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Discrepancy processes in prospective memory retrieval

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Discrepancy processes may be helpful in noticing prospective memory targets (McDaniel, Guynn, Einstein, & Breneiser, 2004). We manipulated the discrepancy of prospective memory targets from the processing coherence established by the ongoing task by preexposing nontarget items in the ongoing task either five times (high discrepancy) or two times (low discrepancy). Prospective memory performance was significantly better in the high-discrepancy group than in the low-discrepancy group. These results support a discrepancy view of prospective remembering.

Prospective memory is crucial to daily life. Remembering to purchase bread on the drive home from work is an example of a prospective memory task. A central feature of prospective memory is that retrieval of the intended action must occur without the explicit request to remember. In considering how event-based prospective memory retrieval occurs, some theorists have suggested that different processes may mediate prospective memory retrieval under different circumstances; however, there is a bias against capacity-demanding monitoring processes that are devoted toward monitoring for the appropriate moment in which to perform the intended action (Einstein et al., 2005). Instead, people may rely on spontaneous processes that do not require additional cognitive resources for prospective remembering (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004).

One potential ongoing cognitive process that might be appropriated for prospective remembering is discrepancy detection and attribution (McDaniel et al., 2004). Whittlesea and Williams (2001a, 2001b) have argued that people constantly evaluate the quality and fluency of their processing. This chronic evaluation sometimes yields discrepancies, resulting in subsequent attributions. McDaniel et al. (2004) have suggested that discrepancy could be one basis for noticing the prospective memory target (an event signaling that the intended action can be executed). When a participant encounters the target, it may be processed in a fashion that is discrepant in comparison with the quality of processing established by other stimuli. The differential quality of processing for the target could occur partially because of the previous encoding of the target with the intended action. Discrepancy may alert the participant that an item is significant. This sense of significance could alert the rememberer that something needs to be done (McDaniel et al., 2004). In this case, prospective remembering would not require an additional strategic process of monitoring for the prospective memory target (cf. Smith, 2003; Smith & Bayen, 2004). If people are chronically evaluating the quality of their processing, prospective remembering can simply "piggyback" onto this continual process. For example, perhaps forming the intention to buy bread on the way home creates a discrepancy in processing the bakery in comparison with processing for other stores that one might pass by. This perception may alert a person to the significance of the bakery.

Guynn and McDaniel (2005) have reported results consistent with the discrepancy approach. Some participants had to complete word fragments and anagrams of two words that were later introduced as the prospective memory targets, and other participants received no preexposure to the targets. Preexposure of the prospective memory targets increased prospective memory performance in comparison with no preexposure. According to a discrepancy-plus-search formulation (McDaniel et al., 2004), preexposing prospective memory targets would augment the differences in the quality of processing for the targets in comparison with that for the nontarget items in the ongoing task. In the context of a prospective memory task, the discrepancy would produce an attribution of significance for the targets, prompting further consideration of them (i.e., search).

The benefit of target preexposure, however, might also be explained by increased activation, or by the familiarity-plus-search view (e.g., see Einstein & McDaniel, 1996; Mäntylä, 1996; Marsh, Hicks, & Bink, 1998; McDaniel, 1995). In the familiarity-plus-search view, an item that exceeds a threshold of familiarity—in the absence of recognition instructions—may prompt a search directed at determining the significance of that item (McDaniel, 1995). The item is thus noticed as a cue for performing an action other than the ongoing activity. Perhaps target preexposure increases familiarity of the target, thereby prompting it to be noticed as a prospective memory cue.

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In another paradigm, McDaniel et al. (2004, Experiments 1 and 2) manipulated nontarget preexposure. In the high-discrepancy condition, the nontargets (i.e., not the prospective memory targets) in the ongoing word rating task were not previously exposed for the participants. In this condition, the prospective memory targets were the only words that participants had seen in the prospective memory task instructions. Thus, they were expected to be discrepant, because exposure during instructions may have subsequently created more fluent processing of the targets in comparison with that of the nontargets in the word rating task. In the low-discrepancy condition, nontarget words were exposed twice (once each in study and recognition tasks) before the word rating task. Here, all items in the word rating task had been preexposed (the nontargets and the prospective memory targets). Thus, processing of the targets was expected to be less discrepant from the processing of the nontargets, thereby diminishing the likelihood of prospective memory retrieval. As predicted by the discrepancy view, performance was significantly higher for participants in the high-discrepancy condition than for those in the low-discrepancy condition. One alternative interpretation of McDaniel et al.'s (2004) findings, however, is that preexposing nontargets (the low-discrepancy condition) may have interfered with the diagnosticity of familiarity for detecting the prospective memory targets.

In the present experiment, we attempted to distinguish discrepancy from familiarity interpretations of the prospective memory effects described above. Familiarity-plus-search would require prospective memory targets to be familiar in order to activate successful prospective remembering, whereas discrepancy-plus-search would predict successful prospective memory performance when the targets are processed differently than other ongoing events. Discrepancy could emerge when the target events are either more familiar or less familiar than other items in the environment. Accordingly, we either preexposed nontargets twice (one study trial–one test trial, as in McDaniel et al., 2004) or five times (four study trials–one test trial). According to the discrepancy-plus-search view, five nontarget preexposures should yield a processing quality in which the prospective memory target will be highly discrepant. With two preexposures, the quality of processing of nontarget items should be more similar (i.e., less discrepant) to that of the prospective memory target. Assuming discrepancy is attributed to significance,[1] prospective memory targets in the five nontarget preexposures condition would more likely be perceived as significant, leading to better prospective memory.

In contrast, a familiarity interpretation of nontarget preexposure effects suggests that five preexposures of the nontargets would interfere with familiarity processes (see, e.g., McDaniel, 1995) in detecting prospective memory targets. Five preexposures of the nontarget items would result in the nontargets' being more familiar than the prospective memory targets and thus ought to produce misleading signals in the noticing of prospective memory targets (see Guynn & McDaniel, 2005; McDaniel, 1995). Consequently, prospective memory should decline in the five preexposures condition.

Working memory capacity was also assessed in this experiment. We reasoned that if discrepancy processes reflect nonstrategic components in prospective remembering—that is, few, if any, additional cognitive resources are required for noticing the prospective memory target and determining its significance—then working memory scores may not be correlated with prospective memory performance. The idea that additional resources may not be required in searching for the significance of the target (e.g., retrieving that something needs to be done) is based on Craik, Govoni, Naveh-Benjamin, and Anderson's (1996) finding of limited resource costs associated with retrieval in a retrospective memory task. Craik et al. further suggested that the limited costs might be associated with maintaining a retrieval mode. Because prospective memory is characterized by the absence of an explicit request to remember, resource costs associated with a retrieval mode might even be precluded.

Alternatively, it is possible that forming attributions to discrepancy that has been experienced or determining the significance of a discrepant item (via search) may require additional resources. If these additional resource demands are not minimal, then high working memory should be positively associated with prospective memory performance. It is important to note that processes required by strategic monitoring for the target could also underlie any observed associations between working memory and prospective memory performance (Smith, 2003; Smith & Bayen, 2004), thereby clouding the interpretation of a correlation. However, the prospective memory task in the present experiment had a minimal number of target events (two), and the targets were focally processed as part of the ongoing task. Such conditions appear to preclude reliance on strategic monitoring for detecting the prospective memory target (Einstein et al., 2005; though see Reese & Cherry, 2002, for working memory–prospective memory correlations under these conditions).

METHOD

Design and Participants

The experiment was a one-factor between-subjects design, where preexposure of the nontargets (in the word rating task) was manipulated. The nontargets were preexposed either twice or five times. Forty-eight University of New Mexico students participated for extra credit or partial fulfillment of a psychology course requirement. There were 24 participants randomly assigned to each condition.

Materials

One hundred fifty-four words were taken from the Paivio, Yuille, and Madigan (1968) corpus. Three lists of 50 words and two sets of two prospective memory targets were generated. Each participant saw 102 words. Fifty words (the fifty nontargets) were presented in the study list, the recognition task—with fifty foils, in random order—and the subsequent word rating task. Each participant saw two prospective memory targets. The two lists of 50 nontarget items were counterbalanced: Half of the participants saw one list, and half saw the other. The prospective memory targets were counterbalanced in the same way. Hyperspace Analogue to Language (HAL) frequency information (Lund & Burgess, 1996) was obtained for all three lists and prospective memory targets via the English Lexicon Project (Balota et al., 2002) (M = 33,502.42 for list 1; M = 59,733.40 for list 2; M = 40,900.96 for the recognition task foils).[2] Half of the participants received the targets *spaghetti* and *thread* (frequency values of 1,161 and 57,162), and the other half received *eraser* and *steeple* (frequency values of 593 and 86). Participants were told to press the "1" key whenever they saw either target in the word rating task.

Procedure

The experiment lasted approximately 45 min. All participants were informed that they would rate words for different characteristics. Participants were asked to watch a list of words displayed on the computer and were informed that there would be either 50 or 200 words (depending on condition). The participants were told that they would be given a memory test for the words. For the study list, words were consecutively and individually displayed on the computer screen for 5 sec each.

After the study list, participants were given the recognition task. The participants were instructed to write an *N* on the provided answer sheet if the onscreen word was not presented in the study list and to write a *Y* if the word was presented. The recognition task was participant paced. There were 100 items in the recognition task (50 nontargets and 50 foils).

Next, participants were given instructions and a short practice session for the word rating task. The participants rated words presented on the computer screen for pleasantness, concreteness, meaningfulness, or familiarity (each item was computer selected at random). They were told that each word would remain onscreen for 7 sec, so they would need to pace themselves accordingly.

Following the word rating instructions and practice, the participants were given the prospective memory instructions (via computer); they were told to remember to press the "1" key on the keyboard whenever they saw either of the two prospective memory targets in the word rating task. After the participants finished reading the instructions, they were asked to repeat them. Any participants who failed to repeat the instructions correctly were asked to reread the instructions until they were able to report them accurately.

Participants received an operation span task (Turner & Engle, 1989) as a gauge of working memory capacity. They received the instructions, followed by 3 practice trials, then 15 actual trials.

The word rating task followed. The participants were briefly reminded of the instructions for the word rating task, but were not reminded of the instructions for the prospective memory task. The word rating task presented 52 items: the 50 nontarget items and the 2 prospective memory targets. The items in the word rating task appeared on the computer screen with a rating scale ranging from 1 to 5 (1 meaning *not* and 5 meaning *very*), along with one of the four dimensions on which participants rated the given item. The participants wrote their answers on numbered answer sheets. Presentation of the nontarget items was randomized, but the prospective memory targets occurred on Trials 20 and 44. After the word rating task, the participants were given a retrospective memory questionnaire, where they were asked to recall the prospective memory targets and the intended action. All participants were able to accurately recall them.

RESULTS

An alpha level of .05 was used for all statistical analyses. The proportion of correct prospective memory responses was calculated. A prospective memory response was scored as correct if the "1" key was pressed when a prospective target was presented in the word rating task. There were no commission errors (intended actions performed at an inappropriate time). Also, 1 participant pressed the F1 key instead of the "1" key when the prospective memory target appeared, but immediately stated to the experimenter that it was an accident. This response was scored as correct. A two-way between-subjects ANOVA was computed on prospective memory performance, with prospective memory targets (either spaghetti and thread or eraser and steeple) and condition (high discrepancy or low discrepancy) as the factors. There was a significant main effect of condition (Ms = .77 and .50 for the high- and low-discrepancy conditions, respectively) [$F(1,44) = 5.04$, $MS_e = 0.18$, $p < .03$] and a significant main effect of prospective memory targets (M = .77 for spaghetti and thread, and M = .50 for eraser and steeple) [$F(1,44) = 5.04$, $MS_e = 0.18$, $p < .03$] (see Table 1). There was no significant interaction between the two conditions ($p > .12$).

Performance on the recognition task was analyzed as well. Because of a computer error, recognition data were available for only 33 out of the 48 participants (n = 20 for the high discrepancy condition, n = 13 for low discrepancy). A one-way between-subjects ANOVA calculating hits minus false alarms showed that four study trials (high discrepancy; M = 43.80, SD = 6.26) produced better recognition than did one study trial (low discrepancy; M = 30.46, SD = 9.94) [$F(1,31) = 22.51$, $MS_e = 62.27$, $p < .001$].

The operation span scores ranged from 0 to 27, with the modal score being 9.[3] As expected, the average score for the two conditions was not significantly different (M = 10.21, SD = 6.80 for the high-discrepancy condition; M = 10.88, SD = 3.75 for the low-discrepancy condition; $F < 1$). To investigate possible relationships between working memory and prospective memory performance, correlations were calculated separately for each condition and prospective memory target set. There were no significant correlations between prospective memory performance and operation span score ($r = .03$, $p > .92$ for the high-discrepancy group with eraser and steeple; $r = .31$, $p > .32$ for the low-discrepancy group with spaghetti and thread, and $r = .03$, $p > .92$ for the low-discrepancy group with eraser and steeple). A correlation could not be computed for the high-discrepancy condition with spaghetti and thread, because of perfect responding in prospective memory performance.

DISCUSSION

The five nontarget preexposures condition produced higher prospective memory performance than did the two

Table 1
Mean Prospective Memory Performance as a Function of Condition and Targets

	Condition			
	High Discrepancy		Low Discrepancy	
Prospective Memory Targets	*M*	*SD*	*M*	*SD*
Spaghetti/thread	1.00	.00	.54	.50
Eraser/steeple	.54	.50	.46	.45
Total	.77	.42	.50	.47

preexposures condition. We did not anticipate this pattern for a familiarity-based view (e.g., the familiarity-plus-search view; McDaniel, 1995). A familiarity-based view would have led us to anticipate better prospective memory performance with two preexposures, because with five preexposures, the nontarget items would have been more familiar to the participants than the prospective memory targets, resulting in poorer prospective memory performance.

The results did confirm the predictions of the discrepancy-plus-search view. The five nontarget preexposures condition presumably created high discrepancy between the quality and coherence of processing target events from the nontargets, whereas the two nontarget preexposures condition presumably produced lower discrepancy. An effect of prospective memory target item set was also found, such that participants who saw *spaghetti* and *thread* as prospective memory targets performed better than those who saw *eraser* and *steeple*. The fact that an effect of preexposure condition was consistently found across various prospective memory targets provides evidence that the discrepancy effect is not restricted to particular materials.

This pattern might also be explained by Smith's (2003) preparatory attentional and memory processes theory (PAM), which states that capacity-consuming processes (e.g., monitoring) and retrospective memory (e.g., target recognition) processes are required for prospective remembering. Perhaps preexposing the nontargets many times made it easier to discriminate between targets and nontargets during a recognition check, in comparison with preexposing nontargets fewer times. The present recognition data may be consistent with this suggestion, because studying the nontargets four times produced better subsequent recognition of the nontargets than did studying them once. Still, this result does not necessarily imply that recognition of the targets themselves would be better when presented with frequently studied nontargets than with less frequently studied nontargets.

Finally, there was no significant correlation between prospective memory performance and working memory. This finding is consistent with the idea that prospective memory does not necessarily involve special resource-demanding (monitoring) processes recruited specifically for prospective remembering (cf. Smith, 2003). The discrepancy-plus-search view would accommodate the absence of a correlation between prospective memory and working memory by the assumption that minimal, if any, additional resources are required in order to notice a prospective memory target. Even the search component (once the target is noticed) may require few additional resources, indicating that nominal working memory capacity is sufficient to support these processes (see Guynn & McDaniel, 2005; Marsh et al., 1998). However, the lack of correlation must be interpreted cautiously, because it is possible that our prospective memory measure was not reliable enough to reveal a correlation.[4] Clearly, more research is needed in order to better gauge the extent to which discrepancy-plus-search requires attentional resources for attributions following the experience of discrepancy, the search process, or both.

We acknowledge that prospective remembering may be mediated by a variety of processes, including monitoring-type processes, depending on factors such as the number of targets to which participants must respond (see McDaniel & Einstein, 2000, for details). For instance, Smith (2003, Experiment 3) found an interaction between working memory span and orthography of target, which suggested that prospective memory retrieval requires capacity, and thus provided evidence for the PAM theory. Importantly, that experiment had six different prospective memory target items, whereas the present experiment used two targets. Using six different targets has been found to stimulate the recruitment of attentional resources (monitoring) for prospective remembering (Einstein et al., 2005). Our objective in the present work was to identify one possible process that people might engage when strategic monitoring is not preferred or possible because of ongoing task demands.

REFERENCES

Balota, D. A., Cortese, M. J., Hutchison, K. A., Neely, J. H., Nelson, D., Simpson, G. B., & Treiman, R. (2002). *The English lexicon project: A Web-based repository of descriptive and behavioral measures for 40,481 English words and nonwords*. Washington University, St. Louis. Available at elexicon.wustl.edu.

Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General*, **125**, 159-180.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 115-141). Mahwah, NJ: Erlbaum.

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General*, **134**, 327-342.

Guynn, M. J., & McDaniel, M. A. (2005). *Does target-event noticing in prospective memory demand resources?* Manuscript submitted for publication.

Kelemen, W. L., Weinberg, W. B., Oh, H. S. Y., Sanford, E. K., & Kaeochinda, K. F. (2005). *Improving the reliability of event-based laboratory tests of prospective memory*. Manuscript submitted for publication.

Lund, K., & Burgess, C. (1996). Producing high-dimensional semantic spaces from lexical co-occurrence. *Behavior Research Methods, Instruments, & Computers*, **28**, 203-208.

Mäntylä, T. (1996). Activating actions and interrupting intentions: Mechanisms of retrieval sensitization in prospective memory. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 93-113). Mahwah, NJ: Erlbaum.

Marsh, R. L., Hicks, J. L., & Bink, M. L. (1998). The activation of completed, uncompleted, and partially completed intentions. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **24**, 350-361.

McDaniel, M. A. (1995). Prospective memory: Progress and processes. In D. L. Medin (Ed.), *The psychology of learning and motivation* (Vol. 33, pp. 191-221). San Diego: Academic Press.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, **14**, S127-S144.

McDaniel, M. A., Guynn, M. J., Einstein, G. O., & Breneiser, J. E. (2004). Cue focused and automatic-associative processes in prospective memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **30**, 605-614.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology Monographs*, **76**(1, Pt. 2), 1-25.

Reese, C. M., & Cherry, K. E. (2002). The effects of age, ability, and memory monitoring on prospective memory task performance. *Aging, Neuropsychology, & Cognition*, **9**, 98-113.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **29**, 347-361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **30**, 756-777.

Turner, M. L., & Engle, R. W. (1989). Is working memory task dependent? *Journal of Memory & Language*, **28**, 127-154.

Whittlesea, B. W. A., & Williams, L. D. (2001a). The discrepancy-attribution hypothesis: I. The heuristic basis of feelings of familiarity. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 3-13.

Whittlesea, B. W. A., & Williams, L. D. (2001b). The discrepancy-attribution hypothesis: II. Expectation, uncertainty, surprise, and feelings of familiarity. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 14-33.

NOTES

1. Note that discrepancy can result in different attributions. The major point is that task context is expected to influence how discrepancy is interpreted (Whittlesea & Williams, 2001a). In a recognition test, discrepancy would likely be attributed to familiarity. That is, an item generating the discrepancy is likely to be judged as having been seen before (in the study task). In other contexts, the feeling of discrepancy may be interpreted as signaling significance.

2. In HAL word frequency norms, the higher the numerical value of the word, the higher frequency (more frequent) the word.

3. The only 0-operation span score was a result of not writing down the words in order, not of a failure to remember any words.

4. Kelemen, Weinberg, Oh, Sanford, and Kaeochinda (2005) found significant test–retest reliability for event-based prospective memory using six prospective memory targets (presented one time each) under some circumstances; more targets were generally needed to produce reliability. In the present study, only two targets were used, and each was presented only once.

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