# Effects of incidental reminders on activity-based prospective memory in 5- and 7- year old children

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## Conflict of Interest Statement

The authors declare no conflict of interest

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## Research Highlights

- Activity-based prospective memory (PM) tasks are prevalent in everyday life but little is known about the development of this ability in young children
- 7-year old children significantly outperformed 5-year-olds in a simple activity-based PM task even though groups did not differ in their performance on the ongoing task
- Subtle environmental cues that were related to the target of the PM task acted as effective reminders for both 5- and 7-year old children
- Incidental cues that were not directly related to the target of PM task did not enhance PM performance compared to a control no reminder condition

**Abstract**

Prospective memory involves remembering to carry out intended actions in the future (e.g., posting a letter on the way to school, taking a medication or passing on a message) and is vital for everyday functioning. Despite growing research on PM in both adults and children, little is known about the development of activity-based PM (executing an intention either before or after finishing a particular task). In this study, 5- and 7-year old children (n = 160) had to remember to 'post' cards with a picture of a dog into a box (placed behind the child) every time they finished working on an activity book with a visual search component. Additionally, the content presented on the last page of each activity book was manipulated to examine the role of incidental reminders on PM. Results showed that 7-year old children significantly outperformed 5-year olds on the PM task despite age-equivalence of performance on the ongoing visual search task. For both age groups, an incidental reminder (a line drawing of a dog) that was similar to the target of the PM task (a card with a colour picture of a dog) significantly improved PM compared to the no reminder condition (a line drawing of a flower), while reminders related to the PM action (a line drawing of a box) or semantically related to the PM task (a line drawing of a cat) were not effective. These findings have important practical and theoretical implications and open up interesting avenues for future research.

Keywords: *prospective memory, activity-based prospective memory, incidental reminders, children, spontaneous retrieval, strategic monitoring*

**Effects of incidental reminders on activity-based prospective memory in 5- and 7- year old children**

Throughout a typical day, people of all ages have to remember a great variety of previously intended actions at times when the appropriate moment for their execution arises. Examples of such daily tasks include remembering to take a medication and pack certain items for work or school in the morning, passing messages to colleagues or teachers, buying something on the way home (e.g., stamps or sweets) and calling a friend or a parent and feeding the fish in the evening. This type of future oriented remembering is called prospective memory (PM) and is distinguished from retrospective memory, which refers to remembering past information like what one did last Sunday or the name of one's schoolteacher (Meacham & Leiman 1982; McDaniel & Einstein, 2007). Interestingly, both adults and children report a higher incidence of prospective than retrospective memory errors, and are more concerned about the former, probably because PM failures may entail more serious consequences than retrospective memory failures (e.g., a child may have an asthma attack if she forgot to take the inhaler to school or the fish may perish if left unfed) (Howard, Fiore, & Jentsch, 2006; Meacham & Singer, 1977; Terry, 1988)

Due to the importance of PM skills in children's everyday functioning, there has been considerable interest in mapping the developmental trajectory of PM and in identifying variables that influence children's PM performance (Kvavilashvili, Kyle & Messer, 2008; Mahy, Moses & Kliegel, 2014a). As in research on adults, most of this research has been conducted on event-based PM, which involves remembering one's intention in response to a pre-specified target event, such as posting a letter when seeing a

post box in the street, or passing a message to parents when they come home. This is partly due to a well-established laboratory paradigm that enables easy manipulation of target events or cues (e.g., their distinctiveness) and characteristics of ongoing tasks (e.g., task difficulty or task interruption) into which these cue events are embedded (Einstein & McDaniel, 1990; Ellis & Kvavilashvili, 2000).

Much less focus has been on activity-based PM, which involves remembering to do something after finishing a particular action (e.g., after watching a TV programme) or before starting another action (e.g., before leaving the house) (see Harris, 1984). In other words, the intention is carried out during the gap that occurs in between the consecutive actions and therefore, by definition, activity-based PM does not involve the interruption of ongoing activity which is a characteristic feature of most event-based PM tasks (Kvavilashvili & Ellis, 1996).

The paucity of research on activity-based PM is surprising given that examination of PM tasks that participants typically encounter in their everyday life has shown that many such tasks do not involve clearly specified target events or times and could therefore be classed as activity-based (Dismukes, 2008; Holbrook & Dismukes, 2009; Schnitzspahn, Kvavilashvili & Altgassen, in press). Consequently, we know very little about the development of activity-based PM during childhood and the factors that determine success. Moreover, most studies have used single-item PM tasks in which children are asked to do something at the end of the experimental session. However, PM performance in such cases is likely to be affected heavily by motivation because children had to request an attractive object or activity (toy, sticker, opening a magic box) when the session finished (Atance & Jackson, 2009; Meacham & Colombo, 1980; Sheppard,

Kvavilashvili & Ryder, 2016). A handful of investigations that used single-item activity-based PM tasks with low incentive value (mimicking most event-based PM studies) resulted in low overall levels of performance and significant age-related improvement when comparing pre-school and school aged children (e.g., Causey & Bjorklund, 2014; Guajardo & Best, 2000; Meacham & Dumitru, 1976; Slusarczyk & Niedzwienska, 2013). These findings from children dovetail nicely with the results of Brewer et al. (2011), who showed, across four experiments, that young adults' performance was significantly worse on activity-based than event-based PM. One possible explanation of these effects is that in activity-based tasks, the end of activity is a less salient cue than seeing a particular target event, object, or a person in the environment as is the case in event-based tasks (Kvavilashvili & Ellis, 1996; see also Walsh, Martin & Courage, 2014).

Accordingly, the first aim of the present study was to fill the gap in the literature by comparing activity-based PM between 5- and 7-year old children using the adapted version of the standard PM laboratory paradigm to obtain more reliable measures of activity-based PM across multiple instances (Kvavilashvili et al., 2001; 2008). Most previous studies with single-item activity-based PM have compared the performance of 3- and 5-year old children (Attance & Jackson, 2009; Guajardo & Best, 2000; Kliegel, Branderberger & Aberle, 2010; Walsh et al., 2014), and reported a significant age effect favouring the latter (see also Slusarczyk & Niedzwienska, 2013 who studied 2- to 6-year olds). It is, however, unclear if this developmental trend continues in the early school period as two studies that examined activity-based PM in 5- and 7-year-olds resulted in contradictory findings, with Kurtz-Costes, Schneider and Rupp (1995) reporting no age effect but Meacham and Dumitru (1976) reporting a developmental improvement.

Another relatively unexamined topic in research on children's PM is the role of reminders. Previous research has shown that preschool children appear to have some insight into their abilities to carry out PM tasks (Kvavilashvili & Ford, 2014) and the usefulness of setting up explicit reminders, for example, putting skates near the door to remember to pick them up in the morning before leaving the house (Kreutzer, Leonard & Flavell, 1975). However, a handful of studies on the effects of explicit reminders on children's PM have yielded an inconsistent pattern. Two of the earliest studies by Meacham and colleagues used single-item activity-based PM tasks. No significant benefit of a reminder was obtained by Meacham and Dumitru (1976) on 5- and 7-year old children who had to remember to enter their drawing into a competition by posting it into a postbox at the end of the session, and were provided with a picture of a postbox in the reminder condition with explicit advice that it would help them to remember the task. In contrast, a significant positive effect of a reminder was obtained in a study by Meacham and Colombo (1980), in which children were requested to ask the researcher to open a surprise box at the end of the session, and half of the children were told in advance that a toy clown on the table would help them to remember to do this.

More recent studies used an event-based PM paradigm in which children had to remember to press a key when seeing a particular picture (e.g., a house) during an ongoing task involving naming or encoding pictures (Cheie, Miclea, & Visu-Petra, 2014 and Guajardo & Best, 2000, respectively). In addition, in an explicit reminder condition, children were guided in placing a picture of the PM target event (e.g., a house) next to the computer screen to help them remember to carry out the PM task. The reminder was not found to improve the PM performance of 3- and 5-year children in a study by Guajardo

and Best (2000), but it had a positive effect on the performance of children aged 3-5 years and 5-7 years in a study by Cheie et al. (2014). In a later investigation by Kliegel and Jäger (2007), the explicit reminder (a box and a real apple placed in front of the child) improved PM in 3-year old children when they had to remember to put a picture of an apple in a box behind them when seeing a picture of an apple in the ongoing picture-naming task. However, the same reminder did not facilitate the PM performance of 4-, 5-, and 6-year old children (for similar non-significant findings in 4- to 6-year old children who were verbally reminded of their PM task just before starting the ongoing task, see Mahy, Mazachowsky & Pagobo, 2018). These inconsistent findings might be considered surprising given robust evidence from studies with adults that salient objects deliberately associated with the intended action at encoding may act as powerful cues bringing the intention to mind via automatic associative processes if they are presented in the time window when the action can be executed (e.g., Rogers & Milkman, 2016; Vortac, Edwards, & Manning, 1995).

By contrast, in the present study we wanted to investigate, for the first time, the role of *incidental* reminders on children's activity-based PM, that is, reminders not formally linked with the PM intention. Specifically, we wanted to evaluate whether exposing children to unexpected environmental cues related to the to-be-carried task at the appropriate moment (i.e., when children finish the ongoing activity) would increase the likelihood of their remembering to carry out the intention. For example, in the case of a child who has the intention to feed their fish after school and their parent forgets to explicitly remind them about this before they leave the house in the morning, if the parent places an incidental cue on the kitchen table (e.g., toy goldfish or fish food) then would

this enhance the chances that the child remembers to feed the fish? Research on adults confirms that incidental cues in the environment have the potential to remind participants of their event-based PM tasks (Kvavilashvili & Fisher, 2007; Taylor, Marsh, Hicks & Hancock, 2004; Scullin, McDaniel & Einstein, 2010). However, no previous study has investigated the effects of such incidental reminders on activity-based PM in either adults or children.

Investigating the effects of incidental cues on children's PM is also important theoretically. According to the multiprocess theory of PM, successful PM performance can reflect either strategic or spontaneous retrieval processes (or their dynamic interplay) depending on the nature of PM and ongoing task demands (McDaniel & Einstein, 2000; 2007; Scullin, McDaniel & Shelton, 2013). In event-based PM tasks, strategic monitoring occurs when the individual keeps their intention in mind during the ongoing activity and deliberately searches the environment for the PM cue or target event. By contrast, spontaneous retrieval occurs when the individual does not deliberately monitor but, instead, relies on the appearance of the PM target event to automatically enhance their already-activated intention and bring it unbidden to conscious awareness. If PM is partly mediated by spontaneous retrieval processes, then successful PM should be observed in early childhood and, indeed, there is evidence in the literature that even 2-year old children succeed in PM tasks under some conditions despite their poorly developed executive functions and monitoring abilities (Niedźwieńska, Janik, & Jarczyńska, 2013; Sommerville, Wellman & Cultice, 1983; but see Kliegel & Jäger, 2007). Moreover, incidental reminders embedded in an activity-based PM task might spontaneously trigger the PM intention in the same way that encountering the target cue triggers the PM

intention in event-based PM.

To investigate the impact of incidental reminders on the activity-based PM of 5- and 7-year-olds, children were asked to play some games with a toy mole (hand puppet) and in the intervals between the games completed three ongoing tasks with activity books involving a visual search component. The PM task involved remembering to put a card depicting a coloured picture of a dog into a small box (placed behind the child) every time they finished working on a book. Additionally, we manipulated the relatedness of the reminder to the to-be-carried out intention across four between-group conditions. In the *target reminder* condition, children saw a line drawing of a dog as the last picture in each book (this was not the same as the dog picture used in the PM task). In the *associative reminder* condition, by contrast, children saw a picture of a cat as the last picture in each book. In the *action reminder* condition, children saw a picture of a box, which related to the completion of their action on the PM task (i.e., putting the dog picture into the box). Finally, in the *control* condition, children saw a picture of a flower at the end of each book, which was not linked with their PM intention.

It was predicted that the dog picture would enhance activity-based PM performance in both 5- and 7-year old children in comparison to the control condition. We assumed that this would be achieved by an automatic spread of activation from the representation of the dog on the last page of the book to the representation of the PM intention, which involved doing something with a picture of a dog. Given that the concepts of cat and a dog are semantically related (with a forward association of .51 from *cat* to *dog*, see Nelson, McEvoy & Schreiber, 1998), we predicted that seeing a picture of a cat would likewise increase the chances of remembering the PM task, albeit to a lesser

degree than seeing a picture of a dog. Indeed, a study by Mullet et al. (2013) showed that when young adults had suspended their intention to respond to the word ‘money’ in a later image-rating task, their responses to words ‘money’ and related concepts (e.g., word ‘wallet’ etc.) were slowed down in the intervening lexical decision task (see also Scullin et al., 2010). This suggests that upon encountering these words, participants automatically recalled their intention and had to evaluate whether it was appropriate to respond or not. Finally, no predictions were made about the action reminder condition due to contradictory results from studies that used explicit action reminders. For example, Meacham and Dumitru (1976) presented 5- and 7-year old children with an explicit reminder card depicting a box into which they had to post their drawing after the end of the session. The reminder failed to boost performance relative to a control condition despite the fact that it was in children’s view throughout the experimental session. In contrast, Guynn, McDaniel and Einstein (1998) observed that an explicit reminder to think about the intended action (i.e., to press a key in response to certain target words) significantly improved PM performance in young adults.

## Method

### Participants

A sample of 175 typically developing 5- and 7-year old children, recruited from four primary schools, took part in the study. However, 15 children (eight 5-year olds and seven 7-year olds) were removed from the data analysis because they were not able to recall the PM instructions at the end of the task (see Procedure). The final sample consisted of 80 5-year old children (age range: 60 to 71 months, $M$ = 64.31, $SD$ = 3.08) and 80 7-year old children (age range: 84 to 95 months, $M$ = 88.77, $SD$ = 3.13), with

equal number males and females in each age group. The sample was predominantly of white ethnic origin and the children came from families from middle class socioeconomic status in the UK. Although permissions to take part in the study were granted by schools' headteachers, each child also provided their verbal consent before taking part in the testing session.

**Design**

The study had a 2 (age: 5 years vs. 7 years) x 4 (incidental reminder: target vs. associative vs. action vs. no reminder) between-subjects factorial design. The children were randomly allocated to the four conditions. In each condition, there were twenty 5-year-olds and twenty 7-year olds with equal numbers of males and females. The target reminder was a line drawing of a dog, the associative reminder was a line drawing of a cat, and the action reminder was a line drawing of a box. In the no reminder condition, the last page in the activity book was a line drawing of a flower.

**Materials**

The PM task (putting a dog picture into a box after finishing an activity book) was embedded in an ongoing visual search task which required children to name a series of pictures while actively searching for a particular target picture. The ongoing task involved four brightly colored ring-binder folders (yellow, red, blue and green) with A4 size laminated pages in corresponding colors and a line drawing on a white background (10 cm x 10 cm) in the centre of each page. Children were asked to name these drawings and, additionally, to look for a target picture that appeared on the first page in slightly larger size (15 cm x 12 cm) and was repeated twice and thrice in the blue/red and yellow/green folders respectively.

The yellow folder was for practice and the remaining folders were used after PM instructions were delivered and each contained one incidental reminder for the PM task (see below). A total of 52 simple line drawings (of clothing, body parts, food, transport, household objects, etc.) were chosen from Cycowicz, Friedman, Rothstein and Snodgrass (1997). Of these, 37 pictures were used with the 5-year-olds and the full set of 52 pictures was used with the 7-year-olds. To ensure that children could name the pictures easily, the age of acquisition of the names of 37 pictures presented to both age groups was well below 60 months and the age of acquisition of the names of the additional 15 pictures presented only to 7-year olds was well below 84 months (Morrison, Chapel & Ellis, 1997).

In an attempt to equate the time spent on completing the ongoing task, 7-year old children had more pages in each folder than did the 5-year olds (see Kvavilashvili et al., 2008). Thus, in addition to first page showing the target picture, there were 15 pages in each of the blue, red and green folders for 5-year old children and 20 pictures in each of the folders for 7-year old children. The yellow (practice) folder contained 9 and 12 pages for 5- and 7-year olds, respectively. To counter the fact that the target pictures for visual search would be salient due to repetition, within each of the blue, red and green folders there were two non-target pictures that similarly were presented twice.

The page depicting the PM incidental reminder (i.e., the dog, the cat, the box) or the neutral cue in the control condition (i.e., the flower) always occurred in the last position in the folder, except for the yellow practice folder which was completed by children before they received any PM task instructions and thus contained no reminders. For the PM task, the materials comprised a set of four identical cards showing a colored

picture of a dog and a small white box with a card–sized slit on top. The cards were to be put into the box. Both the card and the box were placed behind the child's chair.

A hand-puppet mole, named "Morris", was used to introduce the folders to the children and to play additional games (distracter games) with them. The distractor games were suitable for children aged 5 to 7 years (i.e., noughts and crosses, matching picture pairs and picture lotto). They were used to engage the children after they had completed the visual search task and the PM task (if they remembered to do it) for each folder. A stopwatch was used to monitor the time the children took to complete each folder or game. The presentation order of the folders was randomized, as was the presentation order of the intervening games.

**Procedure**

The children were tested individually in a small quiet room provided by the school in a session that lasted about 20 minutes. At the start of the session, the toy mole 'Morris' was introduced and the child was shown a set of games and four folders, described as "activity books", that allegedly belonged to Morris. The researcher went on to explain that because Morris lived underground and could not see very well in the daylight, he wanted the child to help him play the games and look at the activity books. Once the child agreed to help Morris, s/he was shown the yellow folder, to practice the ongoing naming and visual search task without any embedded PM.

The child was asked to name the picture on the first page of the yellow folder (i.e., hammer) and then instructed to turn each page and name all the pictures one by one while, at the same time, looking for another picture of the hammer. The child was informed that whenever the hammer appeared, he or she had to put a tick on that page

with the felt pen provided. Once the child understood the instructions and started the task (i.e., turned the first page), the experimenter switched on the stopwatch to measure the time it took the child to complete the task.

The PM task was introduced immediately after children completed the yellow practice book by providing the following instructions: “Oh, there was something Morris forgot to tell you. Every time you finish these books (blue, green and red folders are pointed out), Morris wants you to stand up and put one of these dog cards into this box”. The white box and dog cards were located behind the child, out of their sight, so that they could not act as explicit reminders during the upcoming PM task. The child was asked to practise carrying out the PM intention (i.e., put one of the dog cards into the box) and after returning to their seat the researcher asked them to describe the task in their own words to ensure understanding.

To introduce a delay interval between the encoding of PM instructions and the beginning of the ongoing task, the first distracter game was played for approximately two minutes. The experimenter provided encouragement and tried to let the child win the game. The child then completed one the remaining three folders without being reminded of the PM instructions. At the end of this folder, a score of 1 was recorded if the child performed the PM task. The procedure was repeated until all three folders and games were finished, hence, there were three opportunities to carry out the PM task.

The children who remembered to carry out the PM task on at least one occasion were asked how they remembered to do it, that is, whether they were thinking about putting the dog picture into the box all the time or whether they remembered only when they finished the activity book. The children who failed to remember the PM task on all

three occasions were questioned to ascertain their retrospective memory of the PM instructions. If a child could not answer the first more general prompt (*Was there anything else that you had to do apart from the activity books and the games?*) they were given a more specific prompt (*Was there anything that you had to do when you finished each activity book?*). The data of children who were not able to explicitly recall PM instructions after this second more specific prompt, were excluded from the analyses.

## Results

### Performance on the ongoing task (visual search task)

All children named most of the pictures in the blue, green and red folders successfully and performed at ceiling level on the visual search tasks (i.e., 100% accuracy in both age groups) by ticking off the target picture shown to them at the beginning of each folder. To examine any age and practice effects on the amount of time to complete the three visual search tasks, the mean number of seconds that children spent on each of the three folders were entered into a 2 (age: 5 years vs. 7 years) x 4 (incidental reminder: target cue vs. associative cue vs. action cue vs. no cue) x 3 (folder: 1$^{st}$ vs. 2$^{nd}$ vs. 3$^{rd}$) mixed ANOVA with repeated measures on the last factor (see Table 1). This analysis resulted in a main effect of age, $F(1, 152) = 4.45$, $p = .037$, $\eta_p^2 = .028$, with 7-year old children taking on average 57.99 seconds ($SD = 10.45$) and 5-year olds 54.58 seconds ($SD = 10.11$) to complete a folder. There was also a significant main effect of folder order, $F(1.91, 290.67) = 42.75$, $p < .0001$, $\eta_p^2 = .22$, demonstrating a practice effect, with children spending significantly longer on completing the first folder ($M = 60.09$, $SD = 12.32$) than the second folder ($M = 55.83$, $SD = 12.13$), which in turn was completed slower than the third folder ($M = 52.94$, $SD = 11.06$), $p$ values < .001. No other effects

were significant, all *F*s < 2.08.

**Performance on the prospective memory task**

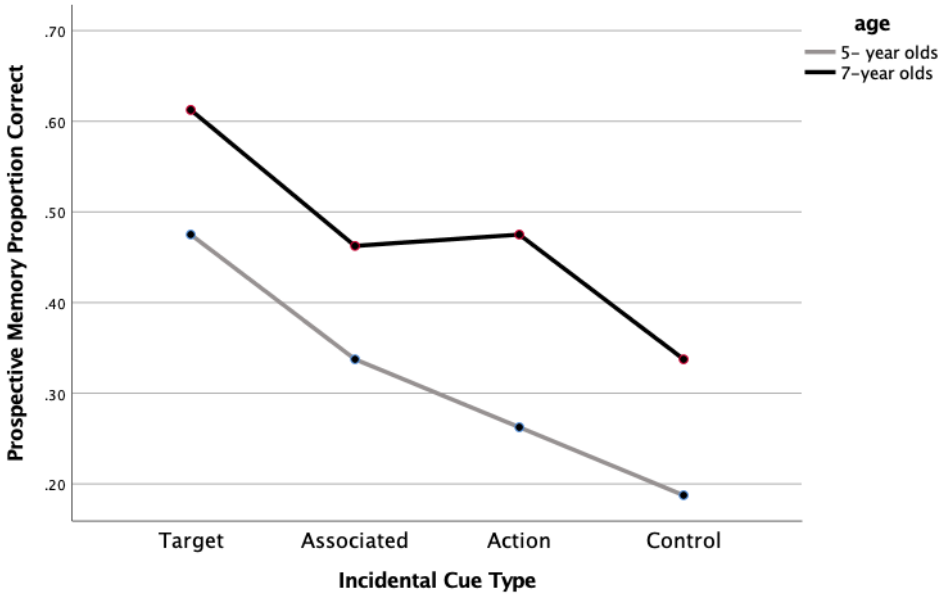
PM performance was measured as a proportion of correct PM actions (putting a dog picture in a box at the appropriate moment) out of three response opportunities (finishing each of the three folders). The majority of children in both age groups either remembered to carry out the PM task on all three occasions (41% and 56%, respectively) or forgot on all three occasions (56% and 33%, respectively). Only two 5-year olds (3%) and nine 7-year-olds (11%) remembered on some occasions and forgot on others.

The mean proportions of correct PM responses were entered into a 2 (age: 5 years vs. 7 years) x 4 (incidental reminder: target cue vs. associative cue vs. action cue vs. no cue) between-subjects ANOVA (for means, see Table 2). This analysis resulted in a significant main effect of age, $F(1,152) = 8.08$, $p = .005$, $\eta_p^2 = .05$, with overall PM performance being significantly higher in 7-year olds ($M = .63$, $SD = .46$) than 5-year olds ($M = .42$, $SD = .49$). The main effect of reminder was also significant, $F(1,52) = 4.49$, $p = .005$, $\eta_p^2 = .08$. As predicted, planned comparisons between the means showed that performance in the target (dog) condition ($M = .73$, $SD = .43$) was significantly higher than in the control condition ($M = .35$, $SD = .47$), $p < .001$. It was also significantly better than in the action (box) condition ($M = .48$, $SD = .49$), $p = .02$. and marginally higher than in the associative (cat) condition ($M = .54$, $SD = .49$), $p = .079$. By contrast, performance in the associative condition was only marginally higher than in the control condition, $p = .067$, and did not differ from PM scores in the action condition, $p = .58$. Performance in the action condition was not significantly different from that in the

control condition, $p = .20$. The age by reminder condition interaction was not significant, $F < 1$.

**Figure 1**

*Prospective Memory Success by Incidental Cue Type and Age*




To examine the possibility that children in the target reminder condition may have developed an expectation of seeing a dog picture as the last picture in each of the three books and hence had effectively converted this activity-based task into an event-based PM task, we repeated the above analysis on PM performance scores in the first activity book only (when no expectation could have yet been formed) and the identical results were obtained in terms of the significant main effects of age, $F(1,152) = 7.90$, $p = .003$, $\eta_p^2 = .05$, and reminder cue, $F(1,52) = 4.84$, $p = .003$, $\eta_p^2 = .09$. Moreover, the planned comparisons between the associative cue and the control conditions became statistically significant, $p = .037$.

Additionally, because the majority of children either remembered or forgot on all

three occasions, we also subjected data to non-parametric analyses by performing a three-way backward loglinear analysis on PM success or failure, age and reminder type. Participants were classified as either forgetting on all three occasions (score = 0) or remembering on at least one occasion (score = 1). Findings were the same as with the analyses of variance reported above: there were significant interaction effects of age and PM success, $\chi^2$ (3) = 11.21, $p$ = .001, and reminder cue type and PM success, $\chi^2$ (3) = 15.12, $p$ = .002, but not age and cue type, $\chi^2$ (1) = 1.0, $p$ = .80.

**Reported prospective memory strategy**

Finally, in the case of children who succeeded on the PM task at least once, we examined responses to the question about their strategy, namely, whether they thought about their PM intention continuously while completing the activity books (i.e., strategic monitoring) or, alternatively, simply remembered upon completion of each book (i.e., spontaneous retrieval). Results showed that 26 of 35 5-year-olds (74%) and 38 of 53 7-year-olds (72%) reported relying on spontaneous retrieval. The frequency of the different retrieval strategies did not differ significantly between the two age groups, $\chi^2$ (1, 88) = 0.07, $p$ = .790.

## Discussion

In this study we had two principal aims. First, we investigated the effects of age on children's activity-based PM; specifically, their ability to remember to put a card depicting a dog into a box upon completing an activity booklet involving a visual search task. Extending previous research, which had focused on ages 2-6 years, we compared the performance of 5- and 7-year-olds. Second, we evaluated the effects of incidental reminders on PM performance by inserting pictures with varying relevance to the PM

task as the last page in the activity booklets. Previous studies of the effects of reminders on children's PM had used only explicit reminders. Results showed a clear developmental trend, with the 7-year old children outperforming the 5-year olds on activity-based PM regardless of the type of reminder. Moreover, we found a significant main effect of reminder with a medium effect size. When the incidental reminder (i.e., a line drawing of a dog) was highly perceptually and conceptually similar to the target of the PM task (i.e., a coloured picture of a different dog), children performed significantly better than in the control no reminder condition (i.e., a line drawing of a flower) or when the cue was related to the completion of the PM action (i.e., a line drawing of a box). By contrast, the associative reminder (i.e., a line drawing of a cat) only marginally increased PM performance when compared to the control condition, while the action reminder did not significantly improve PM performance.

In showing that 7-year olds outperformed 5-year olds on an activity-based PM task, our results support those of Meacham and Dumitru (1976) who tested the same age groups. The present findings demonstrate a strong developmental improvement of activity-based PM even under conditions in which both age groups performed at ceiling level in the ongoing visual search task and spent approximately the same amount of time completing each activity book (in fact, on average 7-year olds spent few seconds longer due to the higher number of to-be-processed pictures). It is worth noting that PM performance in the control condition was only .25 in 5-year olds and .45 in 7-year olds. This was despite the fact that there was no need to interrupt the ongoing activity in order to carry out the PM task, which has been shown to significantly impair children's performance in event-based PM tasks (e.g., Kvavilashvili et al., 2001). Such low

performance levels (see also Kliegel et al., 2013; Kurtz-Costes et al., 1995) are in keeping with the suggestion that activity-based PM is more difficult than event-based PM, as indicated by the study of Brewer et al. (2011) with young adult participants (see also Mahy et al., 2014a; Wang et al., 2011).

Regarding the effects of the incidental reminders, the most important finding is the large superiority of PM performance in the target reminder condition (a picture of a dog resembling the one involved in the PM task) over the no reminder (control) condition. In research showing benefits of incidental reminders for adult participants, it has been suggested that results can be explained by automatic spreading of activation in the network of semantic knowledge from reminder to intention (McDaniel & Einstein, 2000; 2007; Mullet et al., 2013; Scullin et al., 2010). The notion that the PM intention was primed following the unexpected encounter with the incidental reminder could also account for the observation that the advantage of the target reminder was equivalent for 5- and 7-year old children (i.e., there was no age by reminder cue interaction). This is because evidence from both adults and children indicates that spreading of activation is relatively unsusceptible to standard age effects (Balota & Duchek, 1988; Hashimoto, McGregor, & Graham, 2007). Consistent with the interpretation of the reminder effect in terms of spreading activation, the majority of children in both age groups (> 70%) reported not thinking about their PM intention while completing the activity books. That is, it seems they relied on spontaneous retrieval rather than strategic monitoring.

Given that presenting a picture of a box as a reminder (the completion of the PM action) did not enhance performance in comparison to the control condition, and was significantly less effective than presenting a picture of a dog, our results are in line with

those reported by Meacham and Dumitru (1976) for an explicit reminder. They found that providing 5- and 7-year old children with a card depicting a box into which they had to post their drawing after the end of the session, which remained on view throughout, did not enhance PM performance. One possible explanation for the advantage of the 'target reminder' over the 'action reminder' is that when the PM intention is formed, priority is given to earlier segments of the action sequence. Clearly, though, further studies are needed to confirm that our findings hold up regardless of the salience or appeal of different objects involved in the intention. For example, children could be asked to place a picture of a box into a container shaped like a dog or, alternatively, to open a closed box and extract a card depicting a dog. There is also some evidence that both cue and action reminders together (in view throughout the session) support PM understanding in 3 year old children but not older children (Kliegel & Jäger 2007). The current study did not include a combination of cues and further research is needed to understand how a cues may combine to support PM understanding in young children. It would also have been interesting to understand whether there were any cultural or socioeconomic influences may be salient to gain a more complete understanding of the development of PM in children.

In terms of the associate reminder (cat picture), our results are equivocal as PM performance in this condition failed to differ from performance in either the target or action reminder conditions but was marginally higher than in the no reminder condition. Interestingly, both Mullet et al. (2013) and Scullin et al. (2010) found that an incidental associative reminder was effective for younger adults but not for older adults. Specifically, only younger adults showed sensitivity to reminders such as the word

'wallet' (i.e., they responded more slowly) in a distracter task when their event-based PM was to respond to the target word 'money' in a later image-rating task. Possibly, then, we would have succeeded in showing a significant benefit of the associate reminder if we had included slightly older children in our study, who are likely to have developed a stronger mental association between the concepts of cat and dog.

Clearly, the findings of this study have useful practical applications as parents could be advised to use the technique of arranging incidental reminders for their child to jog their memory for important PM intentions. For example, if a 5-year-old keeps forgetting to bring their lunchbox home from school then their parent could try placing a photo of a lunchbox on their rucksack. Our results also point to several new avenues of research that could enhance theoretical understanding of PM. First, it would be informative to directly compare the effectiveness of explicit- and incidental reminders. As pointed out earlier, all previous investigations of the impact of reminders on children's PM have used explicit reminders that were in full view during the ongoing task. Our study could therefore be repeated, only this time including an explicit reminder condition in which children are told at the outset that they will see a picture of a dog on the last page of the activity book to help them to remember the PM task (i.e., equating the level of exposure to the explicit and implicit reminder). Second, future research could manipulate the length and complexity of the PM intention to identify the characteristics of the effective reminders. For example, using counterbalancing of objects that serve as cues to control for their inherent interest and appeal, such research could examine whether the best reminders always refer to the first object involved in the intention or simply to the most conceptually or perceptually salient object involved in the intention.

Third, by extending the age range upwards it would be possible to make a stronger test of the developmental changes in responses to reminders. Given evidence of improvements in meta-memory capabilities as children grow older, it seems reasonable to suppose that older children will gain a greater advantage than younger ones from being provided with explicit reminders. In contrast, age effects in the impact of implicit reminders are likely to be much smaller.

Further to the above, more research on activity-based PM may yield new insights into the development of PM during childhood. For example, studies on event- and time-based PM suggest that such development is driven, at least partly, by the maturation of executive functions, especially for more difficult tasks in which children must withhold their responses to the ongoing task in order to execute their PM intention (for review, see Mahy, Moses, & Kliegel, 2014b). Given that typical activity-based tasks do not require ongoing task interruption, it is possible that the development of activity-based PM is less dependent on executive processes than event- and time-based PM. Interestingly, performance in the target reminder condition of the present study was numerically similar to the scores for event-based PM in the no interruption condition of Kvavilashvili et al. (2001), in which 5- and 7-year old children had to respond to a pre-specified cue (picture of an animal) which occurred at the end of each card-naming task and thus placed minimal demands on inhibition and task switching. A study by Ford, Driscoll, Shum and Macaulay (2012) found a diminished contribution of executive functions to event-based PM in a no-interruption condition relative to an interruption condition. However, the former showed an influence of self-projection abilities that the authors suggested might relate to the capacity for imagining the future. The possibility that age-related

improvements in future thinking could be an essential driver behind the development of activity-based PM is worthy of further exploration.

In conclusion, this study presented novel evidence that children's performance on an activity-based PM task was significantly boosted by an incidental reminder that was similar to the target of their PM intention. Given the dearth of research on how reminders influence children's PM, there is considerable scope for further investigation of the topic. As discussed, future studies that use a wider age range, directly compare the effectiveness of explicit and implicit reminders, and evaluate the impact of reminders linked with different aspects of the PM intention, have the potential to greatly improve our understanding of the mechanisms of PM and its development during childhood.

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**Table 1**

*Mean time in seconds (SD) spent by 5- and 7-year-old children on completing the first, second and third picture-books with visual search component*

| | First picture-book | Second picture-book | Third picture-book |
|---|---|---|---|
| 5 year olds | 57.83 (10.57) | 53.98 (12.19) | 51.94 (11.06) |
| 7 year olds | 62.35 (13.54) | 57.68 (11.86) | 53.94 (11.04) |

**Table 2**

*Mean proportions (SD) of correct PM responses in 5- and 7-year-old children as a function of reminder cue (target vs. semantic vs. action vs. no cue).*

| | Type of reminder cue | | | |
|---|---|---|---|---|
| Age group | Target | Semantic | Action | No cue |
| 5-year olds | .62 (.49) | .47 (.50) | .35 (.49) | .25 (.44) |

| | | | | |
|---|---|---|---|---|
| 7-year olds | .83 (.33) | .62 (.47) | .62 (.47) | .45 (.49) |