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The Effect of Retention Interval Task Difficulty on Young Children's Prospective Memory: Testing the Intention Monitoring Hypothesis

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The current study examined the impact of retention interval task difficulty on 4- and 5-year-olds' prospective memory (PM) to test the hypothesis that children periodically monitor their intentions during the retention interval and that disrupting this monitoring may result in poorer PM performance. In addition, relations among PM, working memory, theory of mind (ToM), and 2 types of planning were investigated. Children ($N = 64$) were randomly assigned to an easy or difficult filler task during the retention interval prior to the PM task. Five-year-olds outperformed 4-year-olds on the PM task, and children receiving the easy filler task outperformed those receiving the difficult filler task. Further, working memory, planning, and ToM were positively associated with PM for children receiving the difficult filler task but not for children receiving the easy filler task. Findings are interpreted with respect to the predictions of the intention monitoring hypothesis as well as the multiprocess framework of PM.

The ability to think about, anticipate, and plan for the future has been proposed as a uniquely human characteristic setting us apart from our recent primate ancestors (e.g., Atance & O'Neill, 2001; Donald, 1991; Suddendorf & Corballis, 2007). One central aspect of future orientation is prospective memory (PM), defined as memory for activities to be performed in the future (Einstein & McDaniel, 1990). PM plays a critical role in the development of children's independence, which requires some ability to remember to carry out intentions (Ford, Driscoll, Shum, & Macaulay, 2012; Kliegel & Jäger, 2007; Kvavilashvili, Messer, & Ebdon, 2001; Mahy & Moses, 2011). In addition, PM failures can have negative consequences in many domains of children's lives including personal safety (e.g., forgetting to put on a bicycle helmet), social relationships (e.g., forgetting to wish a friend a happy birthday), and academic achievement (e.g., forgetting to return homework assignments).

Developmental gains in PM during early childhood are now well established (Kliegel & Jäger, 2007; Kvavilashvili, Messer, & Ebdon, 2001; Mahy & Moses, 2011; Wang, Kliegel, Liu, & Yang, 2008). Whereas toddlers can be quite unreliable in their prospective remembering (Kliegel & Jäger, 2007; Somerville, Wellman, & Cultice, 1983), school-age children show better PM (Ceci & Bronfenbrenner, 1985) with much improvement occurring during the preschool years (Guajardo & Best, 2000; Mahy & Moses, 2011).

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/hjcd.

A typical event-based PM paradigm involves two components: an ongoing task (OT) in which the PM task is embedded (e.g., card naming) and the PM task itself in which a novel action must be carried out in response to a PM cue (e.g., placing a certain type of card in a box when it appears). Characteristically, there is also a retention interval in between the time at which the PM instruction is given and the time at which the OT begins. This delay interval ensures that children are not continuously maintaining the intention and allows for forgetting to occur. Factors shown to influence children's PM include: a) motivation (Guajardo & Best, 2000; Somerville et al., 1983), b) length of the delay or retention interval (Mahy & Moses, 2011; Somerville et al., 1983), c) whether the prospective cue interrupts the OT or appears immediately after it (Ford et al., 2012; Kvavilashvili et al., 2001; Wang et al., 2008), d) nature of the OT (Wang et al., 2008), and e) nature of the PM cue and presence of reminders (Guajardo & Best, 2000; Kliegel & Jäger, 2007; Meacham & Colombo, 1980).

One cognitive ability, executive function (EF), has been found to relate to children's and adults' PM (Kerns, 2000; Mahy & Moses, 2011; Mahy, Moses, & Kliegel, 2014; Martin, Kliegel, & McDaniel, 2003; Shum, Cross, Ford, & Ownsworth, 2008; Ward, Shum, McKinlay, Baker-Tweney, & Wallace, 2005). EF refers to abilities involved in the conscious control of thought and action (Zelazo, Carlson, & Kesek, 2008) including working memory, inhibitory control, set shifting, planning, and monitoring. Like PM, there are marked developments in EF throughout early childhood.

One influential model that implicates EF in PM is the multiprocess framework (McDaniel & Einstein, 2000). According to this framework, PM requires controlled executive processes under cognitively demanding conditions but may rely on automatic processes under less cognitively demanding conditions. If such capacity-consuming processes are potentially important in PM, at least under certain conditions, individual differences in EF may play a role in PM, especially during early childhood when the abilities needed to consciously control thought and actions are still developing (Zelazo et al., 2008). Further, as suggested by the multiprocess framework, the role of controlled processes should be more important in PM tasks that are more cognitively and executively demanding.

In the multiprocess framework, monitoring has been suggested to be a key executive process involved in carrying out one's intentions. This framework, however, focuses on monitoring of the external environment for the cue but does not address the potentially important role of the monitoring of one's own intentions. Monitoring of one's intentions—that is, periodically refreshing or thinking about what one has to do—may be important for recognizing the significance of the PM cue when it appears. To remember the prospective intention, it must be easily retrieved such that when the cue appears the appropriate prospective intention is activated. Periodically monitoring or refreshing the intention during the retention interval prior to the OT or during the OT itself may thus be important for later retrieval of the intention.

An important distinction is that between vigilance processes, in which an intention is continuously maintained in the focus of attention and a search-like process for the cue occurs, and intention monitoring in a PM paradigm, in which other activities are carried out but the intention is periodically refreshed or monitored (see Brandimonte, Ferrante, Feresin, & Delbello, 2001). We argue here that although periodically bringing the intention to mind may take place in PM tasks, continuously holding the intention in mind (as one would do in a vigilance task) is unlikely to occur under anything but the shortest of delays given the competing demands on cognitive resources imposed by the filler task given during the delay as well as by the later OT.

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Evidence from three different sources suggests that intention monitoring may play an important role in the development of PM. First, findings with adults and with older children indicate that EF is related to PM especially in the context of a difficult OT. According to the intention monitoring hypothesis, such findings would be expected because, by consuming limited executive resources, cognitively demanding tasks should limit or interfere with monitoring (perhaps by reducing its frequency). Work with adults has shown that EF accounts for a larger amount of variance in PM performance when the OT is difficult (Martin et al., 2003), that adults were more likely to think about the PM intention under less resource-demanding conditions, and that doing so benefited PM (Einstein & McDaniel, 1996). In children, Ward et al. (2005) found that 7- to 10-year-olds' working memory and focused attention were significant predictors of PM performance in a high cognitive-demand OT (600-ms stimuli presentation) but not in a low-demand task (850-ms stimuli presentation). Similarly, Shum et al. (2008) found that 8- to 9-year-old children and 12- to 13-year-old children's working memory, inhibition, and cognitive flexibility significantly added to the prediction of PM in a more difficult interruption condition (where children needed to interrupt the OT to carry out the PM task) but not in an easier noninterruption condition (where children needed to carry out the PM task after the OT, eliminating the need for interruption). Taken together, these studies suggest that there is a relation between EF and PM under cognitively demanding conditions in older children and adults. We argue that having stronger EF enables better intention monitoring, which in turn aids PM performance under such conditions. Importantly, however, no study has investigated whether EF and PM are more related under difficult rather than under easy task conditions in children younger than 7 years of age.

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Second, Mahy and Moses (2011) manipulated the length of the retention interval in a PM task with young children and found that 5-year-olds outperformed 4-year-olds after a longer (5 min) but not after a shorter (1 min) delay. Indeed, 5-year-olds' PM actually *improved* significantly from the shorter to longer delay, whereas 4-year-olds' performance tended to get worse after a long delay. According to Mahy and Moses, 5-year-olds may be able to take advantage of a longer retention interval to refresh and consolidate their intentions, whereas they do not have as much opportunity to do this during a short delay (see Hicks, Marsh, & Russell, 2000, and Guynn, McDaniel, & Einstein, 1998, for related findings with adults). In contrast, 4-year-olds' monitoring of their intentions may not be as well developed, and therefore, their performance on a PM task is not helped by a longer retention interval.

Third, of particular relevance to the role of intention monitoring in PM are studies that manipulate the difficulty or relevance of the *filler task* during the retention interval. Meacham and Colombo (1980) found that filler task difficulty (an ''easy'' card game vs. a ''difficult'' interview that required children to answer several questions) did not affect 6- and 8-year-old children's PM. However, the two filler tasks differed in ways other than difficulty such as level of interest and specific task stimuli. Further, there was no measure of filler task performance to confirm that the interview was objectively more difficult than the card game. More recently, Kvavilashvili and Ford (2014) asked 5-year-olds to predict their success on a PM task and then presented them with a story either about a forgetful spider (reminder story) or a lazy alligator (control story) during the retention interval. Children who predicted they would remember to complete the PM task and who heard the reminder story tended to show better PM performance than did those who heard the neutral story. The reminder story may have supported children's monitoring of their intentions, especially for those who had confidence in their PM abilities, by encouraging them to think about their intentions or remembering more generally, whereas the

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neutral story may have distracted children from monitoring PM intentions. Kvavilashvili and Ford speculated that children who predicted successful PM performance were more likely to think about themselves carrying out the task, which may have increased sensitivity to reminders in the environment. Although these findings are generally consistent with the intention monitoring hypothesis, a direct manipulation of filler task *difficulty* during the retention interval would more clearly test the claim that refreshing one's intentions during the delay leads to superior PM performance. Further, a single filler task that has an easy version and a difficult version and produces an objective measure of filler task performance would allow for stronger conclusions to be drawn about the relative impact of filler task difficulty on PM.

The three types of evidence reviewed suggest that intention monitoring may play an important role in later PM performance. A first aim of the current study was to investigate whether a difficult filler task might disrupt intention monitoring compared with an easy filler task, leading to worse PM. In addition, many cognitive abilities such as working memory, planning, and theory of mind (ToM) may be involved in or at least related to the ability to monitor the contents of one's mind. A second aim of the study was to examine whether relations between PM and individual differences in these abilities differ for easy and difficult filler task conditions by testing predictions regarding the role of controlled processes from the multiprocess framework of PM. We next describe the executive and social understanding abilities that might be relevant to PM performance in young children.

Working memory may be involved in maintaining the content of the prospective action in mind long enough for it to guide action. For intention monitoring to occur, the intention must be cognitively accessible so it can be periodically refreshed. Marsh, Hicks, and Cook (2005) suggested that intentions can fade in and out of the focus of working memory over time as in Cowan's model of working memory (Cowan, 1995; 2005). Individuals whose working memory is sufficiently developed to allow them to bring an intention into the focus of attention more frequently or for longer periods of time will likely show better PM, perhaps especially so in the face of other cognitively demanding tasks. There is, however, mixed evidence for the relation between PM and working memory in 4- to 6-year-olds (see Ford et al., 2012; Mahy & Moses, 2011), and it has never been tested under easy versus difficult filler conditions, indicating a need for further testing.

Planning may also be relevant to monitoring as children with a superior ability to plan ahead may be more likely to recognize the need to think about an intention to later produce it. In a planning task, children need to monitor their intentions and actions to achieve a successful outcome. They must concurrently monitor the present state of their goals and how this state differs from their final plan (Zelazo, Carter, Reznick, & Frye, 1997). Therefore, children with superior planning ability may have better, more practiced monitoring skills, which may aid their PM performance.

Two types of planning can be distinguished: planning that heavily relies on executive processes (so-called *cognitive* planning; e.g., planning which route to take to minimize time stopped in traffic and fulfilling the plan) and *episodic* planning, which is thought to require the projection of the self into future situations but may rely less on executive processes (e.g., planning that involves future simulation such as imagining how you might feel hungry or cold on a long hike, thus generating a plan to bring a lunch or a warm coat without having to fulfill or execute the plan). Such episodic future thinking tasks have been shown to relate to PM ability, although there are mixed findings on whether this relation disappears after controlling for age (Atance & Jackson, 2009; Nigro, Brandimonte, Cicogna, & Cosenza, 2014). Cognitive planning involves thinking through and carrying out a plan in a novel situation, which should place a high demand on executive processes. In contrast, episodic planning relies on accessing script-based knowledge to create a plan but does not as heavily rely on executive processes as the plan is not carried out. Thus, it is likely that cognitive planning tasks require children to monitor their performance in reference to their final goal, whereas episodic future planning tasks should not rely on monitoring processes as much because the plan is not executed and therefore performance monitoring is unnecessary.

Finally, ToM, the ability to ascribe mental states to oneself and others (Wellman, Cross, & Watson, 2004), may be related to monitoring as children with a better understanding of the mind may be more generally inclined to reflect on mental states and processes. In a recent study with preschoolers, ToM performance predicted PM above and beyond age, working memory, and inhibitory control (Ford et al., 2012), supporting the idea that processes involved in understanding one's mind might be related to monitoring that occurs during PM performance. Such processes might be especially important in cognitively demanding circumstances.

In sum, the current study was designed to examine the intention monitoring hypothesis by filling the retention interval either with an easy task that would potentially allow children to monitor their intentions or a difficult task that would require more executive resources thereby potentially limiting or disrupting the monitoring of prospective intentions. The rationale is that if children are in fact able to take advantage of the retention interval to monitor their intentions (Mahy & Moses, 2011), then completing a cognitively demanding task during this delay should result in worse PM via decreased opportunities to monitor or refresh intentions. Conversely, children's monitoring, and therefore their PM, should be relatively less affected by an easy filler task. We tested this hypothesis in a sample of both 4- and 5-year-olds to examine age effects in PM performance under these conditions. In addition, relations between the individual difference measures discussed earlier and PM performance were examined separately for children who received the easy and difficult filler task conditions to test the hypotheses that children with superior EF (working memory and planning) and ToM may be better able to monitor their intentions and, as a result, may show better PM particularly in the context of a difficult filler task.

The Self-Ordered Pointing Task (SOPT; Petrides & Milner, 1982) was selected as the filler task as it has previously been used with preschool-aged children (Hongwanishkul, Happaney, Lee, & Zelazo, 2005) and has two possible versions: a scrambled version with high executive demands (difficult) and an unscrambled version with lower executive demands (easy). Individual difference measures were the Backward Digit Span (working memory), Truck Loading (cognitive planning), Mental Time Travel (episodic planning), and Restricted View (ToM) tasks. All four of these measures had been used successfully with 4- and 5-year-olds previously (Atance & Jackson, 2009; Carlson, 2005; Carlson & Moses, 2001; Taylor, Cartwright, & Bowden, 1991).

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METHOD

Participants

Sixty-eight 4- and 5-year-old children participated. Four children were not included in the final analysis: Two failed the control question in the PM task, one had participated in a previous study using a similar PM task, and one misunderstood the PM task rules. The final sample consisted of 32 4-year-olds (16 girls; $M_{age} = 4;4$, $SD = 3.36$ months, range = 3;10–4;11) and 32 5-year-olds

(16 girls; $M_{age} = 5;6$, $SD = 3.96$ months, range = 5;0–5;11). Children were assigned to one of two conditions within their age group: an easy filler task condition or difficult filler task condition. Assignment was random with the constraints that an equal number of 4- and 5-year-olds and an equal number of girls and boys were in each condition. There were no significant differences in age between the two conditions within age groups ($ps > .10$). Children were recruited from a university database compiled from birth announcements from local newspapers and were mostly Caucasian and from middle-class backgrounds reflecting the population from which the sample was taken.

Measures

Prospective memory task. The PM task consisted of a card-sorting game requiring children to name objects depicted in four stacks of cards and to provide a novel response to certain target cards (adapted from Kvavilashvili et al., 2001; also see Mahy & Moses, 2011). Children were first introduced to Morris the Mole, a stuffed animal, who had poor daytime vision. They were asked to help Morris learn what was on the cards by naming the pictured objects. Cards were 3-inch × 3-inch (7.62 cm × 7.62 cm) color pictures of everyday objects (e.g., food, furniture, toys). In contrast, target cards pictured animals. In addition to card naming, children were told that Morris was afraid of animals and that if they saw an animal card, they should hide it from Morris by placing it in a box approximately 3 feet behind them. To ensure children understood the OT, they were asked to name the first two cards and to place them on the table in front of Morris.

Once children were familiar with the task and indicated they understood the rules, a picture game was introduced that filled the retention interval. Children were told that before they played the card game, they would first play a picture game (filler task). The delay between the introduction of the PM task rules and the card sorting was approximately 3 min (the length of five trials of the filler task). The filler task consisted of five trials of six-item arrays of the SOPT (Hongwanishkul et al., 2005). In this task, children were asked to point to one of six pictures of objects on a page. The page was then turned, and they were shown the same items and were asked to point to an item to which they had not pointed previously. The procedure continued until children had viewed the array six times, thus giving them the opportunity to point to each of the six items once. The remaining four trials included new six-item arrays.

Children completed either an easy or a difficult version of this task. In the easy version, children were presented with six items that appeared in the same location on each trial so that both location and object identity could be used as memory cues. In contrast, in the difficult version, the pictures were scrambled before each trial so that children could only use object identity as a memory cue. The number of errors children made in their pointing was the dependent variable for filler task performance.

After completing the filler task, children were told that the card game (the OT) would begin and were then asked to name the items in a first stack of cards. Subsequently, children alternated between drawing a picture for 1 min and naming a stack of cards until they had named four stacks of cards. Each stack contained 12 cards; of these cards, 1 was a target card (an animal). Target cards were placed in a fixed position in each stack: 7th, 4th, 11th, and 5th across the four stacks.

After naming the four stacks of cards, children were asked, ''What were you supposed to do when you saw a picture of an animal?'' This control question tested whether children

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remembered the initial rule and thus ensuring that forgetting did not arise from a retrospective memory failure for the task instructions. Only two 4-year-old children were excluded from the final analysis for failing this control question (both from the easy filler task condition), suggesting that the PM task was age-appropriate for the vast majority of children. Children were given a PM score from 0 to 4 based on the number of target cards they correctly placed in the box.

Retrospective memory task. To measure retrospective memory for OT items, children were given a recognition test of cards that were presented in the four stacks. This measure provided an indirect measure of how well children had processed the distractor cards while engaged in the OT task. Children were shown 22 nontarget cards, half of which had appeared in the stacks of cards and half of which were novel pictures drawn from the same general category as the OT items. Participants were asked to indicate whether or not they had seen the cards in the game with Morris the Mole. Recognition accuracy was the number of cards correctly classified out of 22.

Backward digit span task. To measure working memory, children completed the Backward Digits subscale from the Wechsler Intelligence Scale for Children-Third Edition (Wechsler, 1991). They were asked to repeat a series of numbers in backward order after the experimenter read them aloud. They began with two numbers, and after completing two trials successfully, an additional number was added. The task ended when children failed two consecutive trials. Backward Digit Span performance was calculated by summing the number of digit strings children were able to correctly repeat backward.

Truck loading task. This cognitive planning task followed the procedure used by Carlson, Moses, and Claxton (2004). Children were asked to pretend they were mail carriers who needed to deliver party invitations to a neighborhood. Children were shown a one-way street that was lined with cardboard houses. Their attention was drawn to the fact that the color of the invitations corresponded to the color of the houses. Children were asked to place the invitations into the truck and then deliver them while following four rules: a) They could only drive the truck in one direction on the one-way street, b) the invitations needed to be delivered as fast as possible so they should drive down the street only once, c) the invitations must be delivered to the appropriate color-matched house, and d) invitations could only be delivered from the top of the pile in the back of the truck. After these four rules were explained to children, the experimenter demonstrated a trial with two houses. Then, children were asked to practice delivering invitations to the two houses. Once children performed this practice trial correctly, the houses were replaced with two different colored houses and the test trials began. Children were asked to deliver the invitations to houses on the block twice (two trials), and if they successfully delivered the invitation on at least one of the trials, then an additional house was added. There were four levels of trials ranging from two to five houses. If children failed two trials on the same level consecutively, the game was ended. Children were scored on their highest level of achievement from 0 (could not deliver invitations to two houses correctly) to 4 (delivered invitations to five houses correctly).

Restricted view task. In this ToM task (adapted from Taylor et al., 1991), children first were introduced to a game in which they had to guess the contents of several pictures. Each picture was mounted on card stock, and a sheet of blue card stock was taped to one edge to serve as a removable cover. A small rectangular opening was cut in each cover. The extent to which the picture could be seen when the cover was in place varied to create three types of stimuli: a) identifiable, in which sufficient content showed through the opening to allow identification of the picture; b) empty, in which no part of the object could be seen—that is, the view showed empty white paper; and c) nondescript/ambiguous, in which only a small, nondescript part of the picture could be seen so that the identity of the content was difficult to discern. There were two identifiable stimuli (dog/girl), two empty stimuli (turtle/bunny), and one nondescript stimulus (reindeer).

The experimental trials were administered in a fixed order: identifiable, empty, identifiable, empty, and nondescript. The session began by showing children a picture of a dog that had an identifiable cover on it. Children were asked whether they knew what was pictured and were asked to answer ''yes'' or ''no.'' The first trial was designed to elicit a ''yes'' response as the opening in the cover was large enough to show the dog, and the second was designed to elicit a ''no'' response as the picture (a turtle) was completely covered. After children had answered the initial question, the cover was removed and they were asked, ''What is it a picture of?'' The cover was then replaced and children were asked, ''If another child about your age came into this room right now, would they know what this is a picture of?'' Then, children were asked, ''At the beginning, before I took the cover off, did you know that there was a ________ in the picture?'' The responses of interest were the answers children gave about their own prior knowledge of the picture's identity and the knowledge of another naïve child for each of the three trial types. Children were given a score from 0 to 2 based on the average number of correct answers they provided in each of the five trials. Fourteen children guessed correctly at the beginning of the nondescript trial that there was a reindeer in the picture, and so their responses on this trial were excluded from the analysis.

Mental time travel task. This task, adapted from Atance and Jackson (2009), is a planning task that is thought to rely on episodic future thinking. Children were asked to imagine going to four pictured outdoor locations in the future (e.g., a mountain). They were then shown a picture of three objects that they could bring to the specific location (e.g., a bowl, grass, or lunch) and were asked to choose one. There was a correct choice for each location (in this case, lunch) as well as two incorrect options: a distractor item that was semantically related but not useful to bring to the location (grass) and an irrelevant item that was not semantically related to the location (a bowl). Regardless of their choice, children were asked to justify why they chose the selected item. Children's choices were scored on whether they selected the correct item or not, and justifications were scored on whether they were appropriate and future-oriented. Children were given four trials and received 1 point for each correct item choice and 1 point for each reasonable, future-oriented explanation, yielding up to 8 points on this task. Interrater coding reliability of children's justifications was acceptable (Cohen's kappa = .79).

Procedure

Children were interviewed individually by an experimenter in the laboratory. All tasks were administered in a fixed order as is convention in individual differences research: PM task, Retrospective Memory task, Backward Digit Span task, Truck Loading task, Restricted View task, and Mental Time Travel task. At the end of the session, children were given a small toy and

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a gift certificate to a local toy store and were thanked for their participation. The university's institutional review board approved all procedures.

RESULTS

Filler Task Manipulation Check

Table 1 shows means and standard deviations for SOPT errors in each condition broken down by age. A 2 (Age) × 2 (Filler Task Difficulty) analysis of variance (ANOVA) on SOPT errors revealed that children made fewer errors on the SOPT in the easy condition ($M = 1.63$, $SD = 1.82$) than in the difficult condition ($M = 2.88$, $SD = 2.17$), $F(1,\ 60) = 6.28$, $p = .02$, $\eta_p^2 = .10$, confirming that the difficulty manipulation was successful. The main effect of age was not significant, although 5-year-olds ($M = 1.97$, $SD = 1.93$) tended to make fewer errors than 4-year-olds ($M = 2.53$, $SD = 2.23$), $F(1, 60) = 1.27$, $p = .27$. The interaction between filler task difficulty and age was not significant.

Prospective Memory Task

PM performance remained stable across the four stacks of cards, indicating no effect of stack order on PM ($p = .73$). Figure 1 shows PM performance according to age and filler task difficulty condition. A 2 (Age) × 2 (Filler Task Difficulty) ANOVA on PM revealed main effects of age and filler task difficulty. Collapsed across filler conditions, 5-year-olds performed significantly better on the PM task than did 4-year-olds, $F(1, 60) = 5.62$, $p = .02$, $\eta_p^2 = .09$. In addition, collapsed across age, children performed better on the PM task after an easy filler task than after a difficult one, $F(1, 60) = 4.72$, $p = .03$, $\eta_p^2 = .07$. There was no significant interaction between age and filler task difficulty ($p = .17$). However, when age differences were examined in the difficult filler task condition, Bonferroni-corrected comparisons revealed that 5-year-olds

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TABLE 1
Means and Standard Deviations for Self-Ordered Pointing Errors and Individual Difference Measures by Age Group

	Age group			
	4-Year-olds	*5-Year-olds*	*t*	*p*
Easy SOPT Filler Task	2.19 (2.14)	1.06 (1.29)	1.80	.081
Difficult SOPT Filler Task	2.88 (2.33)	2.88 (2.06)	0.00	1.00
Backward Digit Span	0.81 (1.09)	2.29 (1.27)	4.96	.000
Truck Loading	2.28 (1.22)	3.37 (1.13)	3.62	.001
Restricted View task	1.39 (0.40)	1.69 (0.34)	3.21	.002
Mental Time Travel	4.88 (2.51)	6.00 (2.02)	1.98	.053

Note. SOPT = Self-Ordered Pointing Task. Range of possible scores: SOPT = 05 with lower scores indicating fewer errors; Backward Digit Span = 0–16); Truck Loading = 0–4; Restricted View Task = 0–2; Mental Time Travel = 0–8. Standard deviations are in parentheses.

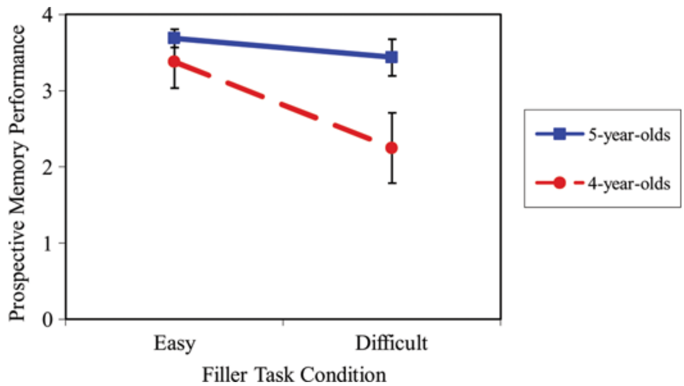

FIGURE 1 Prospective memory performance by difficulty of the condition and age group.

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performed significantly better on the PM task than did 4-year-olds, $F(1, 60) = 7.04$, $p = .010$. In contrast, PM performance did not differ between 4- and 5-year-olds when the retention interval involved an easy task ($p = .488$). Five-year-old children's performance neared ceiling on the PM task in the easy filler task condition, likely affecting our ability to detect an interaction between age and filler difficulty and potentially masking a benefit of the easy filler task on 5-year-olds' PM performance.

The length of the retention interval was coded to rule out the possibility that the effect of difficulty was due to children taking longer to complete the filler task in the difficult condition rather than due to the actual difficulty of the task per se (see Mahy & Moses, 2011). Interrater reliability on the coded length of the filler task (in seconds) was high ($r = .94$) for 25% of the data. Children took significantly longer to complete the SOPT in the difficult condition ($M = 194.4$, $SD = 33.0$) than in the easy condition ($M = 176.4$, $SD = 25.2$), $t(62) = 2.48$, $p = .02$. Importantly, however, when length of time to complete the filler task was added as a covariate, the main effects of age, $F(1, 59) = 6.17$, $p = .02$, $\eta_p^2 = .10$, and filler task difficulty, $F(1, 59) = 5.28$, $p = .03$, $\eta_p^2 = .08$, persisted, and the interaction between age and filler task difficulty remained nonsignificant ($p = .14$). Bonferroni-corrected comparisons revealed that in the difficult filler condition, 5-year-olds outperformed 4-year-olds, $F(1, 59) = 7.57$, $p = .008$, but there was no difference between 4- and 5-year-olds in the easy filler conditions ($p = .448$). Four-year-olds performed significantly worse in the difficult filler condition compared with the easy filler condition, $F(1, 59) = 6.86$, $p = .011$. In addition, length of filler task did not emerge as a significant covariate ($p = .44$) with PM performance.

Retrospective Memory Task

A 2 (Age) × 2 (Filler Task Difficulty) ANOVA revealed no significant effects of age or filler task difficulty on retrospective memory performance. Children did very well on this task and scored near ceiling ($M = 19.84$, $SD = 2.98$) and significantly above chance levels in both age groups and conditions, $ts(15) > 8.77$, $ps < .001$.

TABLE 2
Raw and Age-Controlled Correlations Among Measures in Easy and Difficult Filler Conditions

	1	*2*	*3*	*4*	*5*	*6*
1. Age	—	.32†	.44*	.53**	.44*	.34
2. PM	.25	—	.50** (.45*)	.50** (.44*)	.48** (.50**)	.17 (.11)
3. BDS	.68**	.12 (−.04)	—	.64** (.54**)	.38** (.22)	.17 (.02)
4. TL	.52**	.26 (.17)	.46* (.11)	—	.50** (.36†)	.09 (−.12)
5. RVT	.31†	.23 (.22)	.45* (.19)	.31† (.10)	—	.02 (−.20)
6. MTT	.29	−.21 (−.32†)	.46** (.19)	.23 (−.04)	.36* (.08)	—

Note. PM = Prospective Memory; BDS = Backward Digit Span; TL = Truck Loading; RVT = Restricted View task; MTT = Mental Time Travel. Below the diagonal is performance for children in the easy filler task condition and above is performance for children in the difficult filler condition.

†. $p < .10$. *. $p < .05$. **. $p < .01$. Degrees of freedom range from 31 to 32. Partial correlations controlling for age in months are in parentheses.

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Individual Differences

Means and standard deviations for individual difference measures by age group are shown in Table 1. Five-year-olds performed significantly or marginally significantly better than 4-year-olds on the Backward Digit Span task, Truck Loading task, Mental Time Travel task, and Restricted View task, $ts(60) > 1.98$, $ps < .06$. Children in the difficult filler task condition did not differ from those in the easy filler task condition in later performance on any of the individual difference measures, $ts(60) < 0.69$, $ps > .33$.

Correlations among measures are shown in Table 2 separately for each condition. In the easy filler task condition, children's PM performance was not significantly correlated with any of the individual difference measures. In contrast, the Backward Digit Span, Truck Loading, and Restricted View tasks were positively associated with PM in the difficult filler task condition. These relations remained significant after controlling for chronological age (Table 2). The Mental Time Travel task was not related to PM in either condition.

DISCUSSION

In this study, we examined the effect of age and filler task difficulty on young children's PM as well as assessed individual differences in working memory, two types of planning, and ToM, as they related to PM in different conditions. Five-year-olds outperformed 4-year-olds on the PM task. This task had sufficient sensitivity to detect age-related changes in this narrow age range, as past studies have also shown (Mahy & Moses, 2011; Mahy et al., 2014). Five-year-olds' PM performance was close to ceiling levels in both the easy and difficult filler condition. In contrast, the PM task elicited greater variability in 4-year-olds, who showed lower levels of performance. Filler task difficulty also significantly affected later PM performance with an easy filler task yielding better PM compared with a difficult filler task. No significant interaction emerged between age and filler task difficulty, although follow-up comparisons suggested that 4-year-olds' PM was worse than 5-year-olds' PM after a difficult filler task but not after an easy filler task. Finally, significant age-controlled relations were found between PM and the individual difference measures in the difficult but not the easy filler task condition.

Intention Monitoring Hypothesis

Earlier evidence consistent with the intention monitoring hypothesis showed that 5-year-olds were able to take advantage of a longer delay period to the benefit of their later PM, whereas 4-year-olds were not (Mahy & Moses, 2011). These findings led to the hypothesis that 5-year-olds were refreshing their intentions during the delay (for a similar interpretation with adults, see Hicks et al., 2000). The current study addressed this finding by filling the delay interval with a difficult or easy task following the logic that if children are monitoring their intentions during the delay period, then a difficult task should disrupt that monitoring and therefore result in worse PM. Results showed that the difficult filler task indeed resulted in poorer later PM compared with the easy filler task, supporting the hypothesis that monitoring of intentions may have been occurring during this delay period. Findings from both the current study and from previous work (Mahy & Moses, 2011) suggest that important monitoring processes that impact later PM may occur during the delay interval. Although no significant interaction between age and filler task difficulty was found, simple effects suggested that 4-year-olds' PM was more negatively affected by a difficult filler task than 5-year-olds' PM. These findings suggest that monitoring is present in children as young as 4 years old and that such monitoring may be disrupted especially by difficult resource-consuming tasks in the interval prior to the PM task. Our results are somewhat inconsistent with those of Mahy and Moses (2011), whose findings suggested that 5-year-olds but not 4-year-olds might have been monitoring intentions. Differences between the methodology in the current study and the Mahy and Moses study such as retention interval length (3 min versus 1 min or 5 min) and the nature of the filler task (a working memory task versus a creative drawing task) might be responsible for these differences in PM performance.

More broadly, Estes (1998) found that 4- to 6-year-olds have some awareness of their mental activity, supporting the idea that children of this age may be capable of monitoring the mind's activity. In addition, Flavell, Green, and Flavell (1998) found that by 5 years of age, children seem to be developing an awareness of their mental activity and have some capacity for introspection and reflection (see also Flavell, 1999; Flavell, Green, & Flavell, 1993, 2000; Zelazo, 2004). These findings suggest that the ability to monitor and introspect on the contents of the mind develops in the preschool years and are broadly consistent with the current findings suggesting that even 4-year-olds may be able to monitor their intentions during a delay interval under facilitative conditions. An interesting question for future research is whether PM performance in even younger children is similarly impacted by easy and difficult filler tasks. We suspect that such children would perform equally poorly in both conditions because of executive and metacognitive limitations.

A possible alternative explanation for the findings is that the difficult filler task disrupted the encoding or consolidation of the intention. However, the fact that children could report the PM instruction at the end of the task suggests that at least upon completion of the PM task, all children had encoded and consolidated the intention. It is possible, however, that intention monitoring may be a key process in consolidating one's intention, and future studies should examine the role of intention monitoring in the consolidation of the PM intention.

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Finally, we do not wish to suggest that task difficulty is the only factor that could disrupt monitoring. Indeed, an interesting question in the current study is whether filler task *difficulty* specifically disrupted intention monitoring or whether something like greater task absorption in the difficult condition could have been responsible for negative effects on PM. However, the lack of relation between SOPT performance (a proxy for task absorption during the delay period) and PM performance in both conditions of the current study suggests that absorption during the delay interval was not likely affecting PM. Future studies would do well to examine the impact of a high interest task compared with a difficult task to pinpoint which aspect of the delay task might be disrupting intention monitoring.

Role of Individual Differences in EF and ToM in PM

The correlational analyses suggest that executive processes and ToM may play a more important role in PM when there is a higher cognitive demand during the retention interval. When the retention interval was filled with a difficult task, children with better working memory, planning (as measured by the Truck Loading task), and understanding of the mind remembered to carry out their intentions more often than did children with poorer abilities in these areas. In contrast, when the retention interval was filled with an easy task, no association was found between working memory, planning, understanding of the mind, and PM. Importantly, with age controlled, the relation between PM and working memory, planning, and ToM remained significant in the difficult condition. These results are consistent with findings from studies with older children showing that EF is related to PM in high cognitive-demand conditions but not in lower cognitive-demand conditions during the OT (Shum et al., 2008; Ward et al., 2005). Compared with children with weaker EF abilities, those with superior working memory and cognitive planning may have been better able to overcome the disruption to monitoring their intentions during the delay period in the difficult filler condition by bringing the intention back to the focus of attention more frequently, with less effort, or for longer periods.

Our finding that PM is related to understanding of the mind is consistent with research showing that PM and false-belief task performance are associated in preschoolers (Ford et al., 2012). Notably, the relation we found was only significant after a difficult filler task, suggesting that children with better ToM are better able to cope with a difficult task during the delay to the benefit of their later PM, possibly because of the role mind understanding plays in intention monitoring. The relation between PM and ToM may highlight the importance of the ability to project oneself into the future and perhaps to monitor one's own mind in both ToM and PM.

The link between PM and ToM appears to be metacognitive in nature as they both rely on some understanding of intentions and the mind. Past research indicates that better ToM at 3 or 4 years of age is predictive of better metamemory at 5 (Lockl & Schneider, 2007). Children with more advanced ToM may recruit additional metacognitive strategies to remember to carry out their intentions or may be better able to monitor their intentions.

Relations between PM and ToM support the hypothesis that similar brain networks underlie various forms of mental self-projection including remembering to carry out future tasks and understanding the minds of others (Buckner & Carroll, 2007). The neuroimaging literature suggests a common neural activation for prospection, ToM, and autobiographical memory in the midline structures in the frontal and parietal lobes, also known as the default mode network

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(Spreng & Grady, 2010). This core network may support self-projection in many different contexts, including the ability to mentally project oneself from the present moment into simulation of another time, place, or perspective (Spreng, Mar, & Kim, 2009). The relation between PM and ToM can thus be understood in terms of both similar cognitive processes as well as common neural networks such as the default mode that subserve these abilities.

In contrast to previous work showing a positive relation between planning involving episodic future thinking (as measured by the Mental Time Travel task) and PM (Atance & Jackson, 2009; Nigro et al., 2014), in the current study, the two abilities were unrelated. This discrepancy in findings may be due to differences in PM tasks used in these studies. For example, previous studies that have shown a positive relation between PM and episodic future thinking have relied on more naturalistic-type PM tasks that require the child remind or ask the experimenter for an item, whereas our study used an experimental paradigm that involved multiple PM cues that require children to carry out an action four times. It is possible that projecting oneself into the future is more related to accomplishing a single PM trial that requires one action rather than carrying out a PM task several times. Finally, it is possible that the relation between PM and future thinking is tenuous as the relation did not hold up after age was controlled in Atance and Jackson's (2009) study; however, the relation remained significant after controlling for age in Nigro et al.'s (2014) study. More work into the relation between episodic future thinking and PM is needed to clarify the relation and the circumstances under which they may be related or unrelated.

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Implications for Models of Prospective Memory

Two contrasting models of PM exist: the multiprocess framework according to which PM relies on controlled processes under demanding conditions and automatic processes under less-demanding processes, and the preparatory attentional and memory processes (PAM), according to which PM always relies on controlled processes regardless of demands. One aim of the current study was to examine the relation between PM and executive processes in tasks with low and high cognitive demand to test the predictions of the multiprocess framework of PM. The current study is clearly consistent with the multiprocess model of PM in that under cognitively demanding conditions, executive processes exert an influence on PM performance, but in less cognitively demanding conditions, there is no relation between the two abilities. According to the PAM model, the relation between EF and PM should exist regardless of experimental conditions, as monitoring processes are at the very least necessary to detect the PM cue. Our findings might seem inconsistent with this account as working memory and cognitive planning were related to PM in the difficult filler task condition but not in the easy filler task condition. However, it is possible that in the easy filler condition, monitoring may have been occurring but other factors (such as motivation or interest) may have led to individual differences in performance, and of course, performance was generally very good in the easy filler condition. The manipulation of retention interval difficulty also suggests that disrupting monitoring processes, at least during the retention interval, has a negative impact on later PM. Although some automatic processes may be involved in monitoring one's own intentions (such as when intentions seem to pop into one's mind), our results suggest that intention monitoring cannot be a *completely* automatic process, as in that case, it would not have been disrupted by a demanding task in the retention interval.

Limitations

First, the current study was limited by ceiling effects particularly in the case of 5-year-olds' PM performance in the easy filler task condition. The ceiling effects may have prevented us from finding a significant interaction between age and filler task difficulty. However, they would have also limited our ability to find an even stronger effect of filler task difficulty. Importantly, however, there was considerable variance in children's performance on the easy filler task condition. For example, 5-year-olds showed moderate variance in performance on the easy filler version of the PM task as did 4-year-olds. As a result, we do not believe that ceiling effects completely constrained our ability to find correlations in the easy filler condition. That is, the data suggest that in the easy condition, even children with weaker executive skills perform quite well, but in the difficult condition, for the most part, only those with strong executive skills succeed, which is exactly what would be expected under the intention monitoring hypothesis.

Second, the effects of filler task difficulty on PM should be examined using a non-working-memory filler task so that conclusions can be drawn more generally about the effects of task difficulty on PM rather than executive difficulty on PM. We argue that children with better working memory were able to allocate more resources to intention monitoring during the difficult filler task than were children with poorer working memory. To fully test this hypothesis, however, we would need to assess whether or not a difficult non-working-memory task disrupts intention monitoring as much as a working memory task.

Conclusion

The current study suggests that monitoring one's intentions, particularly in the retention interval, may play an important role in later PM. Further, individual differences in cognitive abilities, specifically EF and ToM, relate to performance on a PM task after a difficult filler task. These findings are consistent with earlier research on older children and adults (e.g., Martin et al., 2003; Shum et al., 2008; Ward et al., 2005) showing that EF and PM are often related in cognitively demanding PM task conditions but not in easy conditions that may not rely on controlled processes. These results are generally supportive of the predictions of the multiprocess framework. Future research should directly explore how often children monitor during the retention interval and the extent to which controlled and automatic processes contribute to this intention monitoring. The role of intention monitoring in PM should be further explored as it has implications for improving children's PM via monitoring instructions as well as for special populations that struggle with maintaining and carrying out their prospective intentions.

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