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Target preexposure eliminates the effect of distraction on event-based prospective memory

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Prospective memory is critical to everyday functioning and can be vulnerable to distraction. We conducted an experiment to explore whether we could buffer prospective memory against distraction. For half the participants, we preexposed stimuli that were later designated as prospective memory targets. Then, all participants performed an ongoing task (in which the prospective memory task was embedded) under standard and high attentional demand (i.e., under full and divided attention). Target preexposure improved prospective memory and eliminated the significant divided attention effect. Thus, target preexposure seems to buffer prospective memory against the disruptive effect of dividing attention. Moreover, target preexposure seemed to help participants to respond with the correct intended action. This result implies that preexposure to the target stimuli facilitated the encoding of an association between the target stimuli and the intended action, perhaps promoting relatively more reflexive retrieval and thereby buffering prospective memory against distraction.

Prospective memory refers to memory—in the absence of a direct request to remember—to execute an intended action at an appropriate point. Real-world examples include remembering to shop for a gift in a particular store, to ask a physician a question at an appointment, and to pack the appropriate gear for an afternoon workout. In the present article, we are interested in event-based prospective memory in which a target *event* indicates when it is appropriate to execute the intended action. A typical laboratory example is remembering to make a particular response when a target word (event) occurs in the context of another, ongoing activity (i.e., the cover task). The purpose of the cover task is to simulate the usual real-world demand to interrupt an ongoing activity in order to perform the prospective memory task at the appropriate point.

Prospective memory can be vulnerable to distraction in that when distraction increases, prospective memory suffers. This occurrence is evident in experiments in which prospective memory is disrupted by increasing the attentional demands of ongoing activities (Marsh & Hicks, 1998; McDaniel, Guynn, Einstein, & Breneiser, 2004; McDaniel, Robinson-Riegler, & Einstein, 1998). An important practical and theoretical question is whether this disruption is inevitable—whether prospective memory can be buffered against the distraction that is caused by demanding ongoing activities. From an applied perspective, this issue is important not only for common everyday prospective memory tasks, but also for prospective memory tasks that have critical consequences in the real world (e.g., medical contexts, aviation settings; see McDaniel & Einstein, 2007, for detailed examples). Theoretically, some views of prospective memory propose mechanisms that conceivably provide leverage for countering negative effects of demanding ongoing activities. In this article, we consider one possible manipulation to render prospective memory resistant to distraction. The idea explored is that sufficient exposure to the target event—prior to its being designated as such—may aid detection of that target, thereby improving prospective memory in the face of demanding ongoing activities. To date, no experiment has directly tested this idea (see Mäntylä, 1993, for a study in which preexposure of the target was nonsystematically present and demands of the ongoing activity were not varied).

Before developing the theoretical motivation for our focus on target preexposure, we first outline the central components of the experiment. Prospective memory target words were embedded in an ongoing word rating task, and the prospective memory task was to write a response word if a target word occurred in the word rating task. In a standard attentional demand condition, the word rating task was presented alone. In a high attentional demand condition, a digit detection task was presented concurrently with the word rating task. Further, for some participants, we required extensive processing of the targets prior to the

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prospective memory instructions. Other participants were not exposed to the targets prior to the prospective memory instructions.

One prominent theoretical view has been that prospective memory involves detecting or recognizing the target event as a cue to execute the intended action (McDaniel et al., 2004; Smith, 2003). Various proposals about the particular processes involved in detecting the target have been offered, and these proposals suggest alternative mechanisms for how target preexposure could benefit prospective memory. One proposal is that targets are detected by engaging preparatory attentional processes that initiate recognition memory tests for the targets (Smith, 2003). On this view, preexposure could benefit prospective memory by facilitating the recognition memory tests (i.e., increase the accuracy of the recognition decisions). However, increasing the demands of the ongoing activity would still be expected to impair prospective memory, because preexposure would not obviate the need for preparatory attentional processes (see Smith & Bayen, 2004, for a formal model that emphasizes the priority of the preparatory attentional processes for detecting the targets). That is, although target preexposure could improve prospective memory (in comparison with no preexposure) with demanding ongoing activities, target preexposure would not eliminate the negative impact of demanding ongoing activities (i.e., an interaction would not be expected).

Another proposal is that an experience of familiarity could underlie the detection of a target (McDaniel, 1995). The experience of familiarity may reflect the automatic integration of the perceptual (Mandler, 1980) or conceptual (Jacoby, Kelley, & Dywan, 1989) features of the target. This experience of familiarity prompts the system to treat the target as something other than a stimulus for the ongoing activity (i.e., stimulates an attribution of significance to the target; cf. Jacoby et al., 1989; Mandler, 1980; Whittlesea & Williams, 2001a, 2001b). Importantly, familiarity-based detection of a target would not necessarily be operative in all situations (see, e.g., experiments by Smith, 2003). In most experiments, the only encounter with a target prior to the ongoing activity is when the prospective memory task is assigned. Such minimal exposure might not stimulate a strong enough feeling of familiarity compared with the nontargets to support detection based on familiarity. One way to enhance the familiarity process and thus to increase the chance of target detection should be to preexpose the targets. With sufficient preexposure, targets would elicit a greater feeling of familiarity than nontargets that have not been preexposed; thus, familiarity would be diagnostic of a target. This contribution of familiarity to target detection would presumably enhance prospective memory. More provocatively, because familiarity is considered a relatively automatic process (see, e.g., Jacoby et al., 1989), if this view has merit, then target preexposure could significantly moderate the negative effect of demanding ongoing activities on prospective memory.

On yet another view, the target is not necessarily detected as a target, per se. Instead, encounter of the target stimulates reflexive retrieval of the intended action (Guynn, McDaniel, & Einstein, 1998; McDaniel et al., 2004; McDaniel et al., 1998). On this view, the critical component for prospective memory is the encoding of a robust association between the target and the intended action (see McDaniel et al., 2004, for supporting evidence). Related to the present focus, preexposure would result in a well-learned target, thereby potentially facilitating encoding of the target-action association (Underwood & Schulz, 1960). Thus, preexposure could result in somewhat more reflexive retrieval of the intended action in reaction to the target, even under demanding ongoing activities (McDaniel et al., 2004). A distinguishing feature of this view from the previous views is that a better target-action association should lead to an increased likelihood of responding with the correct intended action.

To try to illuminate whether target preexposure influences prospective memory through a reflexive retrieval process, we evaluated the extent to which participants could respond with the exact intended action in comparison with an incomplete or incorrect action (the assumption being that reflexive retrieval would operate to produce the exact action that was paired with the target because the instruction focused on encoding that association). Participants were instructed that if they remembered that they had to perform an action upon encountering the target but did not remember the exact action, then they should mark an "X," which would signal that participants remembered that they had to do something but did not remember precisely what they had to do (Mäntylä, 1994; McDaniel et al., 2004). Our assumption was that if preexposure effects hinge on augmenting reflexive retrieval (through a more robust target-action encoding), then the effects would be limited to responses incorporating the exact action.

The above theoretical perspectives that anticipate a benefit of target preexposure on prospective memory notwithstanding, it is not a foregone conclusion that target preexposure will benefit prospective memory. Because the exposure occurs in advance of the stimulus being designated as a target, there may be no effect on prospective memory. Yet another possibility is that target preexposure will impair prospective memory. If the preexposure causes habituation to the stimulus that later becomes a target, then the preexposure may actually impair the detection of the target.

METHOD

Design

The design was a 2×2 mixed factorial ANOVA, with preexposure to the targets (preexposure, no preexposure) varied between subjects and attentional demand during the word rating task (standard, high) varied within subjects. The order of the standard versus high attentional demand periods was counterbalanced across participants in each preexposure group (i.e., participants received alternating periods, half starting with standard attentional demand and half starting with full attentional demand). A separate control group had no target preexposure and no prospective memory instructions or task. They just performed the digit detection task with the word rating task.

Participants

The participants were 82 undergraduates who were enrolled in psychology courses at the University of New Mexico or New Mexico State University and who participated in partial fulfillment of a course requirement or for extra credit.

Materials

For target-action pairs, half the participants in each preexposure group received *eraser–needle* and *steeple–sauce*, and half the participants received *spaghetti–church* and *thread–pencil*. For the preexposure phase, six different word fragments (words with letters deleted, e.g., *e-as-r*) and anagrams (words with letters rearranged, e.g., *raseer*) were constructed for each target.

The stimuli for the word rating task (two targets that were presented twice each in the context of 100 nontargets from Paivio, Yuille, & Madigan, 1968) were presented on the computer with a rating scale from 1 to 5 and a dimension on which to rate the word (*concreteness*, *meaningfulness*, *pleasantness*, or *vividness*). Participants wrote their responses on numbered answer sheets (four pages with 26 lines per page). The targets appeared as the 20th, 44th, 76th, and 100th items. The stimuli for recognition study and test were presented on the computer, and participants wrote their responses on numbered answer sheets.

Procedure

The experiment lasted approximately 1 h. First, the targets were preexposed to participants in this group. Participants were presented with six word fragments and six anagrams for each of two targets (i.e., 24 total preexposures) one at a time in the center of the computer. Participants said the word out loud that completed the word fragment or solved the anagram and wrote the word on the answer sheet. Participants could press the "Enter" key to go to the next word fragment or anagram, but if they did not do so within 32 sec, then the correct word was presented. For the 24 preexposure trials, the two targets alternated with first an anagram and then a word fragment presented for each target.

Participants were next given instructions, examples, and practice on the digit monitoring divided attention task. For this task, digits were presented via a cassette tape every 2 sec during the word rating task for periods of 56 sec. Participants pressed a button on a hand counter each time two consecutive odd digits were presented. The 56-sec periods of digit presentation (i.e., high attentional demand) alternated with 56-sec periods of no digit presentation (i.e., standard attentional demand). Participants practiced this task for 56 sec.

Participants were next given instructions, examples, and practice on the word rating task. For this task, a word to be rated, one of four possible dimensions on which to rate the word (concreteness, meaningfulness, pleasantness, vividness), and a rating scale from 1 to 5 appeared on the computer for 7 sec. Participants rated the word on the given dimension, with 1 indicating *not very concrete*, *meaningful*, *pleasant*, or *vivid*, 5 indicating *very concrete*, *meaningful*, *pleasant*, or *vivid*, and 3 indicating *neutral* on the dimension. Participants wrote the first letter of the dimension and the rating of the word on the answer sheet. Participants practiced this task for four trials—one trial for each dimension—with a different word on each trial.

Following the practice trials, the instructions for the prospective memory task were presented on the computer. If participants ever saw a target as a word to be rated, then they were to write the response word on the line next to their rating. If they could not remember the response word, then they were to mark an "X." Participants indicated when they had read and understood the instructions, at which point they were asked to repeat the instructions. Participants who failed to do so were asked to read and repeat the instructions again. Then participants were asked to fill out a brief questionnaire (to introduce a delay) asking the date and time and their age, gender, and ethnicity, and were then asked to repeat the instructions again. Next, participants were informed that before they did the other tasks, they would do a task involving studying and recognizing a list of words.

For the study phase, 100 words were presented one at a time for 5 sec each in the center of the computer. For the test phase, the 100 studied words and 50 nonstudied words (all from Paivio et al., 1968), randomly intermixed, were presented one at a time in the center of the computer. Participants decided whether each word had been studied, wrote "y" or "n" on the answer sheet, and pressed the "Enter" key to go to the next word.

Participants were reminded of the digit monitoring task and the word rating task, but not of the prospective memory task, and they were informed that they would perform these tasks next. The two targets appeared twice each in the context of the 100 nontargets, once each during a 56-sec period when digits were not being presented (i.e., standard attentional demand) and once each during a 56-sec period when digits were being presented (i.e., high attentional demand).

Participants were given a retrospective memory test for the prospective memory targets and response words. The 9 participants who could not correctly report the words were replaced.

RESULTS

Prospective Memory

For all analyses, the alpha level was .05. The magnitude of the significant and marginal effects is indicated by η^2. We scored prospective memory with both a strict and a lenient criterion. For the strict criterion, participants had to write the designated response word to be tabulated as correct. For the lenient criterion, participants could write either the designated response word or an "X" (or any other word). We submitted each measure (see Table 1) to a 2 × 2 mixed ANOVA with target preexposure (preexposure, no preexposure) as the between-subjects factor and attentional demand of the ongoing activity (standard, high) as the within-subjects factor.

With the strict criterion, target preexposure improved prospective memory in comparison with no preexposure [$F(1,62) = 3.85$, $MS_e = .25$, $\eta^2 = .06$, $p = .05$]. This effect held for both standard and high attentional demand [$F(1,62) = 4.84$, $MS_e = .04$, $\eta^2 = .07$, and $F(1,62) = 23.04$, $MS_e = .04$, $\eta^2 = .27$, respectively]. With the lenient criterion, the general advantage of target preexposure was reduced so that there was no significant main effect [$F(1,62) = 1.85$]; although with high attentional demand, target preexposure did produce better prospective memory than did no preexposure [$F(1,62) = 15.41$, $MS_e = .03$, $\eta^2 = .20$].

Importantly, there was no main effect of attentional demand for either the strict or the lenient criterion [$F < 1$ and $F(1,62) = 1.40$, respectively]. Instead, for both the strict and the lenient criteria, attentional demand interacted with target preexposure [$F(1,62) = 2.99$, $MS_e = .04$, $\eta^2 = .05$, $p < .09$, and $F(1,62) = 4.52$, $MS_e = .03$, $\eta^2 = .07$, respectively]. Inspection of Table 1 reveals that—as expected—increasing the demands of the ongo-

Table 1
Mean Proportion of Prospective Memory Responses

	Strict Criterion				Lenient Criterion			
	Standard Demand		High Demand		Standard Demand		High Demand	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Target preexposure	.80	.36	.83	.33	.83	.30	.86	.29
No target preexposure	.69	.40	.59	.43	.80	.33	.69	.38

ing activity reduced prospective memory when the targets were not preexposed; in contrast, increasing the demands had no negative effect on prospective memory when the targets were preexposed. Simple effects tests confirmed this impression. Dividing attention significantly impaired prospective memory when the targets were not preexposed [$F(1,62) = 4.00$, $MS_e = .04$, $\eta^2 = .06$, and $F(1,62) = 6.45$, $MS_e = .03$, $\eta^2 = .09$, for the strict and lenient criteria, respectively].

The absence of a significant effect of attentional demand when the targets were preexposed was not because of a ceiling effect in this group. Omitting the participants with perfect prospective memory, there was still no hint that prospective memory for the remaining 10 participants suffered under high attentional demand. With both the strict and lenient scoring criteria, prospective memory was actually numerically better under high attentional demand (.45 and .55, respectively) than under standard attentional demand (.35 and .45, respectively).

Digit Detection

The digit detection errors (see Table 2) were submitted to a one-way between-subjects (target preexposure, no preexposure, control) ANOVA. There was a significant effect of group [$F(2,78) = 6.93$, $MS_e = 91.61$, $\eta^2 = .15$]. Pairwise comparisons revealed a significantly greater number of errors in the no preexposure group than in the target preexposure group [$F(1,78) = 6.31$, $\eta^2 = .07$] but not a significant difference between the target preexposure group and the control group [$F(1,78) = 2.06$].

DISCUSSION

Prospective memory is an integral part of everyday life and is vulnerable to distraction; that is, prospective memory can be disrupted when an individual's attention is absorbed by an ongoing activity. Thus, it is of practical import to explore interventions to buffer against the disruption and to improve prospective memory more generally (McDaniel & Einstein, 2007). Our results support the effectiveness of an intervention in which stimuli that will later serve as prospective memory targets are preexposed. Preexposing the targets generally improved prospective memory, as was anticipated by all of the theoretical views outlined previously. Most importantly and decisively from a theoretical perspective, target preexposure eliminated the significant negative effect of increasing the attentional demands of the ongoing activity. We next consider the theoretical implications of the findings.

What processes were invoked to support prospective memory in the no preexposure and target preexposure groups? Participants in the no preexposure group may have engaged preparatory attentional processes, as was evidenced by the significant decline in prospective memory under high attentional demand and—more particularly—by the significantly greater number of digit detection errors in this group than in the control group. The cost to the ongoing activity (digit detection) exacted by the prospective memory task is consistent with the idea that preparatory attentional processes were engaged (Smith, 2003).

Target preexposure may have modified the processes supporting prospective memory. In the target preexposure group, not only was there no hint of a negative effect of high attentional demand, but also there was no significant cost to the digit detection task (in comparison with the control group). Had preparatory attentional processes been heavily utilized in the target preexposure group, then one or both of the above effects would have been expected to emerge (to parallel the effects in the no preexposure group). Thus, target preexposure may change the qualitative nature of the processes that were used to support prospective memory.

What processes might have been facilitated by target preexposure to support prospective memory? Two possibilities that were developed in our introduction are reasonably consistent with the results. On the idea that target preexposure augmented a familiarity-based process, target preexposure would be expected to improve prospective memory relative to no preexposure across standard and high attentional demand and for both strict and lenient scoring criteria. This pattern generally obtained, with the only exception being that target preexposure did not significantly improve prospective memory under standard attentional demand using a lenient scoring criterion.

The other possibility is that target preexposure facilitated the encoding of a strong target-action associative link during the prospective memory instructions. This idea is based on research from the retrospective memory literature that has shown that when there is a well-learned stimulus, paired-associate learning is enhanced (Underwood & Schulz, 1960). The strong target-action link would help to support reflexive retrieval of the intended action in reaction to the target (cf. Moscovitch, 1994). This idea would be consistent with the weaker effect of target preexposure for the lenient scoring criterion.

Another observation consistent with this idea is that target preexposure eliminated nearly all failures to remember the intended action. That is, in the preexposure group, participants rarely realized that they needed to do something when the target occurred, but forgot the intended action. In contrast, in the no preexposure group—on occasion—participants realized that they needed to do something (and indicated this with an "X"), but forgot the intended action. Note, then, that preexposure eliminated the negative effect of high attentional demand (imposed by the digit detection task) for the lenient scoring criterion, not because it increased the incidence of incorrect or incomplete responses, but because it facilitated retrieval of the correct intended action.

The interpretation suggesting facilitation of a target-action association is consistent with the Guynn et al.

Table 2
Mean Digit Detection Errors in the High Attentional Demand Condition

	n	*M*	*SD*
Control group	18	7.83	6.05
Target preexposure	32	11.88	9.17
No target preexposure	31	17.94	11.42

(1998) finding that target-only reminders failed to improve prospective memory. Specifically, these target-only reminders were presented after the prospective memory instructions and thus would not have been able to exact an influence on encoding.

For the reasons mentioned above, we believe that a plausible interpretation of the present results is that when the target stimuli are preexposed, the result is a strong association between the target stimuli and the intended action, and prospective memory is buffered against the disruptive effect of dividing attention because of this strong association. Thus, target preexposure may function much like implementation intentions, in terms of promoting the encoding of a strong target-action association that promotes reflexive or automatic retrieval (Gollwitzer, 1999) and that can buffer prospective memory against distraction. Also, as we have suggested previously (McDaniel et al., 2004), when there is a strong target-action association to support retrieval, then preparatory attentional processes are not needed and may not be engaged. Retrieval can be relatively reflexive, and a significant decline that is due to demanding ongoing activity would not necessarily be expected.

More generally, the overall pattern of results suggests that individuals can adopt different processes to support prospective memory under different conditions and thus provides evidence for a multiprocess view of prospective memory (McDaniel & Einstein, 2000). Moreover, in light of this interpretation, existing accounts hinging on a single theoretical process (or processes) to explain modulations in prospective memory might deserve reevaluation. That is, the current work implies that the manipulation of a variable can produce a qualitative change rather than a quantitative change to the processes relied upon to support prospective memory.

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