memory target. Increasing the task-set overlap revealed a longer-living effect that sporadically slowed performance on those ongoing task trials that had overlapping features with the prospective memory targets. This demonstrates that responding to prospective memory targets can slow subsequent ongoing task performance and must therefore be considered as a potential source of slowing. Importantly, this slowing may affect the cost thought to represent strategic monitoring for the prospective memory targets. However, as we did not assess monitoring separately in the previous study, it was not possible to determine the size of this influence.

The purpose of the present study was to investigate to what extent the after-effects of responding to prospective memory targets contribute to monitoring costs. To this end, we combined the design used by Loft et al. (2008) which involved a between-subjects variation of instruction condition and the design used in our previous study (Meier & Rey-Mermet, 2012) which involved within-subject control blocks. Moreover, we tested the specific trajectory of responding to prospective memory targets for subsequent ongoing task performance. Thus, each experiment involved three conditions. In the first condition ("prospective memory"), participants were instructed for the prospective memory task and they then encountered prospective memory targets. This condition was, in part, a replication of our previous study (particularly Experiments 1 and 4). In the second condition ("expectancy activated"), participants were instructed for the prospective memory task, but they never encountered any targets. Thus, the expectancy for the prospective memory task was activated and we hypothesized that this would lead to strategic monitoring. The third condition was a control condition because no prospective memory task instructions were given.

Participants performed a parity decision on black numerals, a colour decision on red or blue symbols, and a case decision on black letters. Some stimuli for case decisions were turned into prospective memory targets by instructing the participants to press a designated key when they were presented. As our previous study showed that the task-overlap between ongoing task and prospective memory targets affected the size of the after-effects, we varied task-set overlap across experiments. We hypothesized that with higher task-set overlap, stronger after-effects would occur. In Experiments 1 and 2, the prospective memory targets had relevant overlap with one ongoing task (i.e., the case decision). Specifically, they consisted of consonant-vowel-consonant triplicates (e.g., nen) in Experiment 1 and of letters displayed in a different font (e.g., nnn) in Experiment 2. In Experiment 3 and Experiment 4, the prospective memory targets also had relevant features for the case decision task and in addition, they varied on the colour dimension. In Experiment 3, the specific letter colours (yellow and green) were not part of the stimulus set of the colour decision. In Experiment 4, the specific colours (red and blue) were part of the stimulus set of the colour decision. Thus, they had relevant feature overlaps with both the ongoing colour and case decision tasks. With higher task-set overlap stimuli become more focal, and accordingly we expected a decrease in monitoring costs from Experiment 1 to Experiment 4. Table 1 provides an overview of the experiments, the prospective memory targets, and the expected effects.

2. Experiment 1

2.1. Method

2.1.1. Participants

The participants were 60 students (30 men, mean age = 24.2, SD = 5.2) from the University of Bern. Twenty participants were pseudo-randomly assigned to each of the three conditions (i.e., prospective memory, expectancy activated, and control). The study was approved by the local ethical committee of the University of Bern.

Table 1
Overview of the experiments, the prospective memory targets and their expected relationship to task-set overlap, resulting after-effects and monitoring costs.

Experiment	Target	Task-set Overlap	After-effects	Monitoring Costs
1	nen	Lower	Lower	Higher
2	nnn	⇩	⇩	⇧
3	nnn			
4	nnn	Higher	Higher	Lower

Note. In Experiment 3, the prospective memory targets were presented in green or yellow colour (i.e., colours not used for the colour decision task) and in Experiment 4, they were presented in red or blue colour (i.e., colours used for the colour decision task).