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In one ear and out the other: Verbal reminders do not improve young children's prospective memory performance on a virtual task

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ABSTRACT

Prospective memory (PM), or remembering to carry out future intentions, is an ability with which young children often struggle. Thus, it is crucial to determine how to best support the development of their PM skills. Reminders are often used to support PM, and previous research has found that reminders referencing both the PM cue and intended action can improve children's and adults' PM. To date, no studies have investigated the effect of verbal cue and action reminders on preschool children's PM performance, a gap the current study intended to fill. A total of 88 North American children aged 3 to 6 years completed a PM task virtually. The PM task required children to interrupt a card-sorting task to wave at specific cards (those depicting elephants). Children were randomly assigned to receive one of the following: (a) three cue–action reminders, which referenced the PM cue (the elephants) and the intended action (waving); (b) three cue-only reminders, which referenced only the PM cue; (c) three action-only reminders, which referenced only the intended action; or (d) three irrelevant control reminders. The only significant predictor of PM performance was age, which became nonsignificant when the interaction terms were added in the model. Reminders did not have an effect on children's PM. We consider how these findings may lend support to theories of PM development and discuss the implications of using verbal reminders to support children's PM in everyday contexts.

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Introduction

When a school field trip is approaching, children are often asked to take home a permission slip, get it signed by a parent, and return it before the day of the trip. Most parents and teachers offer assistance to children with returning the permission slip in the form of verbal reminders (e.g., "Don't forget to return your permission slip"). A child who completes this task will have demonstrated successful prospective memory (PM), the ability to carry out one's future intentions (Einstein & McDaniel, 1990). PM is a critical milestone in cognitive development, given that children must remember and execute their intentions in academic and social contexts. Despite verbal reminders being the most common reminder type given to young children by parents in everyday life (Mazachowsky et al., 2021), we know relatively little about the impact of these reminders on children's PM. Thus, we need to better understand how parents and caregivers can support children's PM. In the current study, we investigated the effect of verbal reminders on preschool children's PM and examined whether different types of reminders are more beneficial than others.

The development of prospective memory

A growing body of research has investigated the emergence of PM and its development across early childhood. In a naturalistic study, Somerville et al. (1983) found that 2-year-olds could remind their mothers to complete a task of high interest to them (i.e., buying candy while at the store) without prompting. More recently, Kliegel and Jager (2007) used an event-based PM laboratory paradigm to examine the impact of reminders. In this paradigm, children were assigned a PM intention, completed a filler task, and then engaged in an ongoing distractor task that contained the PM cues. When the PM cues appear, children should carry out their intended action (i.e., place cards depicting apples into a box behind them). Contrary to the findings of Somerville et al. (1983), 66% of 2-year-olds could not recall the PM intention and their PM performance was not reliably above zero (Kliegel & Jager, 2007); however, PM performance improved across the preschool years (ages 3–6 years). Many other studies also show that PM improves rapidly across the preschool years (Guajardo & Best, 2000; Mahy et al., 2018; Mahy & Moses, 2011; Ślusarczyk & Niedźwieńska, 2013).

To date, the only theoretical framework that has attempted to explain this early developmental trajectory of PM is the *executive framework of PM development* (Mahy et al., 2014a). This framework proposes that executive functioning (EF), a set of abilities involved in the conscious control of thought and action, drives the development of PM during the preschool and early childhood years. According to this framework, for children to be able to carry out their future intentions, they must first possess a necessary, but not sufficient, level of retrospective memory (i.e., being able to remember what they were supposed to do). However, once a certain level of retrospective memory exists, the main driver of PM performance is EF. PM performance increases as children acquire EF skills, and specific aspects of EF account for age-related differences in preschoolers' PM (Kretschmer et al., 2014; Mahy et al., 2014b). This highlights the need to find ways to support children's EF abilities, given that they seem to underlie PM development across the preschool years.

The effect of reminders on adults' prospective memory

One way that preschool children's PM might be supported is by providing them with reminders. Different reminder types can strengthen recall of the intention, promote cue detection, or reduce the EF resources needed to carry out the intention at the appropriate time. Reminders have a beneficial impact on adults' PM, with a few studies focusing on how the content of a reminder influences PM performance (Guynn et al., 1998; Morita, 2006; Peper et al., 2023). In these studies, reminders were presented visually on a computer screen to remind participants of a previously assigned prospective intention. When the wording of the reminder referenced both the PM cue and the intended action, adults' PM performance was significantly better compared with reminders that referenced only the PM cue, only the intended action, or no reminders (Guynn et al., 1998; Peper et al., 2023). Although Morita (2006) did not examine reminders that referenced both the PM cue and the intended action,

they found that cue-only reminders significantly increased adults' PM compared with a no-reminder control group, whereas action-only reminders did not. Taken together, reminders focusing on both the PM cue and the intended action, or just the PM cue alone, may be effective in supporting adults' PM.

The effect of reminders on children's prospective memory

Visual reminders

Research on children's PM has focused primarily on visual reminders (e.g., Cheie et al., 2014; Guajardo & Best, 2000; Kliegel & Jager, 2007), particularly those that are explicit. Explicit reminders are provided deliberately to activate the PM intention and promote children's successful execution of the PM task (Ryder et al., 2022). For example, in a study by Kliegel and Jager (2007), half of the children were provided with a visual "cue–action" reminder (which referenced both the PM cue and the intended action, i.e., an apple card and the box where children needed to put the apple cards) to help them remember the PM intention. Children aged 3 to 6 years performed significantly better with this reminder compared with children who received no reminder. However, studies using explicit visual reminders that reference only the PM cue have revealed mixed findings. For instance, when 3- to 7-year-old children were shown a card depicting the PM cue (a frog) in the corner of their computer screen, their PM performance was significantly better compared with trials where the card was absent (Cheie et al., 2014). In contrast, 3- to 5-year-olds' PM did not benefit from an image of the PM cue being located near (but not on) the computer screen (Guajardo & Best, 2000). To expand on these findings, Ryder et al. (2022) compared the effectiveness of different types of incidental visual reminders on 5- and 7-year-olds' PM. In contrast to explicit reminders, incidental (or implicit) reminders are not deliberately provided to children but can trigger memory for the PM task through their semantic association with the intention (Ryder et al., 2022). Ryder et al. (2022) found that children who were presented with incidental reminders of the PM cue had significantly better PM performance than children who were presented with incidental reminders of the intended action or a control group. Thus, the impact of visual reminders on young children's PM may depend on whether the children reference the PM cue or intended action (or both), underscoring the need for further research on the effectiveness of different types of reminders.

Verbal reminders

Even less is known about the effect of verbal reminders on children's PM, which is problematic because it is the most common type of reminder that parents provide to support their children's PM (Mazachowsky et al., 2021). One study that investigated the impact of incidental verbal reminders on 5-year-olds' PM found that children who heard a story about a forgetful spider (who experienced several memory failures) and who predicted they would remember the PM task had marginally better PM performance than children who were read a control story (Kvavilashvili & Ford, 2014). Thus, incidental verbal reminders might not be powerful enough to substantially improve young children's PM (Kvavilashvili & Ford, 2014). The only study to date to examine the impact of explicit verbal reminders on children's PM compared the effect of a single cue–action reminder, a single executive reminder (which directed children to maintain their attention and carefully observe each picture), and no reminder (Mahy et al., 2018). Although there was no main effect of reminder type, there was a significant interaction between age and reminder type. Specifically, 5-year-olds performed better than 4-year-olds when provided with a single verbal cue–action reminder, whereas 4-year-olds performed worse than older children when given a single verbal executive reminder. Given the complexity of these results, additional clarity is needed on how different types of verbal reminders affect children's PM. Furthermore, given that the verbal reminders from Mahy et al. (2018) were given just prior to the start of the ongoing task, no study thus far has examined the impact of several explicit verbal reminders embedded within the ongoing task that focus just on the PM cue or action.

The current study

This study is the first to investigate the impact of repeated verbal reminders on 4- to 6-year-old children's event-based PM. In addition, we sought to extend past literature by teasing apart the influ-

ences of cue and action reminders. Children were assigned to one of four conditions: cue-only, action-only, cue–action, or no-reminder control. We had three research questions: (1) Do verbal reminders benefit children's PM performance?; (2) Is there a difference between cue and action reminders regarding their effect on young children's PM performance?; (3) Is there an interaction between age and reminder type?

Based on previous research on the impact of reminders on children's PM, we predicted that multiple verbal reminders embedded in the ongoing task would improve children's PM performance. In addition, we expected cue–action reminders to be the most effective, consistent with past findings (Guynn et al., 1998; Kliegel & Jager, 2007). As for a potential interaction between age and reminder type, there were two distinct possibilities: (1) Younger children may benefit more from cue–action reminders than older children given that younger children struggle more with memory for their future intentions (Kliegel & Jager, 2007); (2) Older children may be better able to use the reminders to execute the PM instructions at the appropriate time, given their advanced EF abilities compared with younger children.

Method

Participants

An a priori power analysis (G*Power; Faul et al., 2007) suggested that, for a multiple linear regression with seven predictors, a sample of 80 participants was necessary to detect a small to medium effect size (f^2 = .20, power = .80, α = .05). We recruited a sample of 127 3- to 6-year-old typically developing, English-speaking children from Canada and the United States to participate. Of these, 39 children were excluded from the analysis for the following reasons: not being able to report the PM intention after the PM task was finished (n = 22), being uncooperative (n = 9), parental interference in the procedure (n = 5), and technical issues (n = 3). Parental interference was deemed to have occurred if the parent restated the PM instructions after they were initially given, the parent explicitly told the child to wave at the elephants when they came on-screen, the parent provided the child with the answer to the memory control question, or it was clear that the parent was prompting the child off-screen. The final sample consisted of 88 children (44 girls, 42 boys, and 2 unreported) with a mean age of 56.9 months (SD = 9.0, range = 37–77). The majority of children were White (58.0% White, 18.2% mixed race, 9.1% Asian, 6.8% Asian Indian, 2.3% Black, 1.1% Middle Eastern, 1.1% Indigenous, and 3.4% did not report). Children were mostly from middle-class families (annual family income: 2.3% earned less than $25,000, 3.4% earned $25,000 to $40,000, 13.6% earned $40,000 to $75,000, 19.3% earned $75,000 to $100,000, 50.0% earned more than $100,000, and 11.4% did not report). Most parents (83.0%) had at least a bachelor's degree (2.3% completed high school, 10.2% had some college or a 2-year degree, 40.9% had a bachelor's degree, 35.2% had a graduate degree, 6.8% had other, and 4.5% did not report). Children were recruited from a participant database at Brock University, day-care centers in the Niagara Region, Children Helping Science, and through advertisements on social media.

Procedure

Data were collected for this study from March 2022 to July 2024. Given that the COVID-19 pandemic was still ongoing when the study was designed and when data collection began, the study was conducted virtually using Microsoft Teams in a live session. Prior to the testing session, parents completed a consent form and demographics questionnaire. Once parents joined the video call, they provided consent for the session to be recorded. Children provided verbal assent and were tested individually in 20-min sessions. They were randomly assigned to one of the four experimental conditions and completed the PM task. The task was hosted on Qualtrics, an online survey platform (https://www.qualtrics.com), and the screen-sharing function of Microsoft Teams was used to present it to children. During the session, parents were encouraged to remain with their children but were specifically instructed to limit their interaction with them and to avoid influencing their responses. When the session was finished, families were thanked for their participation and were later sent a Junior Sci-

entist certificate for their children and a $10 Amazon gift card. All study procedures were granted clearance by the Research Ethics Board at Brock University. The design and analytic plan for the study were not preregistered.

Prospective memory task

Children were first introduced to "Joe the Zookeeper," who needed help in sorting animals into cages. Cards depicting animals appeared on the screen, and each card had either a blue or yellow dot in the bottom right-hand corner. Children were told that animals with blue dots needed to be sorted into the blue cage and animals with yellow dots needed to be sorted into the yellow cage. It was also noted that Joe loved to wave at the elephants; thus, if children saw an elephant on one of the cards, they needed to stop what they were doing and wave at it (the PM task). Children completed three practice trials of card sorting (the ongoing task) to ensure that they understood how to sort the cards into the appropriate cages. For each trial (during both the practice and the actual game), the experimenter asked what cage the animal should go into, and children responded verbally with either "blue" or "yellow." The experimenter indicated children's responses by clicking the appropriate button on the screen, and then the next card appeared. For trials where an elephant (the PM cue) was on the card, if children visibly waved, the experimenter selected a third option on the screen that said "Other" instead of either of the colors (see Fig. 1 for an example of a PM trial).

During the three practice trials, the experimenter gave feedback to children who provided an incorrect answer (e.g., "Remember that you need to match the color of the cage to the color of the dot on the card"). Children were then given a second opportunity to answer. If children still could not answer correctly after receiving feedback on at least two of the three trials, they were excluded from the analysis. Only 1 child failed more than one of the practice trials, but this child had already been excluded due to being uncooperative. After the practice trials, children were reminded of the ongoing task and PM task instructions and then completed a 2-min filler task where they were asked to draw pictures. Children were also informed that there would be reminders during the game to help them remember the PM task.

Depending on the condition to which they were assigned, children were given one of four types of reminders by the experimenter. In the cue-only condition, children were reminded only of the elephants (i.e., "Remember the elephants"). In the action-only condition, children were reminded only about waving (i.e., "Remember to wave"). In the cue–action condition, children were reminded to wave when they saw an elephant (i.e., "Remember to wave at the elephants"). Finally, in the control condition, reminders did not refer to the PM task at all (i.e., "Remember to have fun"). Of the 50 total trials, 4 were PM cues (Trials 12, 17, 35, and 44), and reminders were presented three times during the ongoing card sorting task (immediately prior to Trials 8, 25, and 40). Both the placement of the PM cues and the reminders in the ongoing task were randomly generated, but all children received them in the same fixed order. Children were given a PM score out of 4 (based on how many elephants they waved at).

At the end of the ongoing task, children were asked a main memory control question by the experimenter to see whether they remembered the intention: "What were you supposed to do when you saw an elephant?" If they answered this question incorrectly, they were given three more prompt questions in the following fixed order: (1) "What else did you have to do in this game?"; (2) "What did you have to do when an elephant was on one of those cards?"; and (3) "What did you have to do to help Joe the Zookeeper?" If children provided the correct answer after receiving either the first or second additional prompt question, they were not given the subsequent prompt question(s). Only children who could answer the question correctly by the third prompt were retained in the final sample.

Results

Preliminary analyses

A one-way analysis of variance (ANOVA) was performed to determine whether children's age in months differed among the four reminder conditions. There was no difference in children's age across the conditions, $F(3, 84) = 0.59$, $p = .620$, $\eta^2 = .021$.

Trial 12: Box?

Yellow

Blue

Other

Fig. 1. Example of prospective memory trial.

A chi-square test of equality of proportions was also performed to examine whether there were gender proportion differences in the four conditions. There were no differences in the proportion of boys and girls in any of the conditions (*p*s > .05). Children's gender was not a significant predictor of PM performance (p = .21), so it was excluded from the analyses. Descriptive statistics for the four conditions are shown in Table 1.

Effect of reminders on PM performance

To answer the question of whether verbal reminders improved children's PM performance, a simple regression was performed. The interaction between the presence of cue reminders and action reminders was entered as the predictor, and children's total PM score was entered as the outcome variable. The interaction term was not a significant predictor of total PM score, b = 0.27, t

Table 1
Descriptive statistics for each condition

Condition	*n*	Mean age in months	Gender	Mean PM score for all trials	Mean % accuracy for all trials	Mean PM score excluding Trial 2	Mean % accuracy excluding Trial 2
Control	22	56.77 (8.14)	12 boys, 10 girls	1.59 (1.62)	39.77%	1.27 (1.28)	42.42%
Cue-only	22	58.95 (9.78)	11 boys, 10 girls, 1 unreported	1.91 (1.74)	47.73%	1.50 (1.34)	50.00%
Action-only	22	56.27 (9.58)	8 boys, 14 girls	1.95 (1.81)	48.86%	1.50 (1.37)	50.00%
Cue–action	22	55.50 (8.44)	11 boys, 10 girls, 1 unreported	2.09 (1.72)	52.27%	1.68 (1.32)	56.06%

Note. Standard deviations are in parentheses. Scores on the prospective memory (PM) task ranged from 0 to 4 when all trials were included and from 0 to 3 when Trial 2 was excluded.

(86) = 0.65, $p = .519$. Overall, the model did not explain significant variance in total PM score, $R^2 = .005$, $F(1, 86) = 0.42$, $p = .519$.

Effectiveness of cue versus action reminders

To tease apart the effectiveness of cue and action reminders on children's PM performance, a hierarchical multiple regression with two steps was conducted. In the first step, presence of cue reminders (0 = absent, 1 = present) and presence of action reminders (0 = absent, 1 = present) were entered as predictors, and children's total PM score was entered as the outcome variable. This first step did not explain a significant amount of variance in total PM score, $R^2 = .011$, $F(2, 85) = 0.47$, $p = .626$. Both the presence of cue reminders, $b = 0.23$, $t(85) = 0.62$, $p = .536$, and the presence of action reminders, $b = 0.27$, $t(85) = 0.75$, $p = .458$, did not significantly predict total PM score. In the second step, the interaction between the presence of cue reminders and of action reminders was added. The second step did not explain a significant amount of additional variance in total PM score, $\Delta R^2 = .001$, $F(1, 84) = 0.06$, $p = .805$, and the overall model remained nonsignificant, $R^2 = .012$, $F(3, 84) = 0.33$, $p = .803$. Neither the presence of cue reminders, $b = 0.32$, $t(84) = 0.61$, $p = .542$, nor the presence of action reminders, $b = 0.36$, $t(84) = 0.70$, $p = .486$, nor the interaction term, $b = –0.18$, $t(84) = –0.25$, $p = .805$, was a significant predictor of total PM score.

Interaction between age and reminder type

To examine whether an interaction existed between age and reminder type, a hierarchical multiple regression with three steps was conducted (see Table 2). In the first step, children's age in months, presence of cue reminders (0 = absent, 1 = present), and presence of action reminders (0 = absent, 1 = present) were entered as predictors, and children's total PM score was the outcome variable. This first step explained a significant amount of variance in total PM score, $R^2 = .13$, $F(3, 84) = 4.29$, $p = .007$; however, age was the only significant predictor of PM performance. In the second step, the interactions between age and presence of cue reminders, age and presence of action reminders, and presence of both the cue and action reminders were added. Although the model remained significant, $R^2 = .18$, $F(6, 81) = 2.88$, $p = .014$, the second step did not explain additional variance in total PM score, $\Delta R^2 = .04$, $F(3, 81) = 1.41$, $p = .247$. Age was no longer a significant predictor, and none of the other predictors were significant. Finally, in the third step, the interaction among age, presence of cue reminders, and presence of action reminders was added. Again, the model was significant, $R^2 = .18$, $F(7, 80) = 2.53$, $p = .021$, but the third step did not explain significant additional variance in total PM score, $\Delta R^2 < .006$, $F(1, 80)$ 0.57, $p = .454$. None of the predictors were significant in this step.

Table 2
Hierarchical multiple regression predicting total prospective memory score

	B	*SE*	*β*	*t*	*p*	95% CI	
						LL	UL
Step 1							
Age	0.07	0.02	0.35	3.43	<.001	0.03	0.11
Cue present	0.18	0.34	0.05	0.52	.603	−0.51	0.87
Action present	0.41	0.35	0.12	1.17	.246	−0.28	1.09
Step 2							
Age	0.005	0.04	0.02	0.13	.895	−0.07	0.08
Cue present	−3.27	2.32	−0.96	−1.41	.163	−7.88	1.35
Action present	−3.12	2.28	−0.92	−1.37	.174	−7.65	1.41
Age × Cue Present	0.06	0.04	1.05	1.54	.127	−0.02	0.14
Age × Action Present	0.06	0.04	1.05	1.58	.119	−0.02	0.14
Cue Present × Action Present	0.09	0.69	0.02	0.13	.897	−1.28	1.46
Step 3							
Age	−0.01	0.04	−0.07	−0.30	.764	−0.10	0.07
Cue present	−5.00	3.27	−1.47	−1.53	.131	−11.51	1.51
Action present	−4.85	3.24	−1.43	−1.50	.138	−11.29	1.60
Age × Cue Present	0.09	0.06	1.57	1.62	.110	−0.02	0.20
Age × Action Present	0.09	0.06	1.56	1.63	.106	−0.02	0.21
Cue Present × Action Present	3.45	4.53	0.88	0.76	.448	−5.56	12.47
Age × Cue Present × Action Present	−0.06	0.08	−0.85	−0.75	.454	−0.22	0.10

Note. N = 88. CI, confidence interval; LL, lower limit; UL, upper limit.

Exploratory analyses

As an exploratory analysis, we also conducted a repeated-measures ANOVA to examine whether children's PM performance differed across the four PM trials. It should be noted that three of the four PM cues that appeared throughout the PM task were preceded by a reminder; however, there was no reminder between the first and second PM cues. Thus, lower performance on the second PM trial could provide a potential explanation for our nonsignificant findings.

Mauchy's test of sphericity indicated that the assumption of sphericity was violated, $\chi^2(5) = 18.00$, $p = .003$; therefore, the Greenhouse–Geisser correction was used. There was a significant effect of trial on total PM score, $F(2.62, 228.25) = 2.79$, $p = .049$, $\eta^2 = .031$. To determine whether performance on the second PM trial differed from that of the first, third, and fourth trials combined, a Helmert contrast was performed. This contrast revealed that PM performance on the second trial ($M = .40$, $SD = .05$) was significantly lower than that of the first, third, and fourth trials pooled together ($M = .50$, $SD = .05$), $F(1, 87) = 7.09$, $p = .009$, $\eta^2 = .075$.[1]

Given these findings, we re-ran our previous regression analyses with the second PM trial removed, such that children's total PM score was out of three rather than out of four (see Table 1 for the mean PM score for each condition when the second PM trial was excluded). However, the results of these analyses remained nonsignificant ($ps > .05$).

Discussion

The aim of this study was to investigate whether repeated verbal reminders affect preschool children's PM and whether certain types of reminders were more effective than others. Contrary to our predictions, verbal reminders did not affect children's performance on a virtual event-based PM task.

[1] Given that the cue-only, action-only, and cue–action conditions were designed to improve PM performance and the control condition was not, we also ran these analyses with children from the control condition excluded. However, the findings were similar to those reported here.

In addition, there was no effect of cue reminders (i.e., reminding children of the elephant) or action reminders (i.e., reminding children of the need to wave), and there was no interaction between the reminder types and age. This contradicts previous studies suggesting that visual reminders, specifically those that reference either the cue on its own or both the cue and the action, improve young children's PM (Cheie et al., 2014; Kliegel & Jager, 2007; Ryder et al., 2022). However, our findings align with the more limited research on verbal reminders, which have previously been found to be overall ineffective in improving young children's PM (Mahy et al., 2018).

It is particularly striking that the reminders in this study did not have an impact on children's PM, given how they addressed several limitations of previous research. Mahy et al. (2018) proposed that they did not find an effect of reminders on preschoolers' PM because a single reminder prior to the PM task might not have been salient or temporally close enough to the PM cues to improve children's performance. Even though children received multiple reminders in the current study and the reminders were given during the ongoing task, they still did not affect children's PM. Our finding that performance on the second PM trial was lower than that of the other trials combined suggests that temporal distance from the PM cue may influence the effectiveness of a reminder and the reminders that were given closer to the PM cues were more beneficial. However, it is notable that even when we re-ran our main analyses without the second PM trial, the reminders had no effect.

Given that this study was conducted online during the ongoing COVID-19 pandemic, there are several limitations that are important to acknowledge. For example, children's attention during the PM task might have been poor, which might have prevented the reminders from being as effective as they could have been. This possibility is supported by the fact that 17% of the children (22 of 127) could not report their PM intention at the end of the study. Arguably, children participating in the study virtually from their homes, where there may be more distractions than in a controlled laboratory environment, might be more representative of the contexts in which verbal reminders are given to children in everyday life (e.g., at home, in school classrooms). However, it is also possible that children could not properly encode the reminders due to the amount of input in the online environment being overwhelming for them (especially for children who had less experience with video calls). In addition, even though we excluded children whose parents clearly interfered with the study procedure, it may be the case that there were other instances in which interference occurred that we did not identify. For these reasons, the findings of the current study may be generalizable only to virtual contexts.

Aside from the study's online delivery, another methodological limitation was that even our control condition received reminders (i.e., "Remember to have fun"). Despite these reminders being irrelevant to the PM task, they still prompted children to remember something, which could have implicitly triggered children's memory for the PM intention (thereby reducing our effect sizes). However, our aim was to have a control condition that was as similar as possible to the other three conditions. Therefore, including these reminders was beneficial because it allowed us to enhance experimental control. As a final limitation, it should be noted that our sample was ethnically and socioeconomically homogeneous. Thus, our findings might not be representative of how verbal reminders would affect children's performance on our task in the broader population.

Beyond these limitations, however, there could also be other factors contributing to the lack of effect of verbal reminders on children's PM. One possibility is that children's PM performance is driven primarily by their EF abilities, which aligns with the executive framework of PM development (Mahy et al., 2014a). Notably, although our reminders may have boosted children's memory for the intention, they likely did not affect children's ability to hold the intention in their working memory, monitor for the PM cues, or inhibit the ongoing task to execute the intention at the appropriate time. Given that verbal reminders to pay attention improve PM in young children with better EF (Mahy et al., 2018), supporting EF instead of retrospective memory for the intention may be more beneficial to children's PM performance.

Alternatively, it may be that verbal reminders are ineffective because children do not understand the purpose of reminders or how to use them to improve PM performance. Metamemory (which involves both awareness of memory in general and memory strategies) is positively associated with event-based PM performance in 7-year-olds (Cottini et al., 2018). Thus, additional research on preschoolers' understanding of verbal reminders could clarify the role metamemory plays in PM in this age group. Overall, our results show that even when verbal reminders are given repeatedly and

temporally close to when the intention should be executed, they do not have a beneficial impact on preschool children's PM, at least in a virtual context. These findings challenge the common practice and conception that providing frequent verbal reminders to children is an effective way to improve PM performance, although additional research is needed to determine whether our results are generalizable to in-person contexts. Despite parents' intentions, it may be that their verbal reminders truly go in one ear and out the other.

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Author contributions

Madeline K. Maguire served as lead for investigation and writing–original draft and contributed equally to writing–review & editing, data curation, and formal analysis. Caitlin E. V. Mahy served as lead for conceptualization, funding acquisition, methodology, and supervision and contributed equally to writing–review & editing, data curation, and formal analysis.

Data availability

Our data, materials, and syntax used for data analysis are publicly available at the Open Science Framework (https://osf.io/vfwye/?view_only=689bc82c8f8540a7b8e5dbc2fdff6f63).

References

Cheie, L., Miclea, M., & Visu-Petra, L. (2014). What was I supposed to do? Effects of individual differences in age and anxiety on preschoolers' prospective memory. *International Journal of Behavioral Development, 38*(1), 52–61. https://doi.org/10.1177/0165025413506132.

Cottini, M., Basso, D., & Palladino, P. (2018). The role of declarative and procedural metamemory in event-based prospective memory in school-aged children. *Journal of Experimental Child Psychology, 166*, 17–33. https://doi.org/10.1016/j.jecp.2017.08.002.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(4), 717–726. https://doi.org/10.1037//0278-7393.16.4.717.

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

Guajardo, N. R., & Best, D. L. (2000). Do preschoolers remember what to do? Incentive and external cues in prospective memory. *Cognitive Development, 15*(1), 75–97. https://doi.org/10.1016/S0885-2014(00)00016-2.

Guynn, M. J., McDaniel, M. A., & Einstein, G. O. (1998). Prospective memory: When reminders fail. *Memory & Cognition, 26*(2), 287–298. https://doi.org/10.3758/bf03201140.

Kliegel, M., & Jager, T. (2007). The effects of age and cue–action reminders on event-based prospective memory performance in preschoolers. *Cognitive Development, 22*(1), 33–46. https://doi.org/10.1016/j.cogdev.2006.08.003.

Kretschmer, A., Voigt, B., Friedrich, S., Pfeiffer, K., & Kliegel, M. (2014). Time-based prospective memory in young children—exploring executive functions as a developmental mechanism. *Child Neuropsychology, 20*(6), 662–676. https://doi.org/10.1080/09297049.2013.841881.

Kvavilashvili, L., & Ford, R. M. (2014). Metamemory prediction accuracy for simple prospective and retrospective memory tasks in 5-year-old children. *Journal of Experimental Child Psychology, 127*, 65–81. https://doi.org/10.1016/j.jecp.2014.01.014.

Mahy, C. E. V., Mazachowsky, T. R., & Pagobo, J. R. (2018). Do verbal reminders improve preschoolers' prospective memory performance? It depends on age and individual differences. *Cognitive Development, 47*, 158–167. https://doi.org/10.1016/j.cogdev.2018.06.004.

Mahy, C. E. V., & Moses, L. J. (2011). Executive functioning and prospective memory in young children. *Cognitive Development, 26*(3), 269–281. https://doi.org/10.1016/j.cogdev.2011.06.002.

Mahy, C. E. V., Moses, L. J., & Kliegel, M. (2014a). The development of prospective memory in children: an executive framework. *Developmental Review, 34*(4), 305–326. https://doi.org/10.1016/j.dr.2014.08.001.

Mahy, C. E. V., Moses, L. J., & Kliegel, M. (2014b). The impact of age, ongoing task difficulty, and cue salience on preschoolers' prospective memory performance: the role of executive function. *Journal of Experimental Child Psychology, 127*, 52–64. https://doi.org/10.1016/j.jecp.2014.01.006.

Mazachowsky, T. R., Hamilton, C., & Mahy, C. E. V. (2021). What supports the development of children's prospective memory? Examining the relation between children's prospective memory, memory strategy use, and parent scaffolding. *Journal of Cognition and Development, 22*(5), 721–743. https://doi.org/10.1080/15248372.2021.1939352.

Morita, T. (2006). Reminders supporting spontaneous remembering in prospective memory tasks. *Japanese Psychological Research, 48*(1), 34–39. https://doi.org/10.1111/j.1468-5884.2006.00303.x.

Peper, P., Alakbarova, D., & Ball, B. H. (2023). Benefits from prospective memory offloading depend on memory load and reminder type. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 49*(4), 590–606. https://doi.org/10.1037/xlm0001191.

Ryder, N., Kvavilashvili, L., & Ford, R. (2022). Effects of incidental reminders on prospective memory in children. *Developmental Psychology, 58*(5), 890–901. https://doi.org/10.1037/dev0001035.

Ślusarczyk, E., & Niedźwieńska, A. (2013). A naturalistic study of prospective memory in preschoolers: the role of task interruption and motivation. *Cognitive Development, 28*(3), 179–192. https://doi.org/10.1016/j.cogdev.2012.10.004.

Somerville, S. C., Wellman, H. M., & Cultice, J. C. (1983). Young children's deliberate reminding. *Journal of Genetic Psychology, 143*(1), 87–96. https://doi.org/10.1080/00221325.1983.10533537.