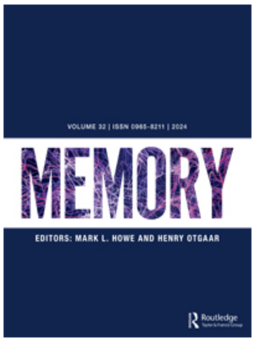

Memory

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/pmem20

Isolating the effects of visual imagery on prospective memory

Joseph W. Abel, Rachel J. Anderson, Graham M. Dean & Stephen A. Dewhurst

To cite this article: Joseph W. Abel, Rachel J. Anderson, Graham M. Dean & Stephen A. Dewhurst (28 Mar 2024): Isolating the effects of visual imagery on prospective memory, Memory, DOI: 10.1080/09658211.2024.2335302

To link to this article: https://doi.org/10.1080/09658211.2024.2335302

Published online: 28 Mar 2024.

MEMORY
https://doi.org/10.1080/09658211.2024.2335302

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Isolating the effects of visual imagery on prospective memory

Joseph W. Abel[a], Rachel J. Anderson [a], Graham M. Dean [b] and Stephen A. Dewhurst [a]

[a]School of Psychology & Social Work, University of Hull, Cottingham Road, Hull HU6 7RX, UK; [b]University of Sunderland, Sunderland, UK

ABSTRACT
Two experiments investigated the role of visual imagery in prospective memory (PM). In experiment 1, 140 participants completed a general knowledge quiz which included a PM task of writing a letter "X" next to any questions that referred to space. Participants either visualised themselves performing this task, verbalised an implementation intention about the task, did both, or did neither. Performance on the PM task was enhanced in both conditions involving visual imagery but not by implementation intentions alone. In experiment 2, 120 participants imagined themselves writing a letter "X" next to questions about space, or in a bizarre imagery condition imagined themselves drawing an alien next to those questions. Relative to the control condition, PM was significantly enhanced when participants imagined writing a letter "X" next to the target questions, but not by the bizarre imagery task. The findings indicate that the robust effects of imagery observed in retrospective memory also extend to PM.

ARTICLE HISTORY
Received 24 October 2023
Accepted 19 March 2024

KEYWORDS
Prospective memory; visual imagery; implementation intentions; bizarre imagery

Visual imagery plays an integral role in many aspects of human memory. Visual images are a core element of autobiographical memories (Brewer & Pani, 1996; Conway & Pleydell-Pearce, 2000) and give rise to the sense of "reliving" past experiences (Rubin et al., 2003). In lab-based studies, memory for verbal stimuli is enhanced by the generation of visual images (Bower, 1970; Durso & Johnson, 1980). Relative to low-imagery words, high-imagery words are more memorable (Paivio, 1971; Richardson, 1975) and more effective cues for the retrieval of autobiographical memories (e.g., Anderson et al., 2017; Williams et al., 1999). In addition to memory, visual imagery also supports future-oriented processes such as "episodic future thinking" (e.g., Anderson et al., 2012; Atance & O'Neill, 2001; D'Argembeau & Van der Linden, 2006; Schacter et al., 2008) and the maintenance of personal goals (Conway et al., 2004). Yet, despite numerous demonstrations of the importance of visual imagery in memory and future thinking, research into the effects of visual imagery on *prospective memory* (PM) is inconclusive. This is due in part to a confound between the effects of imagery and the effects of other strategies such as "implementation intentions", in which participants verbalise an intended action. We report two experiments in which we attempted to isolate the effects of visual imagery on PM.

PM has been defined as "remembering to carry out intended actions at an appropriate point in the future" (McDaniel & Einstein, 2007, p. 1; for a recent theoretical review see Rummel & Kvavilashvili, 2023) and can be either time-based or event-based. In time-based PM tasks, participants have to remember to carry out an intended action at a designated time in the future (e.g., phoning a friend at 5pm). In contrast, event-based PM tasks require one to remember to carry out an intended action in response to a particular cue, which might occur at any time (e.g., passing on a message the next time one sees a friend). Time-based PM tasks can be supported by external aids such as alarms and reminders. Although some event-based PM tasks can be supported by external aids (e.g., shopping lists; see Block & Morwitz, 1999), they typically place more responsibility on the individual to remember the task when the cue is encountered. This has prompted research into cognitive strategies to support event-based PM.

A number of studies have shown that performance in event-based PM tasks is enhanced when participants generate implementation intentions (see Chen et al., 2015, for a review). Originally developed by Gollwitzer (1999), implementation intentions are a goal-directed strategy along the lines of "When situation *x* arises, I will perform response *y*". Subsequent research has shown that they are also effective methods of enhancing PM. A common experimental method for investigating PM is to embed a PM task within an ongoing activity. For example, Cohen

CONTACT Stephen A. Dewhurst s.dewhurst@hull.ac.uk School of Psychology & Social Work, University of Hull, Cottingham Road, Hull HU6 7RX, UK

and Gollwitzer (2008) presented participants with a lexical decision task that included three unassociated word pairs. The PM task was to say the corresponding word whenever the other member of the pair appeared. Compared to a control condition in which participants received verbal instructions, PM was enhanced by an implementation intention in which participants repeatedly wrote down the phrase "If I see the word *window* at any point in the task, then I will say *wrapper* as fast as possible!". In a similar study, Zimmermann and Meier (2010) found that PM performance in a lexical decision task was enhanced when participants repeatedly read aloud the instructions "Whenever I see an animal word I will press the 1-key with my left index finger as quickly as possible".

As noted by Chen et al. (2015), different forms of implementation intentions have been developed, some of which instruct participants to also imagine themselves performing the intended action. For example, Chasteen et al. (2001) gave participants a battery of tests and asked them to write the day of the week on each sheet of paper they were given. Participants in the implementation intention condition were instructed to state this task out loud and also to picture themselves performing the task. Relative to a control group who were simply given verbal instructions, participants in the implementation intention condition showed enhanced performance on the PM task. However, when verbal intentions and imagery are combined in this manner, it is impossible to determine whether any enhancement of PM is produced by participants verbalising the instruction, picturing themselves performing the task, or the combination of the two.

Studies that have attempted to isolate the effects of visual imagery on PM have often failed to find significant effects. For example, Guynn et al. (1998) found that PM was enhanced by verbal reminders of the task but not by imagery instructions. Participants completed an ongoing task of word fragment completion (or anagram solution in one experiment) in which the PM task (circle a target word whenever it appears in the ongoing task) was embedded. The main focus of the study was on the effect of verbal reminders on PM. In this regard, Guynn et al. found that performance was improved by reminders that made reference to the intended action or to both the action and the target, but not by reminders that referred only to the target. The most salient finding from the perspective of the current study was that the effect of action plus target reminders was not enhanced, and was in fact reduced, by the addition of instructions to imagine oneself performing the action. In a similar vein, Einstein et al. (2003) found that performance on a PM task (press the / key when a red screen is shown) embedded in a sequence of computer-based tasks was not enhanced by instructions to visualise oneself performing the task. One limitation of this study was that participants were only allowed 6 s to visualise themselves performing the task. However, both Chasteen et al. (2001) and McDaniel et al. (2008) found that PM was not enhanced by visual imagery when participants were allowed 30 s to imagine themselves performing the task.

In contrast, some studies have found significant effects of imagery independent of the effects of implementation intentions. For example, Meeks and Marsh (2010) used an ongoing task of lexical decision and compared a control condition of pressing the / key whenever an animal word appeared with two experimental conditions, both of which they referred to as implementation intentions. In the first, participants were instructed to visualise themselves performing the target action (essentially an imagery condition without a verbal implementation intention). In the second, participants received the same visualisation instructions followed by an on-screen instruction to say aloud "When I see an animal word, then I will press the slash key!". Performance on the PM task was enhanced both by imagery alone and by the combination of imagery and implementation intentions.

A significant effect of visual imagery was also reported by McFarland and Glisky (2012), who used an ongoing task of answering general knowledge questions in which the PM task was to press the "6" button whenever a question referred to US States. In the "read only" condition, the sentence "If you see questions pertaining to 'states', you should press the '6' key" appeared on the screen and participants read it silently. Participants in the implementation intention condition were given the instructions "When I see the word 'state,' I will press the '6' key". They were asked to write this instruction on a sheet of paper and read it aloud to the researcher. In the imagery condition, participants were asked to imagine themselves seeing a question about states and pressing the "6" key in response to the question. Participants in the combined imagery and implementation intention instructions spent 15 s imagining themselves pressing the "6" key and then wrote and read aloud the implementation intention. McFarland and Glisky found significant effects of imagery, whereby PM was enhanced relative to the "read only" condition, and equivalent to performance in the implementation intention and combined conditions.

Scullin et al. (2017) also found a significant effect of visual imagery in a lexical decision task that included the PM task of pressing the Q key whenever the letter string was the name of a fruit. They found that imagery enhanced the PM task both without a verbal implementation intention (experiment 2) and when combined with a verbal implementation intention. Comparing across experiments, Scullin et al. concluded that verbal implementation intentions and imagery have additive effects. More recently, Henry et al. (2020) found that a combination of implementation intention and imagery instructions enhanced event-based PM in older adults.

As noted above, visual imagery supports other future-oriented processes such as "episodic future thinking" (EFT; Anderson et al., 2012; Atance & O'Neill, 2001; D'Argembeau & Van der Linden, 2006; Schacter et al., 2008). Both EFT and PM illustrate the future-oriented nature of memory (see Klein et al., 2011). Given this overlap, some studies have investigated whether EFT enhances PM. For example, Neroni et al. (2014) asked participants to complete a computer-based task on two consecutive days. The ongoing task required participants to decide whether or not a series of verbs contained double consonants. The PM task was to press the space bar whenever designated target items appeared. After completing the task on the first day, participants were taken to a new lab where the second session would take place the following day. Participants were then assigned to (i) an EFT condition in which they imagined the sequence of events they would follow in order to complete the second task, starting with their arrival at the university, (ii) a map condition in which they drew a map of the university indicating the places they attended, or (iii) a control condition in which they completed the Italian version of the State-Trait Anxiety Inventory (Lazzari & Pancheri, 1980). The main finding was that PM performance was highest for participants in the EFT condition. It is notable, however, that the EFT group were also slower at responding to the ongoing task, suggesting that EFT involves considerable cognitive resources that may inhibit task performance. In contrast, McFarland and Glisky (2012) found that imagining the specific PM task increased PM performance with no deficit in the ongoing task or in a subsequent recognition test for words presented in the ongoing task.

It is clear from the inconsistent findings discussed above that the question of whether visual imagery alone can enhance PM has not been conclusively answered, in part due to the use of instructions that combine or conflate imagery and implementation intentions. The aim of the current studies was to isolate the effects of visual imagery on PM. In experiment 1, imagery and implementation intentions were manipulated in a fully factorial design. Participants took part in an ongoing task of answering general knowledge questions, in which a PM task (Write an "X" next to any question relating to space) was embedded. Prior to the general knowledge quiz, participants received one of four types of instructions: visual imagery, implementation intentions, both visual imagery and implementation intentions, or neither. Based on the findings of Cohen and Gollwitzer (2008) and Zimmermann and Meier (2010), we predicted a main effect of implementation intention. Based on the findings of Meeks and Marsh (2010) and McFarland and Glisky (2012), alongside studies showing powerful effects of visual imagery in retrospective memory (e.g., Durso & Johnson, 1980), we also predicted a main effect of imagery. If, as Scullin et al. (2017) suggested, verbal implementation intentions and visual imagery have additive effects, PM performance should be highest in the combined condition. Such a pattern would also be consistent with dual-coding theory (Paivio, 1971) which states that visual and verbal processes create separate representations. Following on from experiment 1, experiment 2 investigated whether PM is influenced by the type of images participants are instructed to imagine.

Experiment 1

Method

Participants

A priori power analysis using G*Power (Faul et al., 2007) with a medium effect size ($f = .25$) and power of .80 suggested a minimum of 136 participants were required. A total of 140 undergraduate and postgraduate students took part, of whom 105 identified as female and 35 as male, ranging in age from 18 to 54 ($M = 22.99$, $SD = 7.38$). All were fluent English speakers. There were 35 participants in each of the four conditions. Participants were tested individually and received either course credit or a gift voucher for their participation.

Design and stimuli

The experiment used a factorial 2 (visual imagery: present vs absent) x 2 (implementation intention: present vs absent) between-subjects design. Participants completed two experimental tasks, the second of which contained the PM task. For the first task, a series of 90 anagrams were derived from members of familiar categories, such as animals or musicians. This was used as a filler task between the PM instructions and the PM task. The PM task consisted of a general knowledge quiz containing 100 questions covering a variety of subjects, six of which contained direct references to space/astronomy. These appeared in positions 26, 41, 57, 67, 88, and 99 for all participants. Examples included "In which year did humans first land on the moon?" and "What is the largest planet in the solar system?". These served as target items for the prospective memory task. Stimuli are available from the corresponding author on request.

Procedure

Participants were tested individually in a single one-hour session, which took place in a laboratory setting within the School of Psychology and Social Work at the University of Hull. All participants were informed that they would be asked to complete a number of pen and paper tasks, one of which was a free response general knowledge quiz containing 100 questions covering a variety of subjects. After providing informed consent, participants received the PM instructions for the general knowledge quiz, according to the condition to which they were assigned. In the control condition, participants were verbally instructed to "write an X next to any question relating to space" with no instructions to generate images or form implementation intentions. Participants in the implementation intention condition were asked to write down and read aloud the instruction "If I see a question relating to space, then I will write an X next to it" and then to read the same instruction aloud for a further 30 s. Participants in the imagery condition were given the instructions "Imagine yourself in this room answering questions as part of a quiz. When you see a question about space you are going to take the pen and write the letter X next to that question". Participants were given 30 s to visualise this. Finally, participants in the combined condition were asked to write down and verbally state the implementation intention, and then spend 30 s visualising themselves performing the PM task.

Following this, participants began the anagram task, in which they were asked to attempt to solve every anagram on each page, progressing through one page at a time. Participants were given a time limit of three minutes per page, with a timed alarm informing them to progress to the next page. Immediately following the anagram task, participants began the general knowledge quiz. This activity did not have a time limit per page, although participants were informed that they had a total of 25 min to complete the quiz. Participants were asked to attempt to answer every question.

Results and discussion

The numbers of trivia questions correctly answered and the numbers of PM tasks correctly executed were analysed in separate 2 (implementation intention: present versus absent) x 2 (imagery instruction: present versus absent) between-groups ANOVA. Analysis of trivia questions correctly answered showed nonsignificant main effects of implementation intention and imagery and a nonsignificant interaction, all *F*s < 1. Mean proportions of trivia questions correctly answered are shown in Table 1.

In the analysis of PM tasks correctly executed, the main effect of implementation intention was not significant, $F < 1$. There was, however, a significant main effect of imagery, $F\ (1{,}136) = 7.24$, $MSE = 3.32$, $p = .008$, $\eta_p^2 = .051$. Table 2 shows that PM scores were higher in the two imagery conditions than in the two non-imagery conditions. The interaction between implementation intention and imagery instruction was not significant, $F < 1$. Table 2 shows mean proportions of PM tasks correctly executed as a function of implementation intention and imagery instructions.

The main finding from experiment 1 is that PM was enhanced when participants were asked to imagine themselves performing the target action. This enhancement occurred regardless of whether or not imagery instructions were combined with implementation intentions. These findings are consistent with those of Meeks and Marsh (2010) and McFarland and Glisky (2012) who found that imagery instructions enhanced PM both alone and in combination with implementation intention instructions. In contrast to the findings of McFarland and Glisky and Zimmermann and Meier (2010), PM was not enhanced by implementation intentions alone. The findings also contrast with those of Scullin et al. (2017) who suggested that implementation intentions and visual imagery have additive effects. Scullin et al. acknowledged, however, that this suggestion was based on cross-experiment comparisons that should be treated with caution.

Table 1. Mean proportions (and standard deviations) of trivia questions correctly answered as a function of implementation intention and imagery instructions.

	Imagery	No-imagery	Mean
Implementation intention	.42 (.14)	.40 (.19)	.41 (.17)
No implementation intention	.41 (.16)	.38 (.15)	.40 (.16)
Mean	.42 (.15)	.39 (.17)	

Experiment 2

Experiment 1 showed that imagining oneself performing an intended action increases the likelihood of remembering to perform that action. The aim of experiment 2 was twofold. First, we aimed to replicate the effect of imagery on PM. Second, we investigated whether the effect of imagery is enhanced when participants are instructed to generate bizarre images. Bizarre images have long been advocated as a mnemonic aid (e.g., Lorayne & Lucas, 1974), yet early attempts to verify such claims found little evidence to support them. For example, Nappe and Wollen (1973) presented participants with pairs of high-imagery nouns and asked them to generate interactive images that were either common or bizarre. Recall of the word pairs was numerically lower when participants generated bizarre compared to common images. Participants also took longer to generate the bizarre images. Nappe and Wollen suggested that bizarreness would only have an effect when participants were highly trained in the generation of bizarre images. However, Hauck et al. (1976) found no advantage for bizarreness even when participants practiced generating bizarre images over five consecutive days.

More recent studies have found significant effects of bizarreness whereby bizarre sentences are more memorable than mundane sentences. For example, McDaniel and Einstein (1986) asked participants to generate images in response to mundane sentences (e.g., *The dog chased the bicycle down the street*) or bizarre sentences featuring the same items (e.g., *The dog rode the bicycle down the street*). In a free recall test, the bizarre sentences were more likely to be remembered than the mundane sentences. This effect has been replicated a number of times, but typically occurs only when bizarreness is manipulated in a within-subjects design (see McDaniel et al., 1995). There is, however, disagreement over whether the bizarreness effect relies on visual imagery. For example, Besken and Mulligan (2022) found that the mnemonic advantage for bizarre sentences was not reduced by distractor tasks known to interfere with visual imagery.

To the best of our knowledge, the bizarreness effect has not been investigated in relation to PM. Although a typical PM task might appear bizarre (e.g., pressing a particular response key whenever the name of a fruit appears), we are not aware of any studies that directly compared the effects of bizarre and mundane imagery on PM. Intuitively, imagining a bizarre task should be more memorable than

Table 2 . Mean proportions (and standard deviations) of PM tasks executed as a function of implementation intention and imagery instructions.

	Imagery	No-imagery	Mean
Implementation intention	.80 (.25)	.70 (.32)	.75 (.29)
No implementation intention	.79 (.26)	.62 (.37)	.71 (.32)
Mean	.80 (.26)	.66 (.35)	

imagining a mundane task. As noted above, Nappe and Wollen (1973) found that participants took longer to generate bizarre images relative to common images, which suggests they are more effortful. Given the positive effects of cognitive effort at encoding on retrospective memory (e.g., Dewhurst & Hitch, 1999), it is conceivable that increased cognitive effort will benefit PM. Although Nappe and Wollen found no recall advantage following the generation of bizarre images, it is worth noting that their participants had to generate bizarre images for 24 noun pairs, which may have led to fatigue effects. Nappe and Wollen also reported a number of failures to form bizarre images. Consistent with this, Baddeley and Andrade (2000) found that bizarre images were rated as less vivid than "ordinary" images, which they attributed to the greater time required to generate an unfamiliar image. In experiment 2, we sought to limit the effects of these factors by asking participants to generate a single image (bizarre or mundane) and allowing them 30 s in which to do so.

As noted above, the mnemonic advantage for bizarre sentences relies on within-subjects comparisons of bizarre and mundane images. In contrast, studies of PM typically involve between-subjects comparisons of orienting tasks. Manipulating orienting tasks between-subjects also prevents carry-over effects. In order to be consistent with experiment 1 and previous research into PM, we used a between-subjects design in which participants either generated bizarre images, generated mundane images, or took part in the control condition used in experiment 1.

Method

The method was the same as experiment 1 with the following modifications. Power analysis based on the difference between the imagery alone and control conditions in experiment 1 indicated a medium effect size of $f = .255$. With power of .80, a minimum sample size of 117 was required. The participants were a new group of 120 undergraduate and postgraduate students, of whom 104 identified as female and 16 as male, ranging in age from 18 to 43 ($M = 20.82$, $SD = 4.94$). Participants were randomly allocated to either the control condition or one of two imagery conditions; mundane or bizarre. The imagery condition from experiment 1 served as the mundane imagery condition. In the bizarre imagery condition, participants were asked to close their eyes and visualise themselves completing the quiz with the following instructions: "Imagine yourself in this room answering questions as part of a quiz. When you see a question about space, a little alien will float down next to you in a UFO. You will then draw a picture of this alien next to the question".

Table 3 . Mean proportions (and standard deviations) of trivia questions correctly answered as a function of orienting task.

Condition	Mean trivia questions correctly answered
Mundane Imagery	.40 (.15)
Bizarre Imagery	.39 (.13)
Control: No Imagery	.38 (.15)

Results and discussion

The numbers of trivia questions correctly answered and the numbers of PM tasks correctly executed were analysed using a one-way ANOVA with imagery condition (mundane imagery x bizarre imagery x control) manipulated between-groups. Analysis of trivia questions correctly answered showed a nonsignificant main effect of imagery condition, $F < 1$. The mean proportions of trivia questions correctly answered are shown in Table 3.

Table 4 shows the mean PM scores as a function of imagery condition. The main effect was significant, $F(2,117) = 3.99$, $MSE = 3.21$, $p = .021$, $\eta_p^2 = .064$. Bonferroni-adjusted pairwise comparisons showed that performance was significantly higher in the mundane imagery condition relative to the control condition, $p = .018$. In contrast, performance in the bizarre imagery condition was not significantly higher than in the control condition, $p = .284$. PM performance was numerically higher in the mundane imagery condition relative to the bizarre imagery condition, but the difference was not statistically significant, $p = .791$.

Experiment 2 replicated the finding from experiment 1 that imagining oneself performing an intended action increases the likelihood of remembering to carry out that action. The effect was only significant, however, when participants imagined the relatively mundane PM task of writing an "X" next to the target questions. PM was not significantly enhanced when participants imagined a more bizarre action. This pattern suggests that mundane imagery enhances PM relative to the control condition but bizarre imagery does not. In a review of null hypothesis interpretation, Aczel et al. (2018) noted that nonsignificant results do not necessarily support the null hypothesis. In contrast, Bayesian analyses can indicate the relative degree to which data support the null hypothesis or the experimental hypothesis. According to Jeffreys (1961), a Bayes factor above 1 indicates relative support for the experimental hypothesis, whereas a Bayes factor below 1 indicates relative support for the null hypothesis. In order to investigate whether the nonsignificant effect of bizarre imagery supported the null hypothesis, we conducted a Bayesian analysis using the statistical package JASP (JASP Team, 2024). Pairwise comparison between the control and mundane imagery conditions produced

Table 4 . Mean proportions (and standard deviations) of PM scores as a function of imagery condition.

Condition	Mean PM task score (with standard deviation)
Mundane Imagery	.78 (.26)
Bizarre Imagery	.71 (.28)
Control: No Imagery	.60 (.35)

a Bayes factor of $BF_{10} = 5.638$, indicating moderate support for the hypothesis that mundane imagery enhances PM. In contrast, comparison between the control and bizarre imagery conditions produced a Bayes factor of $BF_{10} = 0.686$, suggesting relative but anecdotal (inconclusive) evidence for the null hypothesis.

General discussion

In two experiments, we have shown that imagining oneself perform an intended action increases the likelihood of remembering to carry out that action. Experiment 1 showed that this enhancement occurred regardless of whether or not participants generated an implementation intention. In contrast, implementation intentions alone did not influence the likelihood of remembering to carry out the intended action. Experiment 2 replicated the effect of imagery on PM performance but only when imagining a relatively mundane task. Imagining a bizarre PM task did not significantly enhance performance relative to the control condition.

The findings of experiment 1 are consistent with the findings of McFarland and Glisky (2012) and Meeks and Marsh (2010) that imagery instructions enhanced PM both when performed in isolation and when combined with implementation intentions. In contrast, implementation intentions alone did not enhance PM relative to a control condition. This is somewhat surprising given the robust effects of implementation intention found in previous research. For example, both Cohen and Gollwitzer (2008) and Zimmermann and Meier (2010) found that PM was enhanced by implementation intention instructions that did not include an imagery component. One possible explanation for the divergent results lies in the nature of the stimuli; specifically, in the degree of association between the cue and the target action. Marsh et al. (2003) found that PM was enhanced when the cue and target were semantically related. Cohen and Gollwitzer speculated that implementation intentions work in a similar fashion by creating a link between previously unassociated items. The task used in the current study did not require participants to form links between two discrete items but to simply write an "X" next to any question relating to space, of which there were six. Participants may not have formed the necessary associations between multiple cues and a relatively impoverished target action that lacks semantic content. In contrast, the act of writing an "X" next to the target questions is easy to visualise, hence the significant effect of the imagery instructions. McFarland and Glisky (2012) speculated that implementation intentions and imagery instructions rely on the same underlying mechanism, whereby they facilitate the formation of an association between the cue and the target action. The finding from the current study that PM was enhanced by imagery but not by implementation intention is inconsistent with the view that they rely on the same mechanism.

Although experiment 2 confirmed the effect of visual imagery on PM, the effect only reached statistical significance with the mundane PM task used in experiment 1 and not with a bizarre imagery task. This is consistent with findings from early studies such as Nappe and Wollen (1973) and Hauck et al. (1976) that the generation of bizarre images did not enhance retrospective memory beyond the effects observed when generating common images. We speculated that bizarre imagery might enhance PM by virtue of being a more effortful task (Nappe & Wollen; see also Baddeley & Andrade, 2000) but no significant effect was found. In addition, the Bayesian analysis indicated support for the null hypothesis. It is important to note, however, that the Bayes factor was relatively low at $BF_{10} = 0.686$. According to Jeffreys (1961), a Bayes factor between 1/3 and 1 is viewed as providing only anecdotal evidence for the null hypothesis. Further research is needed, therefore, in order to determine the effects of bizarre imagery on PM. However, if generating bizarre imagery was more effortful than the mundane imagery and control conditions, we might expect this to be reflected in performance of the ongoing task. In order to measure this, we calculated the mean number of target questions attempted (max = 6) for each condition. Contrary to what would be expected if the bizarre imagery condition was more effortful than the other two conditions, the number of target questions attempted was numerically higher in the bizarre imagery condition ($M = 3.58$, $SD = 1.50$) than in the mundane imagery ($M = 3.48$, $SD = 1.66$) and control ($M = 2.80$, $SD = 1.73$) conditions. A one-way ANOVA, however, showed a nonsignificant main effect of task, $F\ (2,117) = 2.66$, $MSE = 2.67$, $p = .074$, $\eta_p^2 = .044$. None of the pairwise comparisons were significant, all $p > .108$. This also rules out any possible effects of the complexity of the target action (drawing an alien versus writing a letter X).

It is also possible that the bizarre task we used was not sufficiently bizarre to produce a significant effect. Alternatively, the images generated may have been less vivid than the mundane images due to the greater time required to generate them (c.f., Baddeley & Andrade). Although we allowed participants 30 s to generate images, we cannot rule out the possibility that the bizarre images were less vivid than the mundane images. We must also acknowledge that the bizarre imagery condition differed from the mundane imagery condition in terms of both the encoding instructions (imagining an alien appearing) and the target action (draw a picture of the alien next to questions about space). Although both of these changes were introduced in order to increase the bizarreness of the PM task, it is conceivable that they cancelled each other out.

The crucial point, however, is that the PM target was the same in all conditions (questions about space). Although the task participants were asked to perform in response to the target questions differed between the bizarre imagery and other conditions, remembering what task to perform is a test of retrospective memory rather than PM (see Smith & Bayen, 2004, for discussion of the role of retrospective memory in PM). Given that participants only had one action to remember (write a letter X or draw a picture of an alien) there is no reason to assume that either one placed a greater load on retrospective memory than the other. Nevertheless, future research should manipulate the bizarreness of the instructions and the target action independently. The critical finding from experiment 2, however, is that PM was enhanced by the generation of images in the absence of implementation intentions, thereby supporting the results of experiment 1.

As discussed in the Introduction, there are clear parallels between PM and EFT, including the finding that both are enhanced by visual imagery. It is apparent, however, that EFT requires greater cognitive resources than imagining oneself performing a relatively simple task (see Mahr, 2020, for discussion of the non-imagery processes involved in episodic simulation). Although Neroni et al. (2014) found that EFT enhanced PM, it also impaired performance of the ongoing task, whereas McFarland and Glisky found that imagery enhanced PM with no detriment to the ongoing task. The current study also found that imagery enhanced PM without reducing ongoing task performance. In terms of facilitating overall performance, the optimal strategy is one that enhances PM at no cost, in which case imagining the specific PM task would appear to be more effective than EFT. Nevertheless, both PM and EFT are examples of how memory can serve future intentions. Indeed, Klein et al. (2011) suggested that memory is "inherently prospective". Discussion of the various ways in which memory serves the future is beyond the scope of this study, but a useful taxonomy of future thinking, that includes both PM and EFT, is provided by Szpunar et al. (2014; See also Kvavilashvili & Rummel, 2020).

To summarise, the main finding from the current study is that PM is enhanced when participants visualise themselves seeing a cue and remembering to perform the target action. The effects of imagery on PM are consistent with the role of imagery in other aspects of memory, including lab-based studies (e.g., Bower, 1970; Durso & Johnson, 1980) and more naturalistic aspects of memory, such as autobiographical memory (Brewer & Pani, 1996; Conway & Pleydell-Pearce, 2000) and EFT (e.g., Anderson et al., 2012; Schacter et al., 2008). Given the critical role of PM in everyday life (see Dismukes, 2012), a useful direction for future research would be to investigate whether visual imagery can enhance performance in more naturalistic PM tasks (see Marsh et al., 1998, for some examples of everyday PM tasks) and in participants for whom PM is compromised, such as older adults and clinical populations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data supporting this research are openly available from the Open Science Framework archive at https://osf.io/sbvpw/

ORCID

Rachel J. Anderson http://orcid.org/0000-0002-9191-0004
Graham M. Dean http://orcid.org/0000-0001-5282-5934
Stephen A. Dewhurst http://orcid.org/0000-0001-5834-0049

References

Aczel, B., Palfi, B., Szollosi, A., Kovacs, M., Szaszi, B., Szecsi, P., Zrubka, M., Gronau, Q. F., van den Bergh, D., & Wagenmakers, E.-J. (2018). Quantifying support for the null hypothesis in psychology: An empirical investigation. *Advances in Methods and Practices in Psychological Science*, *1*(3), 357–366. https://doi.org/10.1177/2515245918773742

Anderson, R. J., Dewhurst, S. A., & Dean, G. M. (2017). Direct and generative retrieval of autobiographical memories: The roles of visual imagery and executive processes. *Consciousness and Cognition*, *49*, 163–171. https://doi.org/10.1016/j.concog.2017.02.010

Anderson, R. J., Dewhurst, S. A., & Nash, R. A. (2012). Shared cognitive processes underlying past and future thinking: The impact of imagery and concurrent task demands. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(2), 356–365. https://doi.org/10.1037/a0025451

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology: General*, *129*(1), 126–145. https://doi.org/10.1037/0096-3445.129.1.126

Besken, M., & Mulligan, N. W. (2022). The bizarreness effect and visual imagery: No impact of concurrent visuo-spatial distractor tasks indicates little role for visual imagery. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *48*(9), 1281–1295. https://doi.org/10.1037/xlm0001038

Block, L. G., & Morwitz, V. G. (1999). Shopping lists as an external memory aid for grocery shopping: Influences on list writing and list fulfilment. *Journal of Consumer Psychology*, *8*, 343–375. https://doi.org/10.1207/s15327663jcp0804_01

Bower, G. H. (1970). Imagery as a relational organizer in associative learning. *Journal of Verbal Learning and Verbal Behavior*, *9*(5), 529–533. https://doi.org/10.1016/S0022-5371(70)80096-2

Brewer, W. F., & Pani, J. R. (1996). Reports of mental imagery in retrieval from long–term memory. *Consciousness and Cognition*, *5*(3), 265–287. https://doi.org/10.1006/ccog.1996.0019

Chasteen, A. L., Park, D. C., & Schwarz, N. (2001). Implementation intentions and facilitation of prospective memory. *Psychological Science*, *12*(6), 457–461. https://doi.org/10.1111/1467-9280.00385

Chen, X., Wang, Y., Liu, L., Cui, J., Gan, M., Shum, D. H., & Chan, R. C. (2015). The effect of implementation intention on prospective memory: A systematic and meta-analytic review. *Psychiatry Research*, *226*(1), 14–22. https://doi.org/10.1016/j.psychres.2015.01.011

Cohen, A.-L., & Gollwitzer, P. M. (2008). The cost of remembering to remember: Cognitive load and implementation intentions influence ongoing task performance. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp. 367–390). Erlbaum.

Conway, M. A., Meares, K., & Standart, S. (2004). Images and goals. *Memory (Hove, England)*, *12*(4), 525–531. https://doi.org/10.1080/09658210444000151

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*(2), 261–288. https://doi.org/10.1037/0033-295X.107.2.261

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*(2), 342–350. https://doi.org/10.1016/j.concog.2005.09.001

Dewhurst, S. A., & Hitch, G. J. (1999). Cognitive effort and recollective experience in recognition memory. *Memory (Hove, England)*, *7*(2), 129–146. https://doi.org/10.1080/741944067

Dismukes, R. K. (2012). Prospective memory in workplace and everyday situations. *Current Directions in Psychological Science*, *21*(4), 215–220. https://doi.org/10.1177/0963721412447621

Durso, F. T., & Johnson, M. K. (1980). The effects of orienting tasks on recognition, recall, and modality confusion of pictures and words. *Journal of Verbal Learning and Verbal Behavior*, *19*(4), 416–429. https://doi.org/10.1016/S0022-5371(80)90294-7

Einstein, G. O., McDaniel, M. A., Williford, C. L., Pagan, J. L., & Dismukes, R. K. (2003). Forgetting of intentions in demanding situations is rapid. *Journal of Experimental Psychology: Applied*, *9*(3), 147–162. https://doi.org/10.1037/1076-898X.9.3.147

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, *54*(7), 493–503. https://doi.org/10.1037/0003-066X.54.7.493

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (1998). Prospective memory: When reminders fail. *Memory & Cognition*, *26*(2), 287–298. https://doi.org/10.3758/BF03201140

Hauck, P. D., Walsh, C. C., & Kroll, N. E. A. (1976). Visual imagery mnemonics: Common vs. bizarre mental images. *Bulletin of the Psychonomic Society*, *7*(2), 160–162. https://doi.org/10.3758/BF03337151

Henry, J. D., Terrett, G., Grainger, S. A., Rose, N. S., Kliegel, M., Bugge, M., Ryrie, C., & Rendell, P. G. (2020). Implementation intentions and prospective memory function in late adulthood. *Psychology and Aging*, *35*(8), 1105–1114. https://doi.org/10.1037/pag0000563

JASP Team. (2024). JASP (Version 0.18. 3) [Computer software].

Jeffreys, H. (1961). *The theory of probability*. Oxford University Press.

Klein, S. B., Roberson, T. E., & Delton, A. W. (2011). The future-orientation of memory: Planning as a key component mediating the high levels of recall found with survival processing. *Memory (Hove, England)*, *19*(2), 121–139. https://doi.org/10.1080/09658211.2010.537827

Kvavilashvili, L., & Rummel, J. (2020). On the nature of everyday prospection: A review and theoretical integration of research on mind-wandering, future thinking, and prospective memory. *Review of General Psychology*, *24*(3), 210–237. https://doi.org/10.1177/1089268020918843

Lazzari, R., & Pancheri, P. (1980). *Questionario di valutazione dell'ansia di stato e di tratto (State-Trait Anxiety Inventory)*. Organizzazioni Speciali.

Lorayne, H., & Lucas, J. (1974). *The memory book*. Ballantine.

Mahr, J. B. (2020). The dimensions of episodic simulation. *Cognition*, *196*, 104085. https://doi.org/10.1016/j.cognition.2019.104085

Marsh, R L, Hicks, J L, Cook, G I, Hansen, J S, & Pallos, A L. (2003). Interference to ongoing activities covaries with the characteristics of an event-based intention. *Journal of experimental psychology. Learning, memory, and cognition*, *29*(5), 861–870. https://doi.org/10.1037/0278-7393.29.5.861

Marsh, R. L., Hicks, J. L., & Landau, J. D. (1998). An investigation of everyday prospective memory. *Memory & Cognition*, *26*(4), 633–643. https://doi.org/10.3758/BF03211383

McDaniel, M. A., & Einstein, G. O. (1986). Bizarre imagery as an effective memory aid: The importance of distinctiveness. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *12*(1), 54–65. https://doi.org/10.1037/0278-7393.12.1.54

McDaniel, M. A., & Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Sage.

McDaniel, M. A., Einstein, G. O., Delosh, E. L., May, C. P., & Brady, P. (1995). The bizarreness effect: It's not surprising, it's complex. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*(2), 422–435. https://doi.org/10.1037/0278-7393.21.2.422

McDaniel, M. A., Howard, D. C., & Butler, K. M. (2008). Implementation intentions facilitate prospective memory under high attention demands. *Memory & Cognition*, *36*(3), 604–616. https://doi.org/10.3758/MC.36.3.604

McFarland, C. P., & Glisky, E. L. (2012). Implementation intentions and imagery: Individual and combined effects on prospective memory among young adults. *Memory & Cognition*, *40*(1), 62–69. https://doi.org/10.3758/s13421-011-0126-8

Meeks, J. T., & Marsh, R. L. (2010). Implementation intentions about nonfocal event-based prospective memory tasks. *Psychological Research Psychologische Forschung*, *74*(1), 82–89. https://doi.org/10.1007/s00426-008-0223-x

Nappe, G. W., & Wollen, K. A. (1973). Effects of instructions to form common and bizarre mental images on retention. *Journal of Experimental Psychology*, *100*(1), 6–8. https://doi.org/10.1037/h0035508

Neroni, M. A., Gamboz, N., & Brandimonte, M. A. (2014). Does episodic future thinking improve prospective remembering? *Consciousness and Cognition*, *23*, 53–62. https://doi.org/10.1016/j.concog.2013.12.001

Paivio, A. (1971). *Imagery and verbal processes*. Holt, Rinehart & Winston.

Richardson, J. T. E. (1975). Concreteness and imageability. *Quarterly Journal of Experimental Psychology*, *27*(2), 235–249. https://doi.org/10.1080/14640747508400483

Rubin, D. C., Schrauf, R. W., & Greenberg, D. L. (2003). Belief and recollection of autobiographical memories. *Memory & Cognition*, *31*(6), 887–901. https://doi.org/10.3758/BF03196443

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, *2*(1), 40–54. https://doi.org/10.1038/s44159-022-00121-4

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events: Concepts, data, and applications. *Annals of the New York Academy of Sciences*, *1124*(1), 39–60. https://doi.org/10.1196/annals.1440.001

Scullin, M. K., Kurinec, C. A., & Nguyen, K. (2017). The effects of implementation intention strategies on prospective memory cue encoding. *Journal of Cognitive Psychology*, *29*(8), 929–938. https://doi.org/10.1080/20445911.2017.1329205

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(4), 756–777. https://doi.org/10.1037/0278-7393.30.4.756

Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014). A taxonomy of prospection: Introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences*, *111*(52), 18414–18421. https://doi.org/10.1073/pnas.1417144111

Williams, J. M. G., Healy, H. G., & Ellis, N. C. (1999). The effect of imageability and predicability of cues in autobiographical memory. *The Quarterly Journal of Experimental Psychology Section A*, *52*(3), 555–579. https://doi.org/10.1080/713755828

Zimmermann, T. D., & Meier, B. (2010). The effect of implementation intentions on prospective memory performance across the lifespan. *Applied Cognitive Psychology*, *24*(5), 645–658. https://doi.org/10.1002/acp.1576