Consciousness and Cognition 20 (2011) 901–907

Contents lists available at ScienceDirect

Consciousness and Cognition

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

Short Communication

# On the role of imagery in event-based prospective memory

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ARTICLE INFO

*Article history:*
Received 14 February 2010
Available online 23 May 2011

*Keywords:*
Prospective memory
Imagery
Encoding
Context
Interference

ABSTRACT

The role of imagery in encoding event-based prospective memories has yet to be fully clarified. Herein, it is argued that imagery augments a cue-to-context association that supports event-based prospective memory performance. By this account, imagery encoding not only improves prospective memory performance but also reduces interference to intention-related information that occurs outside of context. In the current study, when lure words occurred outside of the appropriate responding context, the use of imagery encoding strategies resulted in less interference when compared with a standard event-based intention condition. This difference was eliminated when participants were not given a specific context to associate their intention (i.e., lures occurred within the appropriate responding context). These results support a cue-to-context association account of how imagery operates in certain event-based prospective memory tasks.

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## 1. Introduction

People often rely on external events to cue their intentions in the future. Labeled prospective memories, intentions for future actions are a critical component of human behavior. Prospective memory research is still in its early stages with most of the literature in the area dedicated to exploring cue detection and intention retrieval processes. Encoding processes are necessary for successful retrieval of future actions, however, they have been somewhat neglected in the experimental record (for a brief review see McDaniel & Einstein, 2007). Recent research in implementation intentions underscores the importance of investigating encoding and planning prospective memories (Cohen & Gollwitzer, 2008). In the present study, we investigated a slightly different strategy, namely imagery encoding, in planning intentions. Furthermore, we argue for a contextual-association account of the beneficial role of imagery in encoding prospective memories.

In standard event-based prospective memory tasks, participants are given an intention to respond to some environmental cue. These cues later occur in the context of an unrelated task (Einstein & McDaniel, 2005; Marsh & Hicks, 1998). For example, participants in a typical prospective memory experiment will form a standard encoding intention to make a special response if they encounter an animal word in the context of a lexical decision task. Recently, researchers have developed several other encoding strategies to facilitate participants' ability to respond to prospective memory cues. Forming an implementation intention, for example, increases prospective memory performance (PMP). Participants form implementation intentions by verbalizing their intention at encoding (e.g., participants state "when I see an animal word, I will make a special response"; McDaniel, Howard, & Butler, 2008). Moreover, imagery encoding (e.g., participants imagine themselves witnessing and responding to an animal word while performing the lexical decision task) has been paired with implementation intentions in some cases with the findings being mixed as to whether there are any additional benefits to PMP arising from

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1053-8100/$ - see front matter Published by Elsevier Inc.
doi:10.1016/j.concog.2011.02.015

imagery. Cohen and Gollwitzer (2008) have proposed that imagery is not a vital component of implementation intentions. In line with this notion, McDaniel et al. (2008) reported that imagery encoding alone did not increase PMP above that of standard encoding. However, Meeks and Marsh (2010) found that imagery encoding does produce benefits in PMP above that found in typical encoding conditions for nonspecific cues (e.g., respond to any animal). Thus, the specific role of imagery in encoding prospective memories remains an open topic for prospective memory researchers to explore. Based on many demonstrations of the beneficial effects of imagery encoding on retrospective memory (e.g., Paivio, 1969), it stands to reason that using this strategy to plan the future can have a variety of benefits for prospective memory. Therefore, the current study focused solely on comparing imagery encoding strategies with standard encoding strategies. Using mental imagery to visualize fulfilling intentions corresponds with recent research examining episodic future simulation in which participants rely on episodic memory to imagine future contexts.

At encoding, when participants have additional episodic information about the contexts in which prospective memory cues may occur, they successfully respond to more of the cues. For example, Brewer and Marsh (2010) had participants form an intention to respond to animals in three between-subject conditions. The level of specificity that participants used to encode their intention was manipulated such that some of the participants formed the intention to respond to animals at any point in the experiment before learning the ongoing task in which cues were to occur (i.e., low specificity). Other participants formed the intention to respond to animal words that occurred during the lexical decision task (i.e., standard instructions). In a final condition participants used an implementation intention plus imagery encoding strategy in which they closed their eyes, imagined observing an animal word while completing lexical decision trials, and repeated the statement "when I see an animal I will make a special response" (i.e., high specificity). As expected, participants in each condition had differential PMP where participants in the low specificity group responded to few cues and participants in the high specificity group responded to many cues. Although open to debate, imagery encoding paired with a verbalized implementation intention potentially allowed participants in the high specificity condition to create stronger cue-to-context associations at encoding. In a second experiment, participants either encoded their intention similarly to the standard instructions condition described earlier or they were given practice with the lexical decision task before encoding their intention. The hypothesis tested in this experiment was that providing participants with additional episodic information about the context in which cues would occur *before* encoding their intention could allow them to use that information to encode a more detailed representation of their future context leading to higher levels of PMP. The results from this second experiment supported our hypothesis and the notion that episodic memory and imagery are important components of forming intentions for the future. Therefore, to the degree that using an imagery encoding strategy depends on episodic memory simulation there may be a benefit to PMP.

Considering the aforementioned research, findings are mixed as to whether imagery encoding can facilitate prospective remembering with more recent evidence suggesting a beneficial role of imagery encoding of prospective memories (Meeks & Marsh, 2010; cf. McDaniel et al., 2008). If imagery is beneficial, how does it facilitate encoding prospective memories? Perhaps imagery fosters a cue-to-context association. By this logic, imagery would also reduce interference to temporarily irrelevant intention-related material (i.e., a lure) that occurs outside of the expected context. Whenever an event-based cue is processed, successful intention completion is dependent upon a microstructure of separate cognitive processes. There are at least four component processes of the microstructure of PMP: recognition of the event-based cue, verification of the appropriateness of the cue/context, retrieval of the target action, and coordination of the target response with ongoing task demands (Loft & Yeo, 2007; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Marsh, Hicks, & Watson, 2002). Furthermore, interference to lures functionally relates to the microstructure itself (Knight, Ethridge, Marsh, & Clementz, 2010; Marsh, Hicks, & Cook, 2008). Cues encountered outside of the appropriate context and partial-match lures encountered inside of the appropriate context create response competition by influencing the component processes of PMP (i.e., lure interference; Taylor, Marsh, Hicks, & Hancock, 2004).

We argue that one role of imagery in encoding event-based intentions is to strengthen the cue-to-context association which results in three consequences for ongoing task processing. First, given a strengthened association between cues and a future context in which they are to occur, an elaborately encoded intention will become active when the appropriate context arrives leading to higher levels of PMP (Marsh, Hicks, & Cook, 2006). Second, when context is a critical component of the encoded intention, imagery will allow participants to more quickly verify that cues are in the correct context. Third, participants will verify and subsequently reject intention-related information that occurs outside of the appropriate context more quickly given the stronger cue-to-context association. By the cue-to-context association account, imagery encoding most likely facilitates the verification stage of the microstructure but also may have important consequences for the other processes (e.g., recognition of the cue).

The current experiments examined the role of imagery in prospective memory by seeking to elucidate its benefit to PMP, lure interference, and cue interference. Additionally, the current experiments test the prediction that facilitated contextual processing is afforded by imagery encoding. As such, we used a context-linking paradigm in which we asked the participants to respond to animal words beginning with the letter "c" which occurred in the third phase of a three-phase study (Marsh et al., 2006). In addition to the third-phase cues, we also embedded lures in the first phase that were to be ignored. In Experiment 1B, we requested that participants plan to respond to event-based cues during any part of the experiment, and we embedded partial-match cues (i.e., lures) throughout the first and third phases of the experiment. We chose c-animal prospective memory cues in the current experiments so that we could insert lures that would create interference both out-of-context (c-animals in the first phase) and in context (animals that begin with a letter other than "c"). Previous research from our laboratory has demonstrated that either type of lure can generate lure interference when participants possess an intention to respond to c-animals (Knight et al., 2011). In Experiment 1A, we predicted that imagery would reduce interference caused by both relevant cues and irrelevant lures through a stronger cue-to-context association. This stronger association should speed the verification process in and out of the correct context. Considering the high levels of PMP observed with contextually-linked intentions (Knight et al., 2011; Marsh et al., 2006), we expected both encoding conditions to exhibit high PMP thereby limiting our ability to find a benefit to PMP. By removing the inappropriate context in Experiment 1B, participants should have little need to verify that they are in the correct context. Additionally, we sought to replicate the benefit of imagery on PMP with intentions that are not context-linked. (Meeks & Marsh, 2010). In both experiments, we compared a standard event-based prospective memory encoding condition with an imagery encoding condition.

## 2. Experiment 1A

### *2.1. Methods*

#### *2.1.1. Participants*

Undergraduate students from the University of Georgia volunteered in exchange for partial credit towards a research appreciation requirement. The participants tested in individual sessions lasting approximately 25 min. We equally assigned 80 participants to one of two between-subject conditions.

#### *2.1.2. Materials and procedure*

We instructed the participants that they were going to take part in a three-phase experiment and that two phases (phases 1 and 3) of the experiment would involve making word and nonword judgments to strings of letters (i.e., Lexical Decision Task; LDT). A demographic survey (phase 2) separated the two LDT phases of the experiment. For each LDT phase, the program presented 105 letter strings, of which 52 were valid English words and 53 were pronounceable nonwords. After a response, each letter string was removed from the screen then "waiting" appeared for 3 s between each trial. Phase 2 was held constant, where the experimenter allotted 1 min to complete the demographic survey which consisted of questions about year in school, major, number of classes, etc. (for detailed stimuli and task characteristics see Marsh et al., 2006).

Participants read the instructions on the computer screen that informed them of the appropriate key presses for a word versus a nonword. Participants in both conditions were also told that we were interested in their ability to remember to perform an action in the future. If they encountered an animal word that begins with the letter "c" (e.g., cougar) in the third phase of the experiment, they were to make their word judgment as usual and then press the "/" key during the "waiting" message between trials. Eight c-animal items were randomly selected and four were embedded on the 25th, 50th, 75th, and 100th trials of phase 1 (lures) and the other four were embedded in phase 3 (cues) of the lexical decision tasks. The four c-animal cues included *cat, crow, camel, and cheetah,* while the four c-animal lures were *cow, colt, cobra, and chicken*. During the first phase of the experiment, these items were considered lures and should not have received a "/" key response.

The two conditions differed according to instructional manipulations: standard encoding versus imagery encoding. Participants in the standard encoding condition were told "... by the way, if you ever notice an animal word that begins with the letter "c" during the third phase of word-nonword judgments please press the word key and then press the "/" key during the waiting message." In the imagery condition, after receiving these same instructions, participants were instructed to "close your eyes for 30 s and imagine seeing a c-animal word in the third phase, and then imagine performing the appropriate word response followed by pressing the "/" key during the waiting message." After the experimenter reiterated the instructions and was sure that the participant fully understood the requirements, we administered a 2-min distractor task (i.e., a multiplication task). After this task, we did not mention the intention to respond to c-animals again.

## 3. Results and discussion

The proportion of c-animal cues which received a "/" key response was scored as PMP. We counted late responses as incorrect due to their infrequency and their lack of influence on the results. Average word latencies were defined as participants' mean reaction times to identify words correctly in each phase of the LDT. We defined cue interference as mean LDT reaction time to successful cue response trials occurring in phase 3 and lure interference as mean LDT reaction time to lures occurring in phase 1.[1] To control for differences in participants' average word latencies, cue and lure interference measures had phases 3 and 1 average word latencies subtracted from them respectively. We trimmed reaction times at 2.5 standard deviations within trial type. Three participants responded to lures occurring in the first phase and we replaced their data. As summarized in Table 1, the two instructional manipulations did not differentially affect PMP, $t(78) = -.866$. This result is consistent with prior research demonstrating high levels of PMP with a contextually-linked intention (Marsh, Hicks, & Cook, 2006). Also

[1] We included control words that were matched to the cues on a variety of dimensions known to influence reaction times (for a discussion of this issue see Marsh et al., 2002). Importantly, we matched both the cues and the control words to the other words in the lexical decision task. There were virtually no differences between reaction times for control words and ongoing lexical decision words. Therefore, we used the ongoing word trials as our control to provide a more stable measure of ongoing task processing to compare against any interference caused by lures. We argue here that when there are no differences in appropriately matched control and ongoing task reaction times then it is appropriate to use overall reaction times in lieu of only control word reaction times.

**Table 1**
Mean (standard error) performance for Experiments 1 and 2.

| | PMP | Average Word Latencies | | Cue interference | Lure interference |
|---|---|---|---|---|---|
| | | Phase 1 | Phase 3 | | |
| *Experiment 1* | | | | | |
| Standard | .91 (.02) | 648.61 (17.74) | 709.10 (19.60) | 124.21 (23.09) | 113.41 (15.91) |
| Imagery | .88 (.04) | 626.53 (15.04) | 683.93 (15.58) | 65.71 (19.65) | 63.52 (13.09) |
| *Experiment 2* | | | | | |
| Standard | .74 (.03) | 662.40 (12.42) | 651.23 (12.03) | 149.54 (25.98) | 88.52 (6.95) |
| Imagery | .85 (.03) | 679.50 (13.17) | 675.17 (11.84) | 114.50 (20.52) | 85.40 (8.17) |

*Note*: Because of differences in average word latencies in Phases 1 and 3, it is inappropriate to directly compare the Lure and Cue interference measures.

consistent with previous research on contextually-linked intentions (Marsh et al., 2006), average word latencies were significantly slower for phase 3 when the intention was activated, as compared with phase 1, $F(1, 78) = 62.476$, $p < .001$, $\eta_p^2 = .445$. There were no other differences in average word latencies or an interaction between phase and condition. Moreover, there was a marginal effect of condition on cue interference. LDT latencies to cues were increased more so in the standard encoding condition than in the imagery condition, $t(78) = -1.930$, $p = .057$, $d = .432$. This trend may be indicative of facilitation to the verification stage when there is a contextual association formed between the cues and the ongoing task processing at encoding. Further, there was a significant effect of condition on lure interference (i.e., slowing to c-animal words in phase 1) with participants in the standard encoding condition having significantly longer latencies to respond to lures than participants in the imagery condition, $t(78) = -2.422$, $p < .05$, $d = .542$.

Although speculative at this point, perhaps the contextual association formed at encoding in the imagery condition facilitated the verification stage of the microstructure insofar as a strong cue-to-context association made participants faster at verifying that c-animal lures in phase 1 were not valid cues and that c-animals in phase 3 were cues (though the latter effect was marginal). If this interpretation is correct, then one could hypothesize that removing the inappropriate context should nullify the facilitating role of imagery on the verification stage of the microstructure. The next experiment addressed this specific prediction by using a similar paradigm to Experiment 1A in which participants formed an intention to respond to c-animals any time they encountered them during the experiment instead of specifically linking the intention to the third phase. Additionally, considering that PMP did not differ across conditions, we sought to examine in Experiment 1B if imagery encoding would increase PMP above that of the standard condition when the intention was not context-linked (e.g., Meeks & Marsh, 2010). It is also possible that cue-to-context associations do not increase PMP through verification processes, but rather by some other process (e.g., recognition of the cue).

## 4. Experiment 1B

### *4.1. Methods*

#### *4.1.1. Participants*

Undergraduate students from the University of Georgia volunteered in exchange for partial credit toward a research appreciation requirement. We tested a larger number of participants to have sufficient power to replicate the effect of condition on lure interference found in Experiment 1A. Roughly 60 participants were needed in each condition to have 95% power to detect a lure interference effect of the same magnitude of that found in Experiment 1A at $\alpha = .05$ (G∗Power v.3; Erdfelder, Faul, & Buchner, 1996). Fifty-five participants were randomly assigned to the imagery encoding group and 60 were assigned to the standard encoding group.

#### *4.1.2. Materials and procedure*

In Experiment 1B, we utilized the exact same materials and procedure from Experiment 1A with two exceptions. First, the intention to respond to c-animals was not associated to the third phase of the experiment. Participants were instructed to press the "/" key if they saw an animal word that begins with the letter "c" at any point during the experiment. Second, two c-animal words appeared in both phases 1 and 3. The program randomly selected four c-animal cues from the same eight c-animals used in Experiment 1A. Unbeknownst to the participant, both phases 1 and 3 also had two partial-match lures that were animal words beginning with a letter other than "c"; therefore, the lures matched semantically, but not orthographically. These cues included *fox, sheep, tiger* and *zebra.* This change in lure type was necessary because prospective cues would include all c-animals due to the lack of a contextual association in this experiment (for a more detailed explanation of interference from different lure types see Marsh et al., 2008).

## 5. Results and discussion

As shown in Table 1, the imagery encoding manipulation differentially affected PMP, $t(114) = -2.106$, $p < .05$, $d = .393$. In line with recent findings, imagery encoding improved prospective memory performance above that of standard encoding

(Meeks & Marsh, 2010). Concerning ongoing task processing (i.e., average word latencies), the main effects of condition and phase, as well as the interaction were not significant, largest $F(1114) = 2.167$. Therefore, average word latencies were equivalent across both phases 1 and 3 LDTs. Also, lure interference and cue interference did not differ between conditions, $t(114) = .292$ and $t(114) = 1.058$, respectively. Given that we expected null differences in Experiment 1B, we also calculated the odds in favor of the null hypothesis using Rouder and colleagues (2009) Bayes factor statistic. The Bayes factor is useful in situations where no difference is expected between two conditions because it estimates the odds in favor of the null hypothesis. The odds in favor of no difference in lure interference and cue interference between the imagery and standard encoding conditions were roughly 6 to 1 and 4 to 1, respectively. Thus, the evidence in favor of the null hypothesis supports a cue-to-context account of the benefits of imagery encoding on contextual verification processes. The finding of PMP differences in this experiment but not in Experiment 1A suggests that speeded verification may not be responsible for the benefit of imagery on prospective memory performance. This idea is discussed further in the next section.

## 6. General discussion

The two experiments presented herein demonstrate a clear dissociation between standard and imagery encoding conditions in event-based prospective memory. Imagery encoding facilitated several important aspects of intention fulfillment. In Experiment 1A, lures encountered outside of the appropriate context incurred differential levels of interference between standard and imagery encoding conditions, whereas in Experiment 1B, lures encountered in context had equivalent levels of interference. More specifically, imagery encoding increased the cue-to-context association and thus reduced interference to lures encountered outside of the appropriate context. In addition, there was a marginal effect of imagery on cue interference in Experiment 1A such that imagery reduced reaction times on successful cue trials. All of these results are predictable from a component process theory of event-based prospective memory in which strengthening the cue-to-context association at encoding facilitated the specific processes of the microstructure of PMP (Marsh et al., 2002). In Experiment 1A, participants needed to verify whether they were in the correct context due to the presence of an inappropriate context. We propose that imagery strengthened the cue-to-context relationships, thus resulting in lower cue and lure interference. In Experiment 1B, the participants were always in the correct context and thus did not necessarily need to verify whether they were in the appropriate context. This lack of a need for contextual verification would account for the null interference effects in Experiment 1B.

Encoding prospective memories can be an active process that relies upon episodic memory, planning, and coordination in order to form an intention to perform some behavior in the future (Brewer & Marsh, 2010). During such encoding, multiple associations are formed which include associations to the encoding context, associations between the cue and the target action, and associations between the cue and the future context in which the intention is to be fulfilled. Memory researchers have long since thought that imagery facilitates associations in encoding of retrospective memories (Bower, 1970). As argued throughout, we propose that using imagery while encoding plans for the future strengthens contextual associations. Context is an important determinant in the successful formation and fulfillment of prospective memories (for a review see Marsh et al., 2008). Context determines when it is necessary to engage attentional processes to monitor for occurrences of prospective cues, and specifically linking an intention to a context results in high levels of PMP (Experiment 1A; Marsh et al., 2006). The present data demonstrate that engaging in imagery at encoding serves to better specify the contextual information that is relevant to the intention which facilitates the ease with which one can verify if the characteristics of the current context match those that are associated to the cue. This facilitation of the verification process in turn protects one from distraction by intention-related material that is encountered outside of the appropriate context. Continuously having one's attention captured by material related to a future intention could be quite detrimental to ongoing activities one is engaged in before the opportunity to fulfill the intention occurs. Thus, relying on imagery to strengthen the association between event-based cues and the appropriate responding context would be a worthwhile strategy when encoding an intention.

Importantly, there are other sub processes in addition to verification that imagery encoding may influence (e.g., recognition of the cue). Therefore, an important area of future research will be to develop experimental manipulations that selectively highlight the role of imagery on the component processes of the event-based prospective memory microstructure. In fact, other processes in the microstructure could account for PMP benefits due to imagery. In Experiment 1B, imagery encoding significantly increased PMP (see Meeks & Marsh, 2010 for a similar finding). However, we did not find this effect in Experiment 1A. One possibility is that this null PMP effect is due to the additional cue provided by the context-linking procedure (Marsh et al., 2006). Another related possibility is that speeded verification is not the primary reason why imagery increases PMP with a categorical intention. Meeks and Marsh suggested that one possibility for this improvement is heightened retrieval sensitivity. This increased sensitivity is more analogous to the initial recognition stage of a component process view (Loft & Yeo, 2007; Marsh et al., 2002, 2003). Forming a strong cue-to-context association during imagery encoding may also facilitate the recognition component of the microstructure. The provision of a temporal contextual cue (e.g., context-linking in Experiment 1A) that leads to high PMP, regardless of the type of encoding engaged (see Marsh et al., 2006), likely masked the imagery effects on recognition. The careful reader might expect that if imagery did indeed facilitate the initial recognition of the cues in Experiment 1B, cue interference should have been lower in the imagery condition. The measurement of cue interference, however, only includes successful cue trials. Therefore, all cues that contribute to the cue interference measures have already exceeded the recognition threshold. Increased retrieval sensitivity manifests through increased

PMP in the imagery condition and not necessarily in decreased conditional measures of cue interference. This notion is consistent with the idea that there is not always a direct relationship between PMP and interference measures (Marsh et al., 2003).

In the present paper we provide some of the initial evidence for the cue-to-context association account of imagery encoding in prospective remembering. Future work is also needed to examine how imagery encoding influences cue-to-context associations when different types of contexts are manipulated. The contextual manipulation implemented here was primarily temporal (i.e., the appropriate context of phase 3 occurs after phases 1 and 2). Future manipulations could define context according to perceptual attributes (e.g., background color) or cognitive operations (e.g., type of processing required by the task). Additionally, as the present findings add to a growing body of evidence that suggests a beneficial role of imagery encoding in prospective memory, researchers would be wise to explore how imagery encoding and implementation intentions differ on standard dependent variables typically measured in prospective memory (e.g., PMP, task interference, and cue interference) with and without context manipulations.

Though we propose that increased contextual associations produced the present effects, other theoretical explanations are possible. Participants, for example, may have generated c-animals during the encoding phases of our experiments (Ellis & Milne, 1996). The imagery phase may have afforded the participants more opportunity to generate exemplars. Generation of c-animal exemplars could have created a priming effect and ultimately been responsible for some of our results such as the decreased cue and lure interference in Experiment 1A. More specifically, the initial activation of c-animals may have made those items more accessible and thus led to faster response times (see Mäntylä, 1993 for a related idea). While it is certainly possible that this priming would speed the initial recognition of the lure in the inappropriate context, pervious generation might also create a stronger association between the generated exemplars and the encoded intention. Recent research has demonstrated that out-of-context lures elicit spontaneous cue-related processing (Knight et al., 2011). Given that the participant could not predict whether the c-animals they generated would be a lure or a cue, participants would still need a strong contextual association to reject the lure once these cue-related processes were activated. Further, a pure generation account would predict that c-animals would be primed in Experiment 1B, and thus, we should have observed decreased cue and lure interference for the imagery condition there as well. This absence of priming in these cases weakens the explanatory power of the generation account for these data. Nevertheless, future research is needed to fully differentiate the cue-to-context and a generation accounts.

Component process theories of event-based prospective memory provide a framework in which dissociations between various intentions can be uncovered. We argue here that imagery encoding fosters a cue-to-context association that serves at least two purposes related to event-based intentions. When people encode their intentions using imagery, they create strong contextual associations that facilitate cue verification processes, and potentially recognition processes. The overlap between the encoded intention and the appropriate context seems to determine how quickly one verifies cues in the appropriate context and rejects irrelevant information in the incorrect context. Furthermore, establishing elaborate intentions (via imagery encoding) may operate to increase retrieval sensitivity and thus increase PMP (Meeks & Marsh, 2010). Implementation intentions, episodic future simulation, and now imagery encoding are garnering more attention from researchers and greatly enhancing our understanding of the relation between encoding and retrieval processes in prospective memory. Clearly, this work demonstrates that imagery is an important encoding strategy in terms of successful prospective memory fulfillment and contextual verification processes.

## Acknowledgment

We thank Kelly Tracey, Jason Kinney, and Kristi Jackson for their assistance in collecting the data.

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