Effects of incidental reminders on prospective memory in children

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Abstract

Prospective memory (PM) involves remembering to carry out intended actions in the future (e.g., posting a letter on the way to school or passing on a message) and is important for children's independent functioning in daily life. This study examined, for the first time, the effects of incidental reminder cues on children's PM. Five- and 7-year-old children (n = 160, 50% female, predominantly White from lower middle to middle-class families) had to remember to put 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 line drawing on each page (activity-based PM task). Additionally, the picture 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 target of 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*

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Memory development in young children involves not only retrospective memory, i.e., the ability to remember events that happened in the past, but also the ability to think about the future, and especially to carry out intended actions in the future (Atance & Jackson, 2009; Kvavilashvili et al., 2008; Mahy et al., 2014b). For example, children may have to remember to take a toy when leaving their house, phone their grandmother after finishing homework, watch a favourite cartoon in the evening or pass a message to their father when seeing him at the weekend. These types of simple prospective memory (PM) tasks are essential for successful everyday functioning, suggesting that the ability to carry them out reliably is a crucial developmental achievement (Mahy et al., 2018).

Importantly, successful PM also depends on basic retrospective memory skills because a child has to remember not only their intent to do something, but what they need to do (e.g., phone grandmother) as well as the context in which this intention should be carried out (e.g., after finishing homework) (Kliegel & Jäger, 2007; Ślusarczyk et al., 2018). In most cases, the retrospective component is simple and the difficulty lies in the "remembering to remember" component of the PM task. For example, after finishing her homework, it is the child herself who has to remember to phone the grandmother without a direct prompt to do so (Kvavilashvili & Ellis, 1996). If such a prompt is provided (e.g., *what did you have to do after finishing your homework*?), then the PM task is reduced to a retrospective memory task of recalling the contents of the intention (i.e., *I have to call my grandmother to ask her if I left my toy at her house*).

Both adults and children tend to be more concerned about their PM failures than their retrospective memory failures because the former usually have more serious consequences (e.g., forgetting to take an asthma inhaler to school or to feed a pet fish) (Howard et al., 2006; Meacham & Singer, 1977). Because young children may struggle to remember PM tasks

independently, they often depend on adults to give them reminders to support their PM (Mahy et al., 2018). Such deliberate reminders from caregivers may involve explicit verbal instructions to remember the intention (Mahy et al., 2018) or putting intention-related objects in prominent places (e.g., Guajardo & Best, 2000).

To date, research on the effectiveness of PM reminders for young children has focused exclusively on such explicit reminders. However, research on adults has shown that incidental cues in the environment can similarly remind people of their upcoming PM tasks and enhance chances of remembering their intention at a later time (e.g., Kvavilashvili & Fisher, 2007; Taylor et al., 2004). For example, seeing a milk carton in the staff room may remind a person of their intention to buy milk after work, and may contribute to successful remembering of this intention later on. Therefore, the main aim of the present study was to investigate, for the first time, the effects of incidental reminders on PM performance in children (5- and 7-year-olds). Such an investigation is important not only practically, but also theoretically by providing new insights into mechanisms of PM retrieval. Before describing the rationale and aims of our study, we first review literature on different types of PM tasks, main theoretical models of PM retrieval, and propose a taxonomy of PM reminders.

The nature and types of prospective memory tasks

Prospective memory tasks can vary along several dimensions (Kvavilashvili & Ellis, 1996), but often they have been classified in terms of the context in which the intention is carried out (Einstein & McDaniel, 1990). Thus, in event-based PM tasks, the intention can be carried out only when encountering a particular event at some point in the future (e.g., passing a message to a teacher when a child sees them at school), while time-based PM tasks involve remembering to do something at a particular time (e.g., calling someone at 2:00 pm or in 10 minutes time). By contrast, activity-based PM 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). Because the intention is carried out during the gap that occurs in between the consecutive actions, activity-based PM does not involve the interruption of ongoing activity that is characteristic of most event- and time-based PM tasks (Brewer et al., 2011; Kvavilashvili & Ellis, 1996).

One thing that is common to all PM tasks is that the intention cannot be carried out immediately but only after some time has elapsed (this may vary from minutes to weeks or even longer). Consequently, all PM tasks start with the initial intention formation stage whereby an adult or a child forms a mental representation of an intended action or what needs to be done (i.e., make a phone call) and the recipient or the target of this action (e.g., one's grandmother) as well as the context in which this action needs to be carried out (time, event, activity). This is followed by a delay period filled with other activities (e.g., doing homework, playing, etc.) until the context for the intention execution arrives (e.g., finishing a game). The period in which the intention can be carried out is called the performance window. In the final intention execution phase, the intention is carried out or a decision is made to postpone or cancel it (Ellis, 1996; Kvavilashvili & Rummel, 2020).

Theoretical models of prospective memory

Theoretically, one of the most important questions regarding PM has been to understand what brings the intention to one's mind at the right time or context without an explicit prompt to recall the intended action. According to the preparatory attention and memory (PAM) theory, successful retrieval depends on strategic monitoring of the environment for the appearance of the right time or context, a process that relies on attentional resources and executive control (Smith, 2003). For example, a person who is baking a cake might monitor their intention to remove it from the oven before it gets burnt by regularly checking the clock and/or the appearance of the cake (Ceci & Bronfenbrenner, 1985). By contrast, the multiprocess theory assumes that for most everyday PM tasks with

long delays, such strategic monitoring will not be practical or even feasible, and thus recall may depend on automatic associative retrieval processes that are experienced as the intention simply popping into mind (McDaniel & Einstein, 2000; 2007). Moreover, according to the dynamic multiprocess theory, people can flexibly either adopt a monitoring strategy or rely on automatic retrieval depending on the circumstances (Scullin et al., 2013). For example, for a child who wants to buy some sweets on their way home from school, this intention may pop into their mind when the right context for the intention execution arrives (i.e., when the child starts walking home from school), but thereafter the child monitors the environment so that s/he does not miss the right shop.

Both the PAM and multiprocess theories focus primarily on the processes operating during the final retrieval phase of intention execution or during the performance window in which the PM event may be encountered. By contrast, the pragmatic dual process theory of future thinking (Kvavilashvili & Rummel, 2020) places more emphasis on the formation of the intention representation at encoding and the processes involved in its periodic reactivation during the delay or performance intervals which may result in the intention popping into mind endogenously (i.e., without any external or internal triggers) or in response to incidental cues. Both will result in strengthening of the intention representation and increasing the chances of remembering the intention when the right moment for its execution arrives (for a review of evidence see Kvavilashvili & Rummel, 2020).

A taxonomy of PM reminders

Reminders for PM tasks can be divided into two broad categories: intentional or explicit reminders versus incidental or implicit reminders. Intentional reminders are deliberately created by a child or someone else (usually an adult caregiver) and may comprise a verbal or written reminder (Mahy et al., 2018), or an intention-related object placed in a strategic location (Guajardo & Best, 2000; Meacham & Dumitru, 1976). Such reminders are

usually created at the time of intention encoding or during the delay interval in an attempt to increase the chances of remembering the intention when the right context arrives.

By contrast, incidental reminders are not pre-planned and deliberate. Instead, they occur unexpectedly either as objects in the environment (i.e., external) or a concept in one's thoughts (i.e., internal). Regardless of their nature, they can remind a person of their upcoming task via their semantic or associative relationship to the PM intention (Kvavilashvili & Fisher, 2007; Taylor et al., 2004). For example, if a child intends to phone her grandmother after finishing her homework, the incidental reminder may be related or refer to the target of her intention (i.e., coming across the word 'grandmother' while reading a book) or to the to-be-performed action (i.e., seeing someone on the street making a phone call) (Kvavilashvili & Fisher, 2007). This is different from deliberately putting the grandmother's picture or the phone on the kitchen table with the expectation that seeing this reminder after finishing homework would help the child to remember her intention.

One theoretically important question in relation to these reminders is about how they activate the intention representation when they are encountered. For intentional reminders, a link between the reminder cue and intention representation is created deliberately and, therefore, encountering this reminder in the environment should activate the intention representation in the same way that seeing a cue word activates its associated word in the cued recall tasks (Einstein & McDaniel, 1990; McDaniel & Einstein, 2000). By contrast, the processes involved in activating links between an incidental reminder and a particular intention have not been discussed in much detail in the literature. However, according to the pragmatic dual process theory (Kvavilashvili & Rummel, 2020), this process may be very similar to how incidental cues have been shown to trigger involuntary autobiographical memories in both adults (Kvavilashvili & Fisher, 2007; Mace, 2004) and in young children (Krøjgaard et al., 2017). For example, a child who reads the word "grandmother", may have

an involuntary memory about how she visited her last weekend (Kvavilashvili & Ford, 2021), but if the same child had an intention to call the grandmother in the evening, the thought about this upcoming PM task may pop into her mind instead. Given that the intention representation consists of multiple components such as a target of one's action, the to-be-carried action and the context in which the task can be carried out, it is possible that a wide array of stimuli, which are identical or semantically related to these intention components, can potentially elicit conscious thoughts about an upcoming intention (e.g., see Kvavilashvili & Fisher, 2007).

Another theoretically important question is to find how these explicit and implicit reminders improve PM performance after they have brought the intention to one's mind. The general assumption is that they increase the activation levels of the intention representation by strengthening the association between its components (e.g., between the representation of grandmother and the action of making a phone call) (e.g., Guynn et al., 1998) which, in turn, increases the likelihood of remembering this intention at a later time (i.e., with the intention popping spontaneously into mind) (Ellis, 1996). An alternative, but not mutually exclusive, possibility is that a reminder will increase strategic (intermittent) monitoring for appropriate conditions in which the intention can be executed (Huang et al., 2014; Scullin et al., 2013).

Effects of explicit reminders on children's prospective memory

Although preschool children appear to have some insight into their ability to carry out PM tasks (Kvavilashvili & Ford, 2014) and the usefulness of setting up explicit reminders, for example, putting skates near the front door to remember to collect them before leaving the house (Kreutzer et al., 1975), a handful of studies on the effects of explicit reminders on young children's PM have yielded an inconsistent pattern. Almost all these studies examined the effects of objects placed in strategic locations to remind a child of the PM task when the right context of intention execution arrived (but see Mahy et al., 2018). In early studies by

Meacham and colleagues, children with mean ages of either 5 or 7 years had to remember to do something after the completion of a brief experimental session. While an external reminder in the form of a toy clown placed next to a child was found to enhance the probability that they remembered to remind the experimenter to open a surprise box (Meacham & Colombo, 1980), an external reminder in the form of a picture of a postbox did not enhance children's chances of remembering to post their drawing in a postbox on the way back to their classroom (Meacham & Dumitru, 1976).

In more recent studies, children had to remember to do something when encountering a particular picture (e.g., a picture of a house) while performing an ongoing picture naming task (Cheie et al., 2014) or picture encoding task (Guajardo & Best, 2000). In explicit reminder conditions, 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). Finally, in a study by Kliegel and Jäger (2007), the explicit reminder (a box and a real apple placed in front of the child) improved 3-year-old children's chances of remembering to put a picture of an apple in a box behind them when seeing a picture of an apple during the picture-naming task. However, this reminder did not improve PM performance in 4-, 5-, and 6-year-old children. Similar non-significant findings were reported by Mahy et al. (2018) for 4-, 5-, and 6-year-old children who were reminded of their PM task verbally just before starting the ongoing task.

In summary, out of six studies, only two reported beneficial effects of explicit reminders on young children's PM (Cheie et al., 2014; Meacham & Colombo, 1980), while Kliegel and Jäger (2007) found a positive impact only for the youngest age group tested (3-year-olds). By contrast, explicit reminders did not improve PM performance in the studies by

Meacham and Dumitru (1976), Guajardo and Best (2000) and Mahy et al. (2018). Possible reasons for the inconclusive findings include small samples with only 9 to 13 children per condition in some studies (Kliegel & Jäger, 2007, Mahy et al., 2018; Meacham & Dumitru, 1976) and the presence of confounding variables. In Cheie et al.'s (2014) study, for example, a positive effect of the reminder could be due to practice effects because the reminder condition always occurred after the no reminder condition.

More importantly, in all studies on explicit object reminders, the reminder remained in the full view of participants from the time of encoding the intention until the moment of its execution. In adults, this has been shown to cause habituation to the cue, reducing its effectiveness as a reminder (Loft et al., 2011). Moreover, the successful use of a continuous reminder may depend on the ability to divide one's attention between the ongoing activity and the reminder to periodically refresh the meaning of the reminder in relation to PM task. This type of updating and attention switching requires executive resources, which will be particularly demanding for young children (Mahy et al., 2014b). In everyday life, reminders tend to occur intermittently and the best reminders tend to occur in close proximity to the context in which the intention can be executed (Loft et al., 2011; Vortac et al., 1995).

The present study

Despite a small body of research showing positive effects of implicit reminders on PM in adults (Lourenço & Maylor, 2015; Meier et al., 2006; Taylor et al., 2004), nothing is known about whether incidental reminders are similarly helpful for children's PM. Theoretically, if incidental cues bring intention representations to mind via the accidental spread of activation in one's network of semantic and autobiographical knowledge, then implicit reminders should be able to increase PM performance even in young children. This is because implicit memory processes are less affected by age in contrast to intentional, strategic retrieval processes, which show large developmental changes across childhood and

the lifespan (Balota & Duchek, 1988; Graf, 1990; Hashimoto et al., 2007; Lloyd & Newcombe, 2009; Parkin & Streete, 1988). To address this question, the present study examined the effects of incidental reminder cues on 5- and 7-year-old children's PM. These age groups were chosen to encompass the period of life at which most children are starting to become autonomous in at least some of their PM tasks rather than relying on their parents to either remind them or carry out the task on their behalf. In addition, significant developmental changes in PM have been observed in these age groups (e.g., Kvavilashvili et al., 2001), and we were particularly interested to find out if age differences could be attenuated in some of the reminder cue conditions.

We used a standard laboratory paradigm of PM in children which involves engaging children in simple games (e.g., noughts and crosses, picture lotto, etc.) alternating with brief experimental tasks (e.g., completing activity books) into which a PM task is embedded (Kvavilashvili et al., 2001; 2008). In most developmental studies, event-based PM has been studied by asking children to remember to do something when they encounter a particular picture in the ongoing experimental task (e.g., a picture of a dog). In the present study, we used an activity-based PM task in which children had to remember to do something (i.e., putting a coloured picture of a dog into a small box) every time they finished working on one of three activity books each containing one line drawing per page.

An activity-based PM task was chosen because it enabled us to examine spontaneous retrieval processes in response to a reminder cue, uncontaminated by more deliberate monitoring processes. Indeed, while in event-based tasks participants may resort to strategic monitoring for a target word or a picture during the ongoing activity even if such monitoring is not essential for successful intention retrieval (e.g., Einstein et al., 2005; Scullin et al., 2010), the end of the ongoing activity in activity-based PM tasks is not a type of event that one can deliberately search for in the same way. It is possible that significant decrements in

performance on activity-based PM in comparison to event-based PM in adults (e.g., Brewer et al., 2011) can be partly explained by this feature of activity-based PM. Finally, an activity-based task made it possible for us to use a reminder that was identical to the main components of the intention representation (i.e., to the target of the child's action) whereas in event-based tasks only semantically related reminders can be used (e.g., Taylor et al., 2004) because encountering the target event (e.g., picture of a dog) would signify the arrival of the context of intention retrieval (e.g., press a button when you see a picture of a dog).

Children were randomly assigned to a control condition with no incidental reminders and three experimental conditions in which we varied the relationship between the incidental cue and the components of the intention representation. In the *target reminder* condition, children saw a line drawing of a dog as the last picture in each activity book (this was not the same as the dog picture used in the PM task). In the *associative reminder* condition, 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 in the PM task (i.e., putting the dog picture into the box). Finally, in the *control* condition, children saw a picture of a flower, which was unrelated to their PM intention (see Figure 1).

It was predicted that the dog picture would enhance PM performance relative to the control condition. We assumed that this would be achieved by the picture of the dog activating not only the representation of a dog but also memories of personal events related to dogs including the recently formed intention to put a picture of a dog into a box. Given that the concepts of cat and a dog are semantically related (with a forward association of .51 from *cat* to *dog*, see Nelson et al., 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, 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

related concepts (e.g., the word ‘wallet’) 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 for the action reminder condition due to negative results from two developmental studies that used explicit action reminders. For example, in a study by Meacham and Dumitru (1976) on 5- and 7-year-old children, an explicit reminder card depicting a box into which they had to post their drawing after the end of the session did not improve PM performance in comparison to a control condition. Similarly, a reminder that referred to both the action (picture of a box) and the target of intention representation (a real apple) did not improve PM performance in 4-, 5- and 6-year-old children’s in the study by Kliegel and Jäger (2007).

Method

Participants

A sample of 175 typically developing 5- and 7-year-old children, recruited from four primary schools in UK, 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 forgot the PM task on all three occasions and, in addition, were not able to recall the PM instructions when probed by post-experimental questions assessing their retrospective memory for PM instructions (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 numbers of males and females in each age group. An a priori power analysis was conducted using G*Power3 (Faul, Erdfelder, Lang, & Buchner, 2007) to test the difference using an F test using a medium effect size (.06) and an alpha of .05. Results showed that a total sample of 175 participants was required to achieve a power of .80.

The sample was predominantly White and from lower middle to middle class families. Although permissions to take part in the study were granted by schools' headteachers (in line with Ethics guidelines of British Psychological Society at the time when the study was carried out), each child also provided their verbal assent before taking part in the testing session. The study was approved by the University of Hertfordshire Psychology Department ethics committee (The effect of age and reminders on activity based prospective memory).

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 in which children named a series of pictures while 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 (9.5 cm x 12 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 in blue/red and three times in yellow/green folders.

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 et al. (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 et al., 1997).

Following recommendations by Kvavilashvili et al. (2008), we equated the time spent on completing the ongoing task in two age groups by including more pages in each folder for 7-year-old children. 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. The choice of these numbers was based on extensive piloting of the material which showed that 7-year-olds were faster at naming the pictures. 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 in the activity books for 5-year-olds, and three non-target pictures that were presented twice in the activity books for 7-year-olds.

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 (see Figure1), except for the yellow practice folder which was completed by children before they received a PM task and thus contained no reminders. To make the repeated appearance of the reminder cue in the blue, green and red folders less distinctive, two pictures (tree and trousers) occurred once in each of the four folders for both age groups.

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 had to be “posted” (i.e., placed) into the box. Both the cards and the box were placed on a separate table located behind the child’s chair and were not visible during the visual search task.

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 a picture on the first page of the yellow folder (i.e., hammer) and then to turn each page and name all the pictures one by one while, at the same time, looking for another picture of the hammer. When the picture of a hammer appeared, s/he 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 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 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 of 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.

If a child forgot to carry out a PM task on all three occasions, they were probed with two follow-up questions to ascertain that this failure was not due to retrospective forgetting of PM instructions. In line with standard laboratory procedures for studying PM, 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 (see Kvavilashvili et al., 2008).

If a child remembered to carry out the PM task on at least one occasion, indicating preserved memory for PM instructions, we probed them with different questions to gain some

information about how they remembered the PM task, spontaneously or by constantly thinking about their PM task while working on the activity books. In particular, they were asked "How did you remember to put a dog card into the box?" and were provided with two response options: "Did you think about it all the time or did you remember when you had finished each book?". The child's response was recorded (for similar probing used in children and adults see Kvavilashvili et al., 2001; O'Connor et al., 2021).

Transparency and openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study, and we follow JARS (Kazak, 2018). All data and study materials are available upon request from Lia Kvavilashvili at L.Kvavilashvili@herts.ac.uk. Data were analysed using SPSS, version 25. The study design and analyses were not pre-registered.

Results

Performance on the ongoing task (visual search task)

All children named most of the pictures 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: 1st vs. 2nd vs. 3rd) 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-olds 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 taking significantly longer to complete the first ($M = 60.09$, $SD = 12.32$) 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_s < .001. No other effects were significant, all Fs < 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). In both age groups (5 years and 7 years), the majority of children 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.[1]

The 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 main effect of age, $F(1,152) = 8.08$, $p = .005$, $\eta_p^2 = .05$, with 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, $F(1,52) = 4.49$, $p = .005$, $\eta_p^2 = .08$. Planned comparisons 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 reliably higher than in the action (box) condition (M =. 48, SD = .49), p = .02, and marginally better than in the associative (cat) condition (M =. 54, SD = . 49), p = .079. By contrast, in the associative condition, PM was only marginally better than in the control condition, p = .067, and did not differ from PM scores in the action condition, p =. 58. PM in the action condition was not reliably different from that in the control condition, p = .20. The age by reminder interaction was not significant, F < 1. To examine if children in the target reminder condition had

[1] In 5-year-olds, one was in the target and another in the associative reminder condition. In 7-year-olds, three children were in the target reminder condition, and two children were in each of the remaining three conditions.

developed an expectation of seeing a dog picture as the last picture in each book and hence, had effectively converted this activity-based task into an event-based PM task, we repeated the analysis on PM scores in the first activity book (when no expectation could have yet been formed). The identical results were obtained with 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 difference between the associative cue and control conditions became significant, $p = .037$.

Given that the majority of children remembered or forgot on all three occasions, the data was subjected to 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 ANOVA 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 those children who succeeded on the PM task at least once, we examined responses to the question about their strategy, namely, if they thought about the PM task while completing the activity books (strategic rehearsal) or, simply remembered upon completion of each book (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 percentages of children as a function of reported strategy and the condition are presented in Table 3. The data are pooled across the two age groups because no associations between age and response categories was found across the four conditions (all $\chi 2 < 1.30$). Although children in the target reminder condition were more likely to report thinking about their intention than children in the other three conditions, the association between response category and the condition was not significant, $\chi 2\ (3, 88) = 6.40$, $p = .09$.

Discussion

The present study investigated the effectiveness of incidental external reminders on 5- and 7-year-old children's activity-based PM by manipulating the relationship between the reminder cue (presented as the last picture in the activity books) and the two main components of intention representation (the target of the intended action and the to-be-performed action). Results showed a clear developmental trend, with 7-year-olds significantly outperforming 5-year-olds regardless of the type of reminder. Moreover, we found a significant main effect of reminder with a medium effect size. When the incidental reminder (a line drawing of a dog) was conceptually similar to the target of the PM task (a coloured picture of a different dog), performance was reliably better than in the control condition (a line drawing of a flower) or when the cue was related to the completion of the PM action (a line drawing of a box). By contrast, a reminder that was associatively linked to the PM target (a line drawing of a cat) only marginally increased PM performance compared to the control condition, while the action reminder did not significantly improve PM. Taken together, these findings have important theoretical implications by enhancing our understanding of implicit reminders and retrieval mechanisms of PM, and opening up interesting avenues for future research on both children and adults.

The effects of implicit reminders on prospective memory

While research on adults has studied the effects of both explicit and implicit reminders on PM (e.g., Guynn et al., 1998; Meacham & Leiman, 1982; Meier et al., 2006; Taylor et al., 2004), a few developmental studies have focused exclusively on explicit reminders and resulted in inconclusive findings that do not provide strong evidence for the effectiveness of external verbal or object reminders on children's PM. By contrast, we investigated the effectiveness of implicit reminders that had not been intentionally linked with a PM task at encoding or in the delay period, but were nevertheless conceptually or semantically similar to

the key elements of intention representation. Research on implicit reminders in adults has focused on event-based PM and mostly used incidental reminder cues that were semantically or perceptually related to the PM target event (Meier et al., 2006; Taylor et al., 2004). However, in everyday life, incidental reminders are often identical to key elements of intention representation, and research on adults has not addressed an important question about whether reminders that are identical or conceptually highly similar to elements of intention representation are as effective or even more effective than semantically related reminders.

The most important result obtained in the present study refers to a contrasting pattern of findings for incidental reminders that were conceptually highly similar either to the target of the intention or the to-be-carried out action. Indeed, in both age groups, PM performance in the target reminder condition (a picture of a dog resembling the one involved in the PM task) was significantly better than in the no reminder (control) condition. This novel finding can probably explain superior PM performance observed in event-based tasks with specific target events (e.g., respond to word “tractor” or “bear”) compared to more general, i.e., non-focal events (e.g., respond to words depicting vehicles or animals) (McDaniel & Einstein, 2007). By contrast, presenting children with a picture of a box as a reminder related to the completion of PM action (i.e., putting a card into a box) did not enhance PM compared to the control condition, and was significantly less effective than presenting a picture of a dog. Findings in relation to the action reminder are in line with a study by Meacham and Dumitru (1976) who 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, did not enhance PM performance. It appears that the target of intentions, whether they are event- or activity-based, may have a privileged status in the intention representation compared to its other constituent elements. In other words, the advantage of the ‘target reminder’ over the ‘action reminder’ could be due to the fact that when the PM intention is formed, priority is given to

earlier segments of the action sequence.[2] 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. In addition, it is important to investigate the possibility that some objects (e.g., a phone) are more intrinsically related to intended actions (making a phone call or talking to someone) than other objects such as a box used in the present study.

In terms of the associative reminder (cat picture), our results are equivocal because in this condition, PM performance did not differ from PM in 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 in younger but not in older adults. Thus, 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. It is therefore possible that significant benefits of the associative reminder will emerge in older children, who are likely to have developed a stronger mental association between the concepts of cat and dog. This is clearly a worthwhile avenue for future research.

The effects of age on activity-based prospective memory

Another important set of findings relates to the effects of age on activity-based PM. Extending previous research on explicit reminders that had focused mainly on 2- to 6-year-old children, we compared the performance of 5- and 7-year-olds. In line with Meacham and Dumitru (1976) who tested activity-based PM in 5- and 7-year-old children, we found a strong developmental improvement of activity-based PM in these age groups. This is an important finding given that all precautions were taken to reduce age differences due to confounding variables that can be present in developmental research on PM (Kvavilashvili et

[2] For related research on children's memory for goal-related action sequences see Loucks and Meltzoff (2013).

al., 2008). In particular, all children, who were included in the study, could remember the PM instructions at the end of the session, performed at ceiling in the ongoing visual search task and spent approximately the same amount of time completing each activity book.

Although in both age groups PM performance in the control condition was fairly low, it was comparable to levels reported on activity-based PM in both children and adults (Brewer et al., 2011; Kliegel et al., 2013; Kurtz-Costes et al., 1995). This was despite the fact that there was no need to interrupt the ongoing activity to carry out the PM task, which has been shown to impair children's performance in event-based PM tasks (Kvavilashvili et al., 2001). These decrements in activity-based PM in children are in line with suggestions 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). Taken together, the pattern of results emerging from the present study as well as the previous literature on adults and children suggests that finishing one's activity is not as salient an event as encountering a particular word or picture in event-based PM (Kvavilashvili & Ellis, 1996). Young children, in particular, may be vulnerable to forgetting activity-based tasks, and parents and teachers should try to convert these tasks into event-based tasks by linking PM tasks to a particular event rather than finishing one's activity (Maylor, 1990).

Theoretical implications: Mechanisms involved in Prospective Memory

Developmental research can provide important insights into the mechanisms by which PM tasks are brought to mind at the appropriate moment. For example, if successful PM remembering always requires strategic monitoring and deliberate intention rehearsal processes as suggested by the PAM theory, then very young children should not be able to remember PM tasks because their retrospective memory and executive functions are not yet sufficiently developed. However, there is evidence to suggest that even 2-year-olds can succeed in simple and highly attractive PM tasks despite their poorly developed monitoring

abilities (e.g., Ślusarczyk & Niedźwieńska, 2013; Ślusarczyk et al., 2018; Sommerville et al., 1983; but see Kliegel & Jäger, 2007). At the same time, significant improvements in children's PM have been linked with the development of executive resources (Mahy et al., 2014b), which suggests that successful PM involves an interplay between spontaneous retrieval processes and more strategic monitoring, depending on the context and nature of PM tasks, as suggested by both the multiprocess and the dynamic multiprocess theories.

In the present study, to minimize the chances of monitoring, children had to remember to do something after finishing the activity book. In this situation, deliberate monitoring for the context of intention execution (i.e., finishing the activity book) was less likely to occur (although some children still reported constantly keeping intention in their mind), and hence, enabled us to assess the role of incidental reminders at the end of each activity book more effectively. Indeed, if an incidental cue managed to remind the child of their PM task when they finished the activity book, it is highly likely that this was immediately followed by carrying out the PM task because the context in which the intention could be completed coincided with the intention representation popping into mind.

The results showed that PM scores were 2.5 times higher in the target reminder condition in 5-year-olds and almost twice as high in 7-year-olds compared to the control no reminder condition (see Table 2). This finding demonstrates powerful effects that incidental reminders can have on children's PM performance in situations when target monitoring is either not possible or less likely and provides support for theories that suggest that successful PM is often based on automatic associative activation processes. However, if PM performance in our study was based entirely on such spontaneous retrieval processes then we should have obtained an age by condition interaction, but this did not happen. Instead, both 5- and 7-year-old children benefitted equally from the target reminder and hence the performance in the target reminder condition was still better in 7-year-olds (M = .83) than 5-

year-olds (M = .62). This suggests that some other factors were contributing to 7-year-olds' superior performance in this condition. Potential candidates, suggested in the literature, include children's executive functions (Mahy et al., 2014b) and self-projection abilities (Ford et al, 2012), which were not assessed in the present study. It is interesting that the results of post-experimental probing of children who remembered the PM task at least once showed a non-significant trend for reporting higher levels of intention rehearsal in the target reminder condition compared to the other conditions (see Table 3). This provides support for the dynamic multiprocess theory, which suggests that although the intention may be retrieved automatically upon the first encounter of the appropriate context, thereafter some participants may engage in deliberate monitoring or rehearsal strategies (Scullin et al., 2013). However, our results should be interpreted cautiously because the order of response options was not counterbalanced, and there is a need for replication in future studies.

Our findings also have broader theoretical implications by providing support for the pragmatic dual processes account of future thinking (Kvavilashvili & Rummel, 2020). Findings from the target reminder condition appear to show that seeing particular events in the environment (words, objects, places, people) may automatically activate numerous representations in one's network of semantic and autobiographical knowledge, which may result in a variety of contents (thoughts, memories, music, etc.) popping into mind including thoughts about an upcoming PM task. While there is a small body of research showing that environmental or contextual cues can make 3-year-old children spontaneously remember (i.e., verbally report to their caregiver) previous events related to these stimuli (Krøjgaard et al., 2017; Sonne et al., 2019), our study was the first to demonstrate that incidental external stimuli can also activate representations of future intentions in young children if these stimuli are conceptually similar to the target of the intended activity. This novel finding needs to be replicated and examined in both children and adults to further enhance the understanding of

components of intention representations (an important but neglected topic in PM research) and the processes involved in their activation by incidental environmental stimuli.

Currently, there is a debate in the literature about the relationship between semantic and episodic/autobiographical memory with an emerging consensus that cognitive and brain mechanisms underlying these memory systems are interlinked much stronger than previously thought (Greenberg & Verfaellie, 2010; Mace et al., 2019; Renoult et al., 2019). What we do not yet know is whether seeing a picture of a dog results in a parallel spread of activations in semantic and autobiographical knowledge networks or whether the activation starts first in the semantic network and then spills over to the autobiographical network. However, the content analysis of cues recorded in diary studies of involuntary autobiographical memories has shown that they tend to be conceptually identical/very similar to the key aspect(s) of the memory representation rather than semantically or thematically related to it (Schlagman et al., 2007). For example, memories involving an experience with a dog, are more likely to be triggered by stimuli referring to various characteristics of dogs (e.g., a pet dog in the street, dog food in the shop, etc.) than other semantically or thematically related concepts (e.g., seeing a kitten in the street or cat food, etc.). Therefore, if PM representations are similar to involuntary autobiographical memories then seeing a cat picture should be less likely to elicit thoughts about upcoming PM task involving a dog. Given that PM performance was marginally better in the associative (cat) reminder than in the control condition, it is possible that activations from the semantic network spill over to the network of autobiographical events. This is an interesting question that could be studied in the future on adults and children by manipulating the nature of PM tasks and the contents of incidental reminders.

Some limitations and future directions

The present study has some limitations that will need to be addressed in future research. First, the study was slightly underpowered because 15 children had to be excluded

as a result of post-experimental probing for PM instructions. Table 2 shows that performance in these conditions was nominally higher than in the control condition, but differences did not reach statistical significance. Hence, larger samples will be needed to examine the effects of associate and action reminders on PM. Second, Kliegel and Jäger (2007) showed that an explicit reminder involving both the target and the action of the PM task improved event-based PM, at least in 3-year-olds. In our study, we examined the effects of target, associative and action reminders separately, but future studies should examine possible cumulative effects of combinations of different reminders on PM performance (Guynn et al., 1998).

Third, future studies should compare the effectiveness of explicit and implicit reminders within one experimental study to see if incidental cues are as effective as intentionally created explicit reminders. For example, the target reminder and the control conditions could be identical to the conditions used in the present study, but an explicit reminder condition could be added for which, after receiving instructions for the PM task, participants are asked to insert a picture of the dog into last pages of the three activity books with the instruction that this would help them to remember the PM task when finishing each activity book. One could also vary the position in which the dog picture appears in the activity book to examine if the reminder placed in the middle of the book is as effective as the reminder occurring as the last picture in the book.

In conclusion, this study presented novel evidence that children's performance in activity-based PM was significantly boosted by an incidental reminder that was similar to the target of their intention. Given the dearth of research on how reminders influence children's PM, there is considerable scope for further investigation of the topic. Future studies that use larger samples, directly compare the effects of explicit and implicit reminders, and examine reminders linked with different aspects of the PM intention, will 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	Associative	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)

Table 3

Percentages (frequencies) of children who remembered PM task at least once, pooled across two age groups, and reported either rehearsing their PM task or remembering only after finishing each activity book as a function of reminder condition.

Reminder Condition	Rehearsal	Spontaneous	Total
Target	42% (13)	58% (18)	100% (31)
Associative	22% (5)	78% (18)	100% (23)
Action	10.5% (2)	89.5% (17)	100% (19)
Control	27% (4)	73% (11)	100% (15)
Total	27% (24)	73% (64)	100% (88)