The Development of Children's Prospective Memory:

Lessons for Developmental Science

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Abstract

The study of children's prospective memory has gained new momentum over the past 20 years and is now an active area of research in cognitive development. Yet this resurgence has been accompanied by significant challenges that offer important lessons and insights for other areas of developmental science. In this article, I provide an overview and theoretical accounts of the development of children's prospective memory. I then describe three puzzling findings that remain unresolved in children's development of this kind of memory: 1) the contradictory effects of delay length on prospective memory performance, 2) why reminders sometimes fail to improve prospective memory performance, and 3) why parent reports and behavioral measures of prospective memory might fail to correlate. I discuss how each challenge can be applied broadly to other areas of children's development. I conclude by highlighting challenges and opportunities as the field moves forward.

Keywords: prospective memory, development, delay length, reminders, measurement

Most adults are constantly bombarded by tasks they must remember to do in the future. This is also true for children: By the time they reach school age, children are responsible for remembering to carry out many tasks independently, including returning homework, following hygiene rules, and remembering to wish a friend a happy birthday. Remembering to carry out intentions is known as *prospective memory* (Einstein & McDaniel, 1990). Despite the obvious importance of this type of memory for becoming an independent and productive member of society, until recently, its development has been relatively overlooked. The 1980s saw an emerging literature on this topic (e.g., Ceci & Bronfenbrenner, 1985; Meacham & Colombo, 1980; Somerville et al., 1983), but then research in this area slowed until reappearing in the 2000s (see Kvavilashvili et al., 2008, for an early review). One reason for this slowdown was the lack of a theoretical framework underlying prospective memory prior to 1990. Since then, the field has flourished, increasing its theoretical richness and connecting with other aspects of cognitive development in exciting ways (e.g., Cottini et al., 2018; Ford et al., 2012; Mahy & Munakata, 2015), although the research has largely been done with North American and European, White, middle-class samples.

In this article, I begin by describing how prospective memory has been measured in children and outlining key theories. I then present three lines of research on children's prospective memory that have revealed puzzling results, along with how these results inform other areas of developmental science. I conclude by discussing exciting opportunities in the field moving forward.

How Is Prospective Memory Measured in Children?

Laboratory paradigms of prospective memory (see Figure 1) typically use a dual-task approach that attempts to mimic the demands of daily life (e.g., Kvavilashvili et al., 2001). An intention is assigned to a participant (e.g., putting cards with monkeys on them in a box behind them) and is typically followed by a delay of a few minutes during which an unrelated task (e.g., drawing pictures, completing a measure of verbal ability) is completed to encourage the participant to forget the prospective memory intention. An ongoing distractor task (e.g., sorting cards by category membership) then begins in which the prospective memory cues (i.e., monkey cards) are embedded. When the cue appears (either the occurrence of a specific event, or at or after a certain amount of time has passed), the prospective memory intention must be carried out.

[Figure 1 about here]

The challenge of these tasks is to fulfill the delayed intention despite being distracted by an ongoing activity that occupies attention. Moreover, the appropriate response to the cue must be self-initiated; that is, individuals are not prompted to perform the prospective memory action at the appropriate time. However, reminders are sometimes embedded in the delay period or ongoing task to boost prospective memory by reactivating the intention and reducing demands associated with actively maintaining the intention in mind.

In measuring prospective memory, researchers should ensure that errors are truly *prospective* (i.e., forgetting to carry out the intention at the correct time) rather than *retrospective* (i.e., forgetting what the intention was, henceforth referred to as *memory*). Studies can verify this by asking participants (especially those who failed to carry out the intention) to report what they had to do. Answering this question correctly confirms that memory for the intention was intact.

When children cannot report the prospective memory instructions correctly, it is customary to exclude them from the final sample and analyses.

Among the various kinds of prospective memory tasks are: 1) event-based, where the cue is a certain event occurring (e.g., a monkey card appears), 2) time-based, where the action must be completed at a fixed time or after an amount of time has passed (e.g., at 2 pm or in 15 minutes), and 3) activity-based, where the action must be carried out after completing an activity (e.g., “Write your name on the questionnaire after you complete it”). In addition, *naturalistic* measures of prospective memory attempt to mimic children’s daily tasks, sometimes in laboratory settings (e.g., Ślusarczyk & Niedźwieńska, 2013), but also as parent-report questionnaires of prospective memory (e.g., Kliegel & Jäger, 2007; Mazachowsky et al., 2021; Mazachowsky & Mahy, 2020).

Theoretical Frameworks

Theoretical models of adult prospective memory take one of two stances: 1) Prospective memory always relies on effortful, controlled processes (e.g., attention and monitoring processes) regardless of task demands (preparatory attention and memory model; Smith & Bayen, 2004), or 2) prospective memory can be supported by controlled or automatic processes depending on task demands (multiprocess framework; McDaniel & Einstein, 2000). For example, intentions might automatically pop into mind under nondemanding circumstances (e.g., high cue salience, easy ongoing task, cues appearing in the focus of attention; McDaniel & Einstein, 2000) but require monitoring and effortful processes under demanding circumstances. Although both models have been tested with children (e.g., Kliegel et al., 2013; Smith et al., 2010), neither explicitly refers to developmental processes. Thus, no model explained the underlying mechanisms driving age-related changes in prospective memory during childhood.

This changed in 2014 with the introduction of the executive framework of prospective memory development (Mahy et al., 2014a). This framework made several predictions, with its central argument that a certain level of retrospective memory for the intention was necessary *but not sufficient* to support prospective memory. In addition, executive functioning (EF) is necessary to carry out the prospective memory intention at the appropriate time. EF includes working memory, inhibition, shifting, planning, and monitoring that are involved in the intentional control of thought and behavior (Zelazo & Müller, 2011). Working memory is involved in regularly bringing the prospective memory intention into the focus of attention (i.e., refreshing the intention), rather than maintaining the intention continuously (i.e., through a vigilance process). Inhibition and shifting are involved in detecting the prospective memory cue, inhibiting the tendency to treat it as an ongoing task item, and shifting flexibly between carrying out the intention and the ongoing task (see Figure 1). Planning and monitoring are critical to plan for carrying out an intention, detect the prospective memory cue, and monitor intention (Hicks et al., 2000). During the preschool years, EF drives age-related changes in prospective memory performance. Thus, the executive framework was the first model to explicitly propose a mechanism (i.e., retrospective memory and then EF) for age-related improvements in prospective memory performance during childhood. Laboratory prospective memory tasks that are relatively challenging for children might necessitate reliance on controlled, executive processes until children's EF is more developed, when children might rely on controlled processes only under demanding circumstances (in line with the multiprocess framework).

Whether or not the executive framework is supported by data, any field of developmental science must have strong theory, not only theories borrowed from research with adults (although the connection between developmental and adult theory is important). The field of prospective memory has benefitted substantially from a developmental framework because it allows for testable and specific developmental predictions (e.g., Mahy, Mazachowsky, & Pagobo, 2018; Zhao et al., 2019; Zuber et al., 2019) rather than trying to apply to children's development of prospective memory adult theories that do not explicitly propose developmental mechanisms.

Early Developmental Trajectories

Although some 2-year-olds show evidence of prospective memory ability, in studies of this type of memory, two-thirds of middle-class, predominantly White children cannot remember what they had to do in the first place (Kliegel & Jager, 2007; Ślusarczyk et al., 2018). Thus, their errors are mostly due to retrospective memory failures rather than prospective failures. By 3 to 4 years, children become more reliable in remembering the contents of their intention (i.e., what they are supposed to do), but often fail to carry it out. Indeed, 4-year-olds remember to carry out their intentions only about half the time, despite having intact retrospective memory for the intention (Mahy, in press), suggesting that immature EF might contribute to poor prospective memory in the early preschool years. However, 2- to 6-year-olds can remember to carry out intentions for which they have high interest (e.g., choosing a sticker; Ślusarczyk & Niedźwieńska, 2013; Somerville et al., 1983), suggesting an important role for motivation in early prospective memory performance. Indeed, perhaps tasks of high interest lessen retrospective memory and EF demands, allowing even very young children to succeed in carrying out motivating intentions. By 5 or 6 years, children's prospective memory improves to the point of carrying out event-based tasks more consistently (Mahy & Moses, 2011; Mahy et al., 2014b). This developmental trajectory supports predictions of the executive framework that 2- to 3-year-olds struggle with prospective memory as a result of retrospective memory limitations, whereas 4- to 6-year-olds fail at these tasks because of challenges with EF, despite their more developed retrospective memory abilities.

Event-based prospective memory continues to improve into middle childhood (7 to 12 years; Yang et al., 2011; Zhao et al., 2019), as does time-based prospective memory (e.g., Kerns, 2000), once children become more proficient in telling time. Indeed, children become increasingly strategic in monitoring time in time-based prospective memory tasks, showing a J-shaped pattern indicating early time calibration and then a steep increase in time monitoring as the target time approaches (e.g., Ceci & Bronfenbrenner, 1985). These studies have been conducted in primarily White, middle-class samples in North America and Europe, so the age trends need to be tested in more diverse Western samples, as well as in samples that are not western, educated, industrialized, rich, and democratic.

Next, I describe three puzzles that have arisen recently in the field and how they relate to the executive framework of prospective memory development. Each of these challenges can inform other areas of development science.

Puzzle 1: The Curious Case of the Delay Interval

In one study, longer delay intervals posed a challenge to 2- to 4-year olds' prospective memory and increased forgetting (e.g., Somerville et al., 1983). Yet a more recent study suggests that delay intervals can provide children with an opportunity to remember by refreshing their intention and engaging in self-reminding behavior. For instance, 5-year-olds had better prospective memory after a 5-minute compared to a 1-minute delay, suggesting a role for self-reminding or perhaps even a necessary amount of time for encoding the prospective intention (Mahy & Moses, 2011; see also Hicks et al., 2000). Another study found no impact of delay length on 7- to 11-year-olds' event-based prospective memory (e.g., Nigro et al., 2002). This small literature of mixed findings suggests two possibilities: 1) an interplay between forgetting and self-reminding during the delay, and 2) individual differences in how children approach the delay that dictate whether it helps or harms prospective memory.

According to the executive framework, working memory plays an important role in bringing a prospective intention to the focus of attention during the delay interval. Thus, children with better working memory might engage in more self-reminding behavior during the delay interval. Although this interval was originally designed to encourage forgetting by moving it out of active working memory, this might not always happen. In studies with adults, researchers have manipulated the length of time between the start of the ongoing task and the appearance of the first cue, finding that longer intervals without active rehearsal and strategic monitoring (limited by the ongoing task) resulted in worse prospective memory (Martin et al., 2011). Studies have not been done with children to manipulate the length of time before the appearance of the first prospective memory cue in the ongoing task, but the executive framework predicts that in the absence of refreshing the prospective intention (a function of working memory), children's prospective memory performance should suffer. More research is needed to draw firm conclusions.

However, it is clear that filling the delay interval with a cognitively demanding task harms later prospective memory performance in North American children who are predominantly White and from middle-class backgrounds (see Mahy, Schnitzspahn et al., 2018;

O'Connor et al., 2021, for mixed findings with adults). Both increasing visual working memory demand and the presence of articulatory suppression during the delay period resulted in worse prospective memory performance in preschoolers (Mahy & Moses, 2015; Mahy et al., 2016). Thus, the lack of effect of delay interval length in some studies might be because children approached the delay interval differently. For example, some children might have found the delay task more cognitively demanding, whereas others might have found it less difficult and therefore expended fewer cognitive resources and engaged in more self-reminding. More work is needed to examine individual differences in what children are doing naturalistically during delay intervals since much of this literature is based on experimental studies. An approach that considers individual differences might provide additional insight, especially when a delay interval is filled with an undemanding task during which children can more flexibly allocate cognitive resources.

These findings illustrate that children do not always perform as expected, especially when they are given free time or undemanding tasks during experimental paradigms. In some cases, children whose minds wander during these periods might have decreased performance due to distraction, but in other cases, such diversion might benefit performance, especially when self-reminding or reflection can be helpful.

Puzzle 2: Why Reminders Can Fail

Since children often struggle to carry out their intentions, researchers have focused attention on children's knowledge of memory strategies (e.g., Kreutzer et al., 1975) and whether these strategies improve performance. Research suggests that visual reminders help improve young children's prospective memory, but reminders that refer to both the cue *and* the action (e.g., a picture of a monkey and a box when the instruction is to put a card with a monkey on it in a particular box) are more effective than cue-only reminders (e.g., a picture of a monkey; Guajardo & Best, 2000; Kliegel & Jager, 2007). In one study with adults, cue-action reminders were more effective at improving prospective memory than cue-only reminders (Guynn et al., 1998).

Verbal reminders (cue-action reminders or executive reminders to pay attention) do not improve the prospective memory performance of North American children (most of whom are White and from middle-class backgrounds), although a reminder focused on paying attention (i.e., "Remember you need to pay attention to every picture and keep watching them all the time") had a positive impact on the prospective memory of children with better EF (Mahy, Mazachowsky, & Pagobo, 2018). Although reminders might strengthen the retrospective memory for the intention or the association between the cue and the action (in the case of cue-action reminders), they likely have no impact on children's EF. Thus, children could be reminded many times but if executive abilities are a key developmental mechanism driving prospective memory performance (as the executive framework predicts), reminders would fail to improve this type of memory if they only activated or boosted the strength of the intention. Perhaps EFs are necessary to maintain (and refresh) the reactivated intention in working memory and thus, cue-action reminders in the absence of mature EF have limited efficacy. A reminder that focuses on strategies to ensure that children carry out the intention at the appropriate time might be more effective.

Overall, few studies have examined the role of reminders in children's prospective memory performance given the relevance of this type of memory for performance in school and life contexts. Research has focused on increasing the availability of the prospective intention (cue and cue-action reminders) rather than using reminders that might help children carry out the prospective memory task at the appropriate time (e.g., cueing them to pay attention when a prospective memory cue will be presented). Timely reminders or reminders that focus on carrying out the intention at the appropriate time (e.g., reminders to pay attention or that the prospective memory cue will appear in a certain context) might be more effective because they might activate executive processes (similar to findings in studies with adults that reminders are more effective when they occur in the context in which prospective memory targets are encountered; e.g., Loft, Finnerty, & Remington, 2011; Loft, Smith, & Bhaskara, 2011).

The lesson for developmental science is that manipulations that make sense intuitively but fail to have an effect might be targeting the incorrect mechanism. Theory is critical to mapping the underlying mechanisms that contribute to cognitive development, thus explaining why certain types of interventions do not improve behavioral performance. In the case of reminders, the executive framework suggests that unless they target children's EF, they might have a limited impact on prospective memory performance once children have sufficient retrospective memory to encode, store, and retrieve their intentions.

Puzzle 3: What Parents Say Versus What Children Do

Although laboratory measures of prospective memory are common and well standardized in middle-class, predominantly White samples, parent reports of children's prospective memory ability via questionnaires often fail to relate positively to children's behavioral performance in the lab (e.g., Mazachowsky & Mahy, 2020). Among the reasons this could occur are the internally cued nature of prospective memory and the invisible nature of intentions, and parents' difficulty distinguishing prospective (executive) from retrospective memory failures. Evidence from my lab supports the latter possibility. Indeed, if a child fails a prospective memory task in a lab because they forget what they have to do (retrospective memory failure), they are usually excluded from later analyses because the error does not represent a pure failure of prospective memory (Kvavilashvili et al., 2001). However, in real life, parents are unlikely to be able to determine *why* their child failed to remember to carry out a future intention because they do not have insight into the child's internal processes.

In studies, parent ratings of children's prospective memory did not correlate positively with behavioral performance in the lab, but did correlate with naturalistic lab-based prospective memory tasks (e.g., remembering to ask the experimenter to return a drawing) when children were not excluded because they could not remember what they had to do (Mazachowsky & Mahy, 2020). Parent reports might accurately reflect naturalistic prospective memory in daily life, but likely conflate retrospective memory and prospective memory abilities. Parents' ratings of their children's retrospective memory *and* prospective memory relate indiscriminately to behavioral prospective memory performance, suggesting that parents do not distinguish between retrospective memory and prospective memory (Kliegel & Jager, 2007). Thus, parents seem to view their child's memory as a single, global ability and may not recognize the role of self-regulation in prospective memory (in addition to retrospective memory abilities). Considering other areas of children's development, such as EF (although see Toplak et al., 2013), theory of mind, and temperament, might elicit more accurate parent reports, perhaps because of their more specific, observable nature (e.g., Garon et al., 2016; Rothbart et al., 2001; Tahiroglu et al., 2014).

Thus, this third puzzle represents the tradeoff between children's observable behavior in daily life and conceptual specificity between different facets of memory that researchers can tease apart in the lab. In the real world, the reason a child forgets might not matter—the final result is the same: forgetting to carry out the intention. In contrast, in the lab, we can determine whether forgetting was due to a retrospective memory or a true prospective error (due to failures in EF), which is critical to examining underlying mechanisms and informing intervention efforts. However, this poses a challenge for reconciling behavioral results with parent reports.

Researchers need to understand how parents view their children's cognitive development since this offers a broader perspective than laboratory tasks alone, even if their development might not align perfectly with their behavioral performance. Parents may have a more accurate perspective on their children's cognitive development, and behavioral tasks in the lab might miss the mark due to the lack of ecological validity of the task or because artificial laboratory settings capture only a narrow slice of behavior. The broader lesson is that more information is always better; information from multiple informants, including both parents and children, can provide a more nuanced perspective on children's development, even if the information does not fully agree.

Challenges and Opportunities for the Field

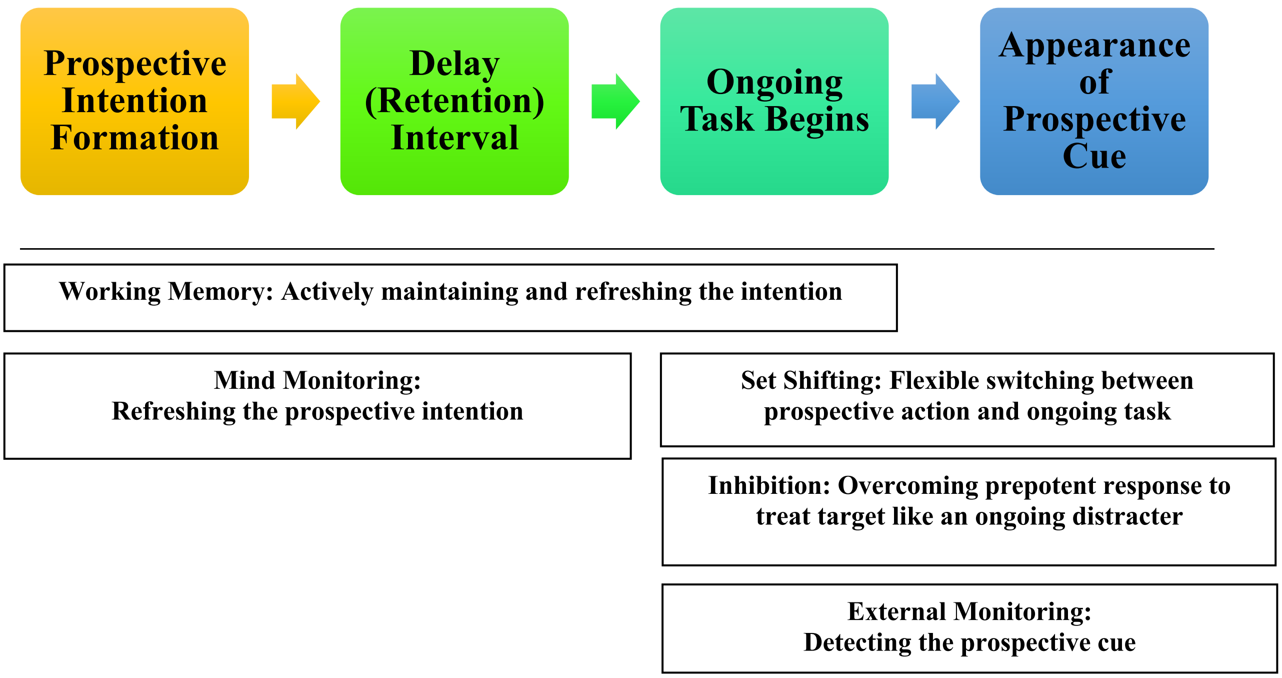
We have learned much from studying children's prospective memory behaviorally and, although more study needs to be done, other techniques can shed light on both new and old questions. For example, through eye tracking, researchers can examine children's monitoring behavior (see Hartwig et al., 2021). Neuroimaging techniques such as electroencephalogram/event-related potentials might help reveal the temporal dynamics behind automatic and controlled processes involved in prospective memory because these methods can shed light on processes that occur prior to or after conscious deliberation. Few studies have examined children's prospective memory using event-related potentials (although see Hering et al., 2016) and we know relatively little about children's use of strategies to support their prospective memory. Researchers have explored the role of children's strategies and parents' scaffolding in children's prospective memory (Mazachowsky et al., 2021), but we have scant information about individual differences in knowledge and use of prospective memory strategies, and how they relate to performance. Researchers should examine whether children use prospective memory strategies spontaneously and at what point this occurs in development, as well as how children's metacognitive abilities interact with their strategy use and prospective memory performance (Cottini et al., 2018). Finally, exploring prospective memory development in more diverse samples of children is important since most studies have been of middle-class, mostly White children from North America or Europe.

Conclusion

The study of children's prospective memory development has flourished in the past 20 years. During this time, it has encountered several puzzles that I have highlighted: 1) the inconsistent impact of delay interval length on prospective memory, 2) why reminders sometimes fail, and 3) why behavioral and parent-report measures of children's prospective memory sometimes differ. None of these puzzles are unique to the field of prospective memory and thus, they offer important lessons for other areas of developmental science. With novel approaches to methods, design, and analysis, researchers can explore these puzzles as they relate to the predictions of the executive framework. Novel techniques and approaches founded on solid developmental theory offer exciting possibilities for tackling new and old questions in the field.

Figure 1

The Role of Executive Function in Children's Prospective Memory



Adapted from Mahy et al., 2014a

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