The Relation Between Young Children’s Memory and Metacognition

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Abstract

Prospective memory, the ability to remember to carry out future intentions (PM; Einstein & McDaniel, 1990) is a critical skill in children’s daily lives. Despite this, little is known about children’s awareness of their own PM ability and how this might be affected by the difficulty of a PM task. The current study sought to examine the effect of task difficulty on children’s predictions, postdictions, and actual PM performance. Four-to 6-year-old children \((N = 132)\) completed an easy or difficult PM task and made predictions and postdictions before and after the task. Results showed that: (1) children’s PM increased with age and was worse in the difficult condition, (2) PM predictions and postdictions did not vary with age but PM postdictions were more accurate than PM predictions, and (3) PM postdictions were affected by difficulty of the PM task with children reporting having remembered to carry out their intention fewer times in the difficult compared to the easy condition. Overall, children’s PM postdictions were more accurate than their predictions, and difficulty of a PM task only affected children’s reflections (and not predictions) of their PM performance.

Keywords: PM, metamemory, executive functioning, child cognition
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The Relation Between Young Children’s Memory and Metacognition

In order to function independently in daily life, children must have the ability to recall past experiences and information (retrospective episodic memory; RM; Burgess & Shallice, 1997), and the ability to remember to carry out future intentions at the appropriate time (prospective memory; PM; Einstein & McDaniel, 1990). Even in early childhood, RM and PM are vital for academic and social functioning. For example, forgetting a friend’s name or a teacher’s instructions are two examples of how RM errors in daily life can have negative social or academic consequences. Similarly, forgetting to hand in homework on its due date (i.e., PM failure) will negatively impact children’s academic performance and forgetting to meet a friend on the playground at recess might compromise children’s friendships. In order to avoid such negative consequences from both PM and RM errors, memory strategies could be used to help children carry out their future intentions and encode, store, and retrieve information from the past successfully. However, in order to use strategies effectively, children must first be aware of their memory ability in the first place. A better awareness of one’s memory ability might allow children to better monitor their performance and thus be able to utilize different memory strategies in order to improve their memory performance.

An awareness of one’s memory ability is called metamemory (Flavell, 1979). A common method to examine children’s metamemory ability is to ask children to make predictions and reflections (called postdictions) of their memory performance before and after a memory task. Children with better metamemory tend to have better memory performance (Fabricius & Hagen, 1984; Henry, 1996; Kurtz & Weinert, 1989), suggesting that metamemory might support superior memory performance. For example, Henry (1996) examined 4- and 5-year-old children’s metamemory by verbally presenting a metamemory questionnaire to them and found
that children’s metamemory scores were significantly predictive of their actual RM performance. Children with better metamemory scores also tended to use more complex strategies such as grouping (sorting similar objects together when memorizing). This is supported by various studies that show that young children with better metamemory tend to use a wider variety and more complex memory strategies in later childhood, suggesting that greater awareness of one’s own memory performance may support memory performance via greater awareness and use of memory strategies (Grammer, Purtell, Coffman, & Ornstein, 2011; Schlagmüller & Schneider, 2002; Schneider & Ornstein, 2019). Clearly, metamemory and memory performance are related, but is the relation consistent across different types of memory? Specifically, what do we know about the relation between metamemory and RM versus metamemory and PM? A review of the literature on metamemory and RM follows.

**Relation Between Metamemory and Retrospective Memory**

In general, there is a positive relation between children’s metamemory ability and RM performance, but there are mixed findings surrounding the relation between children’s predictions and postdictions of their actual memory ability (Destan, Hembacher, Ghetti, & Roebers, 2014; Kvavilashvili & Ford, 2014; Schneider, 1998; Schneider, Visé, Lockl, & Nelson, 2000). For example, Schneider, Visé, Lockl, and Nelson (2000) asked 6-, 8-, and 10-year-olds to study a series of items and then predict how many items they thought they would remember either immediately or after a short delay. It was found that children’s predictions were significantly related to their actual memory performance, particularly in the short delay condition. In contrast, Schneider (1998) found that while all children overestimated their RM performance, 4- and 6-year-olds were significantly more accurate in their postdictions compared to their predictions. Similarly, Bertrand and colleagues (2016) conducted a study among five age
groups that were on average 5, 8, 11, 23, and 77-years-old respectively on their ability to predict and postdict their episodic recall performance. It was found that young children, particularly the 4- to 6-year-old age group, tended to overestimate their performance for both predictions and postdictions but were significantly more accurate in their postdictions compared to their predictions. Overall, young children tend to overestimate their performance, although current evidence suggests that young children’s RM postdictions are more accurate than their RM predictions.

It is even less clear whether children’s predictions and postdictions are related to their actual PM performance. Given that PM develops rapidly in the preschool years (e.g., Kliegel & Jager, 2007; Mahy & Moses, 2011) and that older children still struggle to successfully carry out their intentions (Shum, Cross, Ford, & Ownsworth, 2008), it is important to know whether a greater awareness (as determined by predictions/postdictions) of one’s own PM ability is related to superior PM. If so, the awareness of one’s own PM ability might be a prime target for intervention with populations who struggle with PM such as young children (e.g., Kliegel & Jager, 2007) or children with attention disorders (Kerns & Price, 2001).

The Development of Prospective Memory in Children

PM shows an inverted U-shape developmental trajectory across the lifespan, with poorer PM performance in early childhood, increases in PM across childhood into young adulthood, before declining again in older adulthood (Kliegel, Mackinlay, & Jäger, 2008; Maylor & Logie, 2010; Yang, Chan, & Shum, 2011). PM development has particularly steep increases in very early childhood (e.g., Ford et al., 2012; Kliegel & Jäger, 2007). For example, Kliegel and Jäger (2007) found that 4- to 6-year olds performed significantly better than 2- and 3-year-olds on a PM task. Similarly, Mahy and Moses (2011) found that 5- and 6-year-olds performed
significantly better on a PM task than 4-year-olds. However, when a PM task is highly motivating (such as reminding one’s mother to buy ice cream) children as young as 2 and 3 years of age can successfully fulfill their PM intentions (Somerville, Wellman, & Cultice, 1983). Age-related increases in PM performance continue into middle childhood (Kliegel, Mahy, Voigt, Henry, Rendell, & Aberle, 2013). For instance, children aged 9 to 10 performed significantly better on PM tasks compared with children aged 6 to 7 (Kliegel et al., 2013). Additionally, Kerns (2000) found that among 7- to-12-year-olds, older children had significantly fewer PM failures than younger children. Thus, PM abilities emerge in the toddler years and develop significantly during the preschool years. An open question is whether awareness of one’s PM performance (i.e., metamemory) follows a similar developmental trajectory in early childhood. Thus, a goal of the current study is to examine how young children’s predictions and postdictions of PM performance change with age.

**Relation Between Metamemory and Prospective Memory**

There has been limited research on the relation between PM and metamemory in children, and the research that has investigated its relation has revealed mixed results (Cottini, Basso, Saracini, & Palladino, 2019; Kreutzer, Leonard, Flavell, & Hagen, 1975; Kvavilashvili & Ford, 2014). For example, when 4- to 11-year-old children were asked to state all possible PM strategies they could think of, older children generated more strategies than younger children and could better describe how the strategies could be used to improve performance (Kreutzer, Leonard, Flavell, & Hagen, 1975). These findings suggest that there is development in the understanding of one’s PM and the generation and use of potential strategies that could improve memory performance over the preschool to middle childhood years. In studies that have examined metamemory using children’s predictions and postdictions of PM performance, there
is less consistency. For example, Kvavilashvili and Ford (2014) found that 5-year-old children’s predictions of their PM performance were significantly more accurate than their predictions of their RM performance, with 66% of children accurately predicting their PM performance and only 36% of children accurately predicting their RM performance. In contrast with these findings, Cottini, Basso, Saracini, and Palladino (2019) found that 7- and 8-year-olds’ PM predictions were not significantly related to their actual PM performance but postdictions (reflections on their past performance) were related to PM performance. Thus, there is mixed evidence on whether awareness of one’s PM ability in the form of predictions is more closely related to PM performance, or if postdictions are more closely related. However, these studies suggest that there is a positive relation between metamemory and PM performance broadly speaking. Another open question is whether children’s awareness of their memory performance is sensitive to task difficulty. In other words, are children aware that a more difficult PM task would likely result in worse PM performance than an easy PM task? Though there is very little literature on the effect of task difficulty on PM predictions and postdictions, a review of the literature on the impact of task difficulty on RM predictions and postdictions is instructive.

**Effect of Difficulty on Children’s Predictions of Retrospective Performance**

Several studies have shown clearly that young children perform worse on difficult PM and RM tasks than easy ones (e.g., Destan, Hembacher, Ghetti, & Roebers, 2014; Kliegel, Mahy, Voigt, Henry, Rendell, & Aberle, 2013; Kvavilashvili & Ford, 2014; Mahy, Moses, & Kliegel, 2014a). For example, low PM cue salience, PM cues outside of the focus of attention, or a difficult delay task all have a negative impact on children’s PM performance (e.g., Mahy, Moses, & Kliegel, 2014b). The influence of metamemory on children’s performance on memory tasks of varying difficulty is unclear. For example, Kvavilashvili and Ford (2014) found that 5-year-old
children’s predictions of their RM performance was unaffected by task difficulty. Children predicted that they would remember the stuffed animal’s name at the end of the task regardless of whether it was an easy (Mr. Rainbow) or difficult (Mr. Tainbow) to remember name. Despite children’s optimistic predictions, there was a significant impact of task difficulty on children’s actual memory performance: 94% percent of children in the easy condition accurately recalled Mr. Rainbow’s name, but none of the children in the difficult condition accurately recalled Mr. Tainbow’s name. In contrast, Destan, Hembacher, Ghetti, and Roebers (2014) had 5- to 7-year-old children rate how sure they were that they would remember the meaning of different kanji (Japanese characters) of varying complexity as a measure of difficulty on RM performance. It was found that 5- to 7-year-old children predicted they would remember more of the less complex kanji compared to the more difficult kanji, which corresponded with their actual performance. These findings show that while task difficulty certainly impacts RM performance, children’s awareness of that impact is inconsistent across two studies conducted with the similar age range.

Despite the research on the impact of task difficulty on children’s RM predictions, less is known about how task difficulty might impact children’s predictions and postdictions of PM performance. Although the negative effect of task difficulty on young children’s PM performance is well-documented (Kliegel, Mahy, Voigt, Henry, Rendell, & Aberle, 2013; Mahy, Moses, & Kliegel, 2014a), there are currently no studies that examine the effect of difficulty on young children’s predictions and/or postdictions of their PM performance. Thus, this study focused on whether children’s estimations of their PM performance would be affected by PM task difficulty.
Role of Executive Functioning in Prospective Memory and Metamemory

The self-regulatory abilities that allow one to continuously monitor and update information, inhibit pre-potent responses, and switch attention between different cognitive tasks are called executive functions (Diamond, 2013). There are three main executive functions: working memory/updating, inhibition, and set shifting (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). Working memory is necessary to update the PM intention in one’s mind while engaged in the ongoing task. Similarly, inhibition is required to prevent treating the PM cue like an ongoing task item in order to enact the prospective intention. Finally, set shifting is critical in flexibly switching between completing the ongoing task and fulfilling the prospective intention. The important role of these executive functions in children’s PM performance is outlined by Mahy, Moses, and Kliegel (2014b) in their executive framework of the PM development. This framework suggests that from 4 years of age, executive functions play a critical role in driving PM development. Indeed, this prediction is supported by findings that show that: (1) 4- to 5-year-olds’ PM performance was positively related to children’s working memory, inhibition, and set-shifting, and (2) inhibition accounted for age-related PM increases in young children (Mahy, Moses, & Kliegel, 2014a). In addition to the three executive functions described above (working memory, inhibition, and set shifting), Mahy et al. also suggested that monitoring of the external environment for the PM cue as well as monitoring of one’s intentions internally play a critical role in PM performance. Monitoring for the external environmental involves allocating attention to search and detect the PM cue, whereas monitoring one’s intentions involves refreshing the PM intention in one’s mind. Supporting the suggestion that these two types of monitoring play a role in PM performance, executive functioning, PM, and metacognitive monitoring have been found to be significantly positively correlated in young
children (Spiess, Meier, & Roebers, 2015; Spiess, Meier, & Roebers, 2016). In a longitudinal study, Spiess and colleagues (2016) found that cross-sectionally, executive functioning, PM, and metacognitive monitoring were significantly positively correlated with each other. They also found that not only did executive functioning, PM, and metacognitive monitoring performance increase over time but executive functioning predicted 8-year-old children’s PM performance seven months later. Thus, executive functions are generally positively related to children’s PM performance and longitudinal evidence suggests that executive functions may also play a role in driving PM development (e.g., Mahy, Moses, & Kliegel, 2014b; Spiess et al., 2016).

Additionally, metacognitive monitoring may be an important factor in PM development. It has been widely accepted that PM and executive functioning are significantly positively correlated in early and middle childhood (e.g., Atance & Jackson, 2009; Ford, Driscoll, Shum, & Macaulay, 2012; Mahy & Moses, 2011), and as outlined earlier in this paper, positive relationships between metamemory and PM exist as well (Cottini, Basso, & Palladino, 2018; Kvavilashvili, & Ford, 2014; Spiess, Meier, & Roebers, 2015; Spiess, Meier, & Roebers, 2016). Thus, a logical question to ask is what the relation among these three cognitive processes is: PM, metacognitive monitoring, and executive functions. The current study aims to examine whether metacognitive monitoring mediates the relationship between executive functioning and PM that is well-established among young children. It is possible that in order to use executive functions to benefit PM performance, a child must first be aware of the limitations of their knowledge and abilities.
Limitations in the Literature

There are several limitations in the literature pertaining to the relation between PM, executive functioning, and metamemory in young childhood. One limitation is the fact that although there have been studies that investigated the effect of difficulty on the performance of a PM task (e.g., Mahy, Moses, & Kliegel, 2014a), no studies have investigated the effect of difficulty on the predictions and postdictions of a PM task in young children. Additionally, there is limited research comparing predictions and postdictions of memory performance across early childhood as the majority of studies have investigated either predictions or postdictions of RM or PM in a fairly narrow age group (e.g., Cottini, Basso, & Palladino, 2018; Kvavilashvili & Ford, 2014). This prevents researchers from understanding how the relation between PM, RM, and metamemory might change over development in the early childhood years. The current study will fill this gap in the literature.

The Current Study

The current study examined young children’s predictions and postdictions of their PM and RM performance. Specifically, I examined the impact of task difficulty (salient vs. non-salient PM condition) on children’s predictions and postdictions of their PM performance. I was interested in developmental changes in memory and memory predictions and postdictions with age and whether metamemory mediated the relation between executive functions and PM performance.

I predicted that: (1) Children would have worse PM performance and lower predictions in the non-salient condition compared to the salient condition of the PM task, (2) Older children would have more accurate memory predictions and postdictions and perform better on all tasks.
than younger children, (3) Predictions and postdictions would be more accurate for PM than for RM (replicating Kvavilashvili & Ford’s (2014) findings), (4) PM and RM predictions would be more accurate than postdictions across all ages (based on findings Lavis & Mahy, in progress suggesting that children are not aware of their PM performance after they have completed a task), (5) Children with higher metacognitive awareness would be more accurate in predictions and postdictions for both PM and RM tasks, and (6) executive functioning would predict PM performance in children, but that the relation would be mediated by metacognitive monitoring performance.

Method

Participants

An *a priori* power analysis was conducted using G*Power3 (Faul, Erdfelder, Lang, & Buchner, 2007) to determine a sufficient sample size required to detect main effects of age group and difficulty condition as well as any interactive effects assuming a medium effect size (*f* = 0.3) with power of .80 and alpha of .05. Results showed that a total sample of 111 was recommended. One hundred and fifty-five children participated in the study: 61 four year olds (32 female, 29 male; *M* = 53.85 months, *SD* = 3.55), 44 five year olds (23 female, 21 male; *M* = 66.20 months, *SD* = 3.48) and 50 six year olds (28 female, 22 male; *M* = 78.44 months, *SD* = 3.60). Children were excluded for the following reasons: not being able to answer control questions that confirmed understanding of the task (*N* = 11), and experimenter error (*N* = 2). The final sample consisted of 132 children: 47 four year olds (25 female, 22 male; *M* = 54.19 months, *SD* = 3.39), 39 five year olds (19 female, 20 male; *M* = 66.31 months, *SD* = 3.53) and 46 six year olds (26 female, 20 male; *M* = 78.42 months, *SD* = 3.66). Participants were predominantly Caucasian (80.0%) and from a middle class background (57.4% had a family income of $75,000 and
above). Participants were recruited from the Growing with Brock database maintained by five developmental psychology labs at Brock University and local daycares in the Niagara region.

**Procedure**

Parents filled out a consent form (See Appendix E) allowing their children to participate in the study and a brief demographics form (See Appendix F). All children provided verbal assent to the study by answering ‘yes’ to the question: “I am here today to play some games with you that help me learn about how children think. Your mom/dad/guardian has said it is okay for you to play these games with me. If you want to stop at any time that’s okay, you can just tell me and I won’t be mad. Would you like to play these games?” Once parent consent and child assent was obtained, tasks were administered in the following fixed order: A Prospective Memory task, a Simon Says task, Episodic Recall task, Metacognitive Monitoring task, and a Backward Word Span task. The tasks took approximately 20 minutes to complete. All procedures were granted clearance by the Research Ethics Board at Brock University (See Appendix D).

**Measures**

**Prospective Memory Task**

A PM card sorting task (adapted from Mazachowsky, & Mahy, 2020) was conducted in which children were told to sort cards into two boxes based on the colour of a sticker dot on each card (ongoing task). In the easy condition, children were told “If you see an elephant on a card, you should stop what you are doing and help Joe return the elephants to their cage by putting the elephant pictures in the box behind you (PM intention). There will be four elephants in the stack of cards, and they will be on a bright yellow background so they’ll be easy to notice”. In the difficult condition, all instructions were the same except children were told that all the elephant
would be on the same white background as the ongoing task items, so they would be hard to notice. Children in both conditions were asked to predict how many elephants they thought they would remember to put in the box behind them with the help of a visual aid. Children were then given a filler task of drawing for one minute. Then the card sorting task began. Immediately at the end of the task, children were asked a control question (‘what were you supposed to do when you saw an elephant?’) and were then asked to make an overall reflection (i.e., postdiction) of how many of the elephants they remembered to put in the box behind them. Children were then shown each elephant card (which were all unique images of elephants with the corresponding background depending on the difficulty condition) and were asked to respond either ‘yes’ or ‘no’ to whether they had remembered to put that specific card in the box behind them. Children’s predictions and postdictions were made using the help of a scale that visually represented the possible number of elephants they potentially could remember from zero to four (see Appendix A). All responses were recorded and only children who could answer the control question were included in the analyses for this task.

**Simon Says Task**

In this measure of inhibition (Strommen, 1973), children were asked to follow the experimenter’s instructions but only when they were preceded with “Simon Says”. Children were first given a practice trial in which one action was preceded by ‘Simon says’ and another was not. This trial was repeated a maximum of three times to confirm children understood the rules. If children still could not complete the trial correctly that child’s data was not included in the analyses for this task. Children’s performance was scored out of 15, with a maximum score of 3 based on whether children fully inhibited their movement (score of 3), made a different movement (score of 2), partially inhibited their movement (score of 1), or fully copied the
experimenter’s movements (score of 0) for each of the 5 non-imitation trials in which the experimenter did not say ‘Simon Says’ and thus the child should not have followed the experimenter’s request. Fifteen children were excluded for the following reasons: being unable to pass the practice trial and demonstrate understanding of rule ($N = 11$), and being uncooperative ($N = 4$).

**Episodic Recall Task**

In this measure of episodic RM (Naito, 2003), children were given 20 seconds to study eight line drawings of everyday objects (i.e. a pear, scissors, bus, carrot, tree, candle, castle, and shoe). They were asked to name these objects as well. Children were then asked to predict how many of the items they thought they would remember at the end of the task using a scale. This scale visually represented each number of items using animal graphics which were unrelated to actual items they had to recall (see Appendix B). The experimenter instructed the child on how to use the scale (i.e., clarified that this row represented remembering no items, second row represented remembering one item, etc.) and then allowed children to select their choice from it. A filler task (completing a simple maze for 1 minute) was conducted and then children were asked to recall as many of the cards as they could. After children had recalled as many items as they could, they were asked how many items they thought they remembered, again using the scale of possible items they could have recalled. Children were then shown each card individually and asked if they thought that they remembered the card or not. All responses were recorded. No children were excluded from this task.
Metacognitive Monitoring Task

Children were given a metacognition task that was adapted from Roebers and colleagues (2012). Children were first trained on how to use a 5-point confidence scale (see Appendix C for an image of the scale). Children were then shown pictures of ten cards with an animal on each one that varied in how common it was (i.e., Alpaca, Seal, Porcupine, Panda, Beaver, Manatee, Panther, Squirrel, Goat, Groundhog) and were asked to name each animal. After each card was named, children were immediately asked, “How sure are you that this is a(n) ______?” and had to rate how confident they were that they identified the animal correctly. After naming and rating their confidence for each card, children were told to sort cards into two piles; ones that they thought they named correctly and ones they thought they named incorrectly by sorting them into a ‘treasure box’ or ‘garbage can’ respectively. Children’s responses and ratings and final sort decisions were recorded. One child was excluded for being uncooperative.

Backward Word Span Task

In this measure of working memory (Carlson, Moses, & Breton, 2002), children were asked to repeat words that a puppet said in a backward order. Children were given a practice trial during which they had to repeat two words in a backward order (fruit, zoo). They were then given two trials for each level of difficulty (from two to five words). Children’s performance was then scored based on whether they got at least one out of two trials correct at each level of difficulty. Children could achieve a maximum score of 4 if they got all trials correct on all four levels. Thirty-one children were excluded for the following reasons: being unable to pass the practice trial and thus demonstrate understanding of the task rules (N = 30), and being uncooperative (N = 1).
Data Analysis

In order to examine the effects of task difficulty and age on children’s PM performance as well as PM predictions and postdictions, multiple 2 (condition: salient vs. non-salient) by 3 (age group: 4-year-olds vs. 5-year-olds vs. 6-year-olds) ANOVA were conducted. Absolute difference scores were computed by subtracting actual memory performance from memory predictions and postdictions. Then, to determine if accuracy differed between predictions and postdictions, dependent samples t-tests were conducted for both the PM and episodic recall tasks. In an exploratory analysis, the effects of age on PM and episodic recall prediction and postdiction accuracy were analyzed with four one way ANOVAs. A dependent samples t-test was also conducted to determine if overall PM task judgments (calculated as the mean of PM prediction and postdiction accuracy scores) were more accurate than overall episodic recall task judgements (mean of episodic recall prediction and postdiction accuracy scores). Simple linear regressions were conducted to determine if predictions and postdictions on the PM and episodic recall tasks were predictive of their actual memory performance on the PM and episodic recall tasks separately. An executive function composite score was computed by combining the Backwards Word Span task and Simon Says task. Bivariate correlations between age, an executive functioning composite, and performance scores on all other tasks were conducted. A simple mediation analysis was conducted to test the prediction that metacognitive monitoring would mediate the relation between executive functioning and PM performance.

Results

Figure 1 shows means and standard deviations for prospective memory task predictions, performance, and postdictions by age group and task difficulty.
Means and standard deviations for prospective memory task predictions, performance, and postdictions by age group and task difficulty.

Table 1 shows means and standard deviations of Episodic Recall task predictions, Episodic Recall task performance, Episodic Recall task postdictions, Simon Says, Metacognitive Monitoring task, and Backward Word Span task by age group.
Table 1.

Means and standard deviation of episodic recall predictions, postdictions, performance, Simon Says, Metacognitive Monitoring, and Backward Word Span Tasks

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Episodic Recall Predictions (0-8)</th>
<th>Episodic Recall Score (0-8)</th>
<th>Episodic Recall Postdictions (0-8)</th>
<th>Simon Says Score (0-15)</th>
<th>Metacognitive Monitoring Score (0-10)</th>
<th>Backwards Word Span Score (0-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-year-olds</td>
<td>6.72 (2.41)</td>
<td>3.34 (1.87)</td>
<td>5.62 (2.85)</td>
<td>5.21 (5.66)</td>
<td>5.93 (1.93)</td>
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<td></td>
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<td>N = 47</td>
<td>N = 47</td>
<td>N = 42</td>
<td>N = 46</td>
<td>N = 28</td>
</tr>
<tr>
<td>5-year-olds</td>
<td>7.00 (1.75)</td>
<td>4.46 (1.35)</td>
<td>5.77 (2.12)</td>
<td>8.97 (5.55)</td>
<td>6.87 (1.45)</td>
<td>1.14 (.55)</td>
</tr>
<tr>
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<td>N = 41</td>
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<td>5.57 (1.77)</td>
<td>10.71 (4.67)</td>
<td>7.02 (1.99)</td>
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The Effect of Age and Task Difficulty on Prospective Memory Performance

To investigate the effect of children’s age and task difficulty on children’s PM performance, a 2 (Condition: salient vs. non-salient) by 3 (Age group: 4 vs. 5 vs. 6-year-olds) ANOVA was conducted. Results showed a significant main effect of age group in that older children performed significantly better in the PM task compared to younger children, $F(2,126) = 3.85, p = .024, \eta^2_p = .06$. Tukey post hoc tests revealed that 6-year-olds ($M = 3.04, SE = .23$) performed significantly better than 4-year-olds ($M = 2.14, SE = .23; M_{Diff} = .89, SE = .33 p = .020$) in the PM task. There was no significant difference in performance between 5-year-olds ($M$
= 2.59, \( SE = .25 \) and 6-year-olds \((M = 3.04, \ SE = .23; \ p = .582)\) or between 4-year-olds \((M = 2.14, \ SE = .23)\) and 5-year-olds \((M = 2.59, \ SE = .25; \ p = .544)\). There was a significant main effect of condition, \( F(1,126) = 8.40, \ p = .004, \eta_p^2 = .06 \), in that children in the salient condition had significantly better PM performance \((M = 2.99, \ SE = .20)\) than children in the non-salient condition \((M = 2.19, \ SE = .20)\). There was no significant interaction between age group and condition on children’s PM performance, \( F(2,126) = .97, \ p = .381, \eta_p^2 = .02 \), suggesting that the difficulty of the task had an equal impact on children’s PM regardless of age.

**The Effect of Age and Task Difficulty on Children’s Predictions and Postdictions of their Prospective Memory Performance**

A 2 (Condition: salient vs. non-salient) by 3 (Age group: 4 vs. 5 vs. 6-year-olds) ANOVA was conducted on children’s PM performance predictions. Results showed no significant main effect of age group, \( F(2,125) = 1.80, \ p = .169, \eta_p^2 = .03 \), task difficulty, \( F(1,125) = .16, \ p = .692, \eta_p^2 = .001 \), nor an interaction between age group and task difficulty, \( F(2,125) = 1.00, \ p = .371, \eta_p^2 = .02 \). This indicates that children’s predictions were unaffected by the difficulty of task and age of the child.

Similarly, a 2 (Condition: salient vs. non-salient) by 3 (Age group: 4 vs. 5 vs. 6-year-olds) ANOVA was conducted on children’s *postdictions* of their PM performance. Results revealed no main effect of age group, \( F(2,126) = 1.43, \ p = .244, \eta_p^2 = .02 \). There was a significant main effect of task difficulty, \( F(1,126) = 4.41, \ p = .038, \eta_p^2 = .034 \). Pairwise comparisons revealed that children postdicted that they had remembered to carry out the PM task significantly more in the salient condition \((M = 3.63, \ SE = .14)\) compared to the non-salient condition \((M = 3.23, \ SE = .14)\). The interaction between age group and task difficulty was not significant,
$F(2,126) = .32, p = .728, \eta_p^2 = .01$, suggesting that although children’s performance was impacted by difficulty, children’s postdictions remained the same across age groups.

**Accuracy of Prospective Memory and Episodic Recall Predictions and Postdictions**

Children’s predictions in the episodic recall task approached ceiling levels with children predicting that they would remember almost 7 out of 8 line drawings on average ($M = 6.73, SD = 2.22$). Children’s predictions in the episodic recall task did not improve with age, $F(2, 129) = .49, p = .617, \eta_p^2 = .007$. On average, children’s actual performance on the episodic recall increased with age, $F (2,129) = 12.89, p < .001, \eta_p^2 = .167$. Tukey *post-hoc* analyses showed that 6-year-olds ($M = 4.91, SE = .23$) performed significantly better than 4-year-olds ($M = 3.34, SE = .23$) on the episodic recall task ($t = 1.57, p < .001$). Five-year-olds ($M = 4.45, SE = .25$) also performed significantly better on the episodic recall task compared to 4-year-olds ($M = 3.34, SE = .22; t = 1.12, p = .003$). There was no significant difference between 5- and 6-year-olds in episodic recall task performance ($p = .537$). Children’s *postdictions* were numerically lower than predictions but still quite high with children reporting remembering almost 6 out of 8 line drawings ($M = 5.64, SD = 2.29$). Children’s postdictions in the episodic recall task did not improve with age, $F (2, 129) = .09, p = .916, \eta_p^2 = .001$.

To calculate the accuracy of PM and episodic recall task predictions and postdictions, absolute difference scores were calculated between the prediction or postdiction and children’s actual performance. Thus, larger scores indicated lower levels of accuracy and smaller scores indicated greater accuracy.

To determine if children’s predictions were more accurate compared to their postdictions for the PM and episodic recall tasks, dependent samples t-tests were conducted. In the PM task,
children’s postdictions ($M = .95, SD = 1.50$) were significantly more accurate compared to their predictions ($M = 1.40, SD = 1.59$; 95% CI (.25, .65), $t(130) = 4.43, p < .001$). Likewise, in the episodic recall task, children’s postdictions were significantly more accurate ($M = 2.12, SD = 2.06$) compared to their predictions ($M = 2.98, SD = 1.86$; 95% CI (.54, 1.18), $t(131) = 5.32, p < .001$).

In order to examine the impact of age on children’s prediction and postdiction accuracy, we conducted four one way ANOVAs in exploratory analyses to determine if children’s prediction and postdiction accuracy for the PM and episodic recall task improved with age.¹ For the PM task, there was a main effect of age on children’s prediction accuracy, $F(2,129) = 4.42, p = .014$, and children’s postdiction accuracy, $F(2,130) = 6.05, p = .003$. Tukey post-hoc analyses indicated that 6-year-olds’ PM predictions ($M = .86, SD = 1.30$) were significantly more accurate than 4-year-olds’ ($M = 1.83, SD = 1.65$; 95% CI [-1.10, -.12], $p = .010$), but were not significantly different from 5-year-old’s prediction accuracy ($M = 1.40, SD = 1.66$; 95% CI [-.17, .85], $p = .254$). There was no significant difference in PM prediction accuracy between 4- and 5-

¹ A 3 (age group: 4 vs 5 vs 6-years-old) by 2 (judgment type: predictions vs postdictions) repeated measures ANOVA was also conducted to examine judgment type prediction and postdiction accuracy. It was found that for PM, there was a significant effect of age on children’s judgment accuracy, Wilk’s Lambda = .87, $F(1,127) = 18.32, p < .001, \eta^2 = .13$. Post-hoc comparisons indicated that 6-year-old’s judgment accuracy ($M = .59, SE = .21$) was not significantly different from 5-year-olds ($M = 1.25, SE = .22, p = .091$), but was significantly more accurate than 4-year-olds ($M = 1.59, SE = .20; p = .002$). Five-year-old’s judgment accuracies did not significantly differ from 4-year-olds ($p = .768$). There was no significant interaction between judgment type and children’s age ($p = .629$). Importantly, children’s postdictions ($M = .92, SE = .13$) were significantly more accurate than their predictions ($M = 1.36, SE = .14$; 95% CI [-.65, -.24], $p < .001$).

For RM another 3 (age group) by 2 (judgment type) repeated measures ANOVA was conducted and it was found that there was a significant effect of age on children’s judgment accuracy, Wilk’s Lambda = .82, $F(1,128) = 28.56, p < .001, \eta^2 = .18$. Post-hoc comparisons indicated that 6-year-old’s judgment accuracy ($M = 1.77, SE = .25$) was not significantly different from 5-year-olds ($M = 2.42, SE = .25; p = .203$) but was significantly more accurate than 4-year-olds ($M = 3.40, SE = .24; p < .001$). Five-year-old’s judgment accuracies were also significantly more accurate than 4-year-olds’ ($p = .014$). There was no significant interaction between judgment type and children’s age, although it did approach significance ($p = .076$). Children’s postdictions ($M = 2.10, SE = .17$) were significantly more accurate than their predictions ($M = 2.96, SE = .16$, 95% CI [-1.17, -.54], $p < .001$).

These results did not differ from the four one-way ANOVAs reported.
year-olds (95% CI [-.77, .23], $p = .402$). Six-year-olds’ PM postdictions ($M = .33, SD = .72$) were significantly more accurate than both 5-year-olds ($M = 1.10, SD = 1.65, p = .046$) and 4-year-olds ($M = 1.34, SD = 1.69, p = .003$). However, there was no significant difference between 4- and 5-year-old’s postdiction (95% CI [-.67, .31], $p = .654$) accuracy. Overall, 6-year-olds’ PM predictions were only significantly more accurate than 4-year-olds’ but their PM postdictions were significantly more accurate than both 4 and 5-year-olds, although there was no difference in prediction or postdiction accuracy between 4 and 5-year-olds.

For the episodic recall task, there was a significant main effect of age on children’s episodic recall prediction accuracy ($F(2,130) = 5.00, p = .008$) and postdiction accuracy ($F(2,130) = 5.00, p = .008$). Tukey post-hoc analyses indicated that 6-year-olds had significantly more accurate predictions ($M = 2.40, SD = 1.42$) than 4-year-olds ($M = 3.60, SD = 2.19; 95\% CI [-1.13, -.16], p = .006$). Five-year-olds ($M = 2.90, SD = 1.72$) did not significantly differ in their prediction accuracy with 6-year-olds (95\% CI [-.24, .76], $p = .445$) or 4-year-olds (95\% CI [-.88, .11], $p = .158$). Similarly, 6-year-olds were significantly more accurate in their episodic recall postdictions ($M = 1.14, SD = 1.32$) compared to 4-year-olds ($M = 3.21, SD = 2.42; 95\% CI [-1.46, -.55], p < .001$) but not 5-year-olds ($M = 1.98, SD = 1.69; 95\% CI [-.87, .08], p = .123$). However, 5-year-olds were significantly more accurate in their postdictions compared to 4-year-olds (95\% CI [-1.07, -.15], $p = .006$). Overall, 6-year-olds were significantly more accurate in their predictions than 4-year-olds and both 5- and 6-year-olds were more accurate than 4-year-olds in their postdictions, although they did not differ in accuracy between each other.

To examine the hypothesis that children were more accurate for predictions (PM and episodic recall) compared to postdictions (PM and episodic recall), first composite accuracy
scores were formed by combining: (1) absolute difference scores for predictions on the PM and episodic recall task (total score out of 12) and (2) absolute difference scores for postdictions on the PM and episodic recall task (total score out of 12). Then, a dependent samples t-test was conducted to compare the accuracy of predictions and postdictions overall. Children were significantly more accurate in their memory postdictions ($M = 3.08$, $SD = 3.01$) than their memory predictions ($M = 4.40$, $SD = 2.56$; 95% CI (-1.70, -.92), $t(130) = -6.64$, $p < .001$). Thus, children’s postdictions were significantly more accurate than predictions across both PM and episodic recall memory tasks.

*Relation Between Children’s Predictions, Postdictions, and Actual Performance*

To see whether predictions or postdictions were more predictive of children’s PM and RM performance, hierarchical linear regressions were conducted for both PM and episodic recall tasks. Children’s PM task predictions did not predict their actual PM task performance, but children’s postdictions did ($\beta = .41$, $t = 5.09$, $p < .001$; see Table 2). In the episodic recall task, children’s predictions independently predicted their actual episodic recall performance ($\beta = .19$, $t = 2.04$, $p = .043$), whereas children’s postdictions did not (see Table 2).
Table 2.

*Hierarchical linear regressions for PM and episodic recall performance*

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*p < .05    **p < .01

The Relation Between Metacognitive Monitoring and Prospective Memory and Episodic Recall

Predictions and Postdictions

To determine whether children with better metacognitive monitoring also had more accurate predictions and postdictions in both the PM and episodic recall task, prediction and postdiction accuracy scores were compared to metacognitive monitoring scores. Metacognitive monitoring was significantly negatively correlated with children’s PM prediction accuracy scores, r = -.28, p = .001. Since smaller accuracy scores meant less difference between children’s predictions and actual performance, this negative correlation shows that children with higher metacognitive monitoring scores also had more accurate PM predictions. There was no significant relation between metacognitive monitoring and the measures of PM postdictions (p = .148), episodic recall predictions (p = .099), or episodic recall postdictions (p = .181).
An executive function composite was created by combining z-scores on Simon Says and Backward word span tasks. Correlations among age in months, executive function composite score, PM, episodic recall, and metacognitive monitoring tasks were examined. As shown in Table 3, children’s PM performance was significantly positively correlated with all other measures in the study, as was age and executive functioning. Thus, as age increased, so too did children’s performance on all tasks. Additionally, children with higher PM and executive functioning performance also tended to perform better on all other tasks.

Table 3.

Correlations among measures

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<th>Executive Functioning Performance</th>
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<td>.40**</td>
<td>.51**</td>
<td>.28**</td>
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</table>

*\(p < .05\)  **\(p < .01\)

Because children’s PM performance was positively correlated with the executive function composite, \(r = .35, p < .001\), and children’s metacognitive monitoring ability, \(r = .31, p < .001\), we
sought to examine whether metacognitive monitoring might account for the effect of executive functions on PM performance.

We used a mediation analysis with bootstrapping (Preacher & Hayes, 2008) to examine whether metacognitive monitoring performance mediated the relation between executive function and PM performance. Executive function significantly predicted both PM (path [c] in Figure 1) and metacognitive monitoring (path [a]). When the relation between metacognitive monitoring and PM (path [b]) was added, while executive function remained a significant predictor of PM (path [c’]), metacognitive monitoring significantly predicted PM performance as well. Sobel tests indicated that the association between executive function and PM was partially mediated by metacognitive monitoring ability, $b = .085$, BCa CI [.011, .23]. However, this represents a relatively small effect, $K^2 = .045$, 95% BCa CI [.01, .12].

**Figure 2.**

*Mediation of metacognitive monitoring on the effect of executive functioning on prospective memory performance.*

Metacognitive monitoring as a mediator of the association between executive function and PM performance. The effect of executive function on metacognitive monitoring is path [a]. The effect of metacognitive monitoring on PM, controlling for executive function, is path [b]. Path
[c] represents the effect of executive function on PM. Path [c’] represents the effect of executive function on PM after including metacognitive monitoring in the model. The coefficient for path [c’] is in parentheses. * p < .05   **p < .01.

Discussion

This study examined the development of PM in early childhood and how metamemory and metacognition were related to PM. Young children’s PM increased with age and was worse in a non-salient cue condition compared to a salient cue condition. Although there was no significant effect of age on the accuracy of children’s PM predictions or postdictions, there was an effect of difficulty on children’s PM postdictions. That is, children’s PM postdictions were significantly higher in the salient condition compared to the non-salient condition. Children’s PM postdictions were more accurate and significantly predictive of PM performance compared to their PM predictions. Children’s episodic recall performance increased with age and their postdictions were significantly more accurate than their predictions. Across both memory tasks (PM and episodic recall) children had more accurate postdictions compared to their predictions, suggesting they were better able to reflect on their performance than they were at predicting it. Despite being more accurate in their episodic recall postdictions than predictions, children’s predictions captured a significant amount of variance in their actual episodic recall score whereas their postdictions did not. Thus, it seems that there were individual differences in children’s predictions that contributed uniquely to variance in their episodic recall scores. For example, it seems that the children who relied on previous experiences of their retrospective memory ability to inform their RM predictions had better episodic recall performance, whereas others might have not. Children with better metacognitive monitoring ability also had more accurate PM performance predictions. Finally, when examining whether metacognitive monitoring
performance mediated the relation between executive function and PM performance, executive function significantly predicted both PM and metacognitive monitoring. When metacognitive monitoring was also entered into the model the association between executive function and PM was partially mediated by metacognitive monitoring ability, however, this mediation had a small effect size.

Age and Prospective Memory Performance

The finding that 6-year-olds outperformed 4-year-olds on the PM task is consistent with past literature suggesting increases in PM ability during the early childhood years (Ford et al., 2012; Kliegel & Jager, 2007; Mahy et al., 2014a), as is the findings that as age increased performance increased on all tasks. Interestingly, in the current sample PM performance did not differ between 4- and 5-year-olds or between 5- and 6-year-olds suggesting that PM changes more gradually over this period of development such that changes are more likely to be seen across a period of 2 or more years (between 4- and 6 year-olds). This is somewhat reflective of some past literature (e.g., Mahy, Mazachowsky, & Pagobo, 2018; Mahy & Moses, 2011) that has found that PM does not differ between 5- and 6-year-olds (Mahy, Mazachowsky, & Pagobo, 2018) and that PM does not differ between 4- and 5-year-olds (Mahy & Moses, 2011). Overall, this study supports previous PM literature that shows PM increases during the preschool years.

Effect of Difficulty on the Prospective Memory Task

The finding that non-salient cues resulted in worse PM performance was in line with our prediction as well as past research that has demonstrated that cue salience has a significant impact on young children’s PM performance (e.g., Mahy, Moses, & Kliegel, 2014b). While the current study was the first to highlight the entire background of the PM cue card as a
manipulation of cue salience, past research has shown that more subtle salience manipulations such as putting a red border around PM cues (Mahy, Moses, & Kliegel, 2014a), having specific (i.e., being told they needed to press a different key when they saw a picture of a sandwich, candy, and a ball) versus broad (i.e., being told they needed to press a key whenever they saw a picture of fruit) PM cues (Cottini, Basso, & Palladino, 2018), or placing the cue in the centre of one’s attention (Kliegel et al., 2014) are effective in improving children’s PM performance.

Further to date, there has been very little work examining the impact of task difficulty on children’s predictions and postdictions of PM performance. Although children in the current study were overly optimistic in their PM predictions and postdictions across the salient and non-salient conditions, only children’s PM postdictions were significantly lower in the non-salient condition compared to the salient condition. This finding suggests that children take into consideration the difficulty of a task only when reflecting on their PM performance (i.e., after the task), and that first-hand experience with completing a relatively easy or difficult PM task is necessary in order for postdictions to reflect children’s actual performance. Verbal information that the experimenter provided to the child about the PM task being easy or hard prior to the testing was insufficient to affect children’s predictions. This study was the first to provide children information about the difficulty of a PM task before they completed the task. However, task difficulty has been examined in the context of children’s predictions for a RM task. Specifically, Kvavilashvili and Ford (2014) asked 5-year-old children to predict whether they would remember the last name of a stuffed animal in an easy condition (Mr. Rainbow) versus a difficult condition (Mr. Tainbow). Results showed that despite all children in both conditions predicting that they would remember the animal’s name, 94% of children in the easy condition did successfully remember the animal’s name whereas none of the children in the difficult
condition did. Thus, children’s predictions were unaffected by difficulty whereas their performance was significantly impacted by task difficulty. In contrast, Destan, Hembacher, Ghetti, and Roebers (2014) found that 5- to 7-year-old children predicted they would remember more items in an easy episodic recall task compared to a difficult task. Thus, there is mixed evidence as to whether or not children’s predictions are sensitive to difficulty in RM tasks. Overall, our study indicates that children do not consider information about a task’s difficulty in predicting PM performance, particularly if that information is provided to them verbally. However, young children can incorporate their experience with task difficulty in their PM postdictions.

**Accuracy of Predictions and Postdictions for Prospective Memory**

In contrast with my original hypothesis based on Kvavilashvili and Ford’s (2014) finding that 5-year-olds’ PM predictions were surprisingly accurate, only children’s postdictions were significantly predictive of their actual PM performance. This finding is supported by some literature, such as Cottini, Basso, Saracini, and Palladino (2019), who also found that 7 and 8-year-old children’s postdictions were significantly more related to children’s actual PM performance compared to their predictions. It should be noted that similar to the current study, there were five PM cues in the task and children were asked how many they had remembered (out of 5) as part of their postdiction. Unlike my study, children were not asked how many prospective cues they thought they would remember in their prediction but were only asked if they thought they would remember to fulfill the intention for the 5 items or not (i.e., an all or none judgment). Additionally, Kvavilashvili and Ford (2014) only had one PM cue that children had to detect, and thus their PM prediction was a yes/no response to whether or not children thought they would remember the intention. This does not allow for as much variability in
children’s predictions as in the current study that asked children to indicate how many cues they would remember to fulfill out of 4. It is worth noting the differences in the two studies’ procedures as well. In the current study, children had to place elephant cards in a box behind them whereas in Kvavilashvili and Ford (2014)’s study children were required to tell a stuffed animal not to be afraid (PM intention) whenever they saw a picture of a tractor (PM cue). Perhaps children’s predictions were less accurate in the current study because the PM task was more difficult than that in Kvavilashvili and Ford’s study. In my task, the PM intention required a motor action (putting the card in a box directly behind them) which was distinct from their ongoing task (which included both a verbal and motor action [i.e., naming the colour of a dot on the card and also sorting cards into separate coloured boxes]). Alternately, Kvavilashvili and Ford (2014)’s PM task intention only required a verbal response from children (telling a stuffed animal not to be afraid) as they sorted through cards and naming what was on the cards (ongoing task). None the less, the 53% success rate observed in Kvavilashvili and Ford (2014)’s task was difficult enough for children such that it should have had an impact on their predictions. Overall, children’s PM predictions were quite optimistic and only postdictions were predictive of actual PM performance. However, children’s accuracies in their predictions and postdictions improves with age, as noted by the exploratory findings that 6-year-olds were more accurate in their PM predictions compared to 4-year-olds, and their PM postdictions were more accurate than both 4- and 5-year-olds. It should be noted that children’s performance improved substantially with age, and thus this increase in prediction and postdiction accuracy could be driven by children’s performance catching up with their optimistic predictions and postdictions rather than their judgements becoming more accurate with age.

Accuracy of Predictions and Postdictions for Retrospective Memory
The finding that children’s RM performance increases with age is well supported by previous literature (Destan, Hembacher, Ghetti, & Roebers, 2014; Schneider, 1998). Less intuitive is the finding that in the episodic recall task children’s predictions significantly predicted their actual RM performance, whereas their postdictions did not, despite being significantly more accurate in relation to their actual RM performance. These findings may be due to the fact that individual differences in predictions were more related to individual differences in the episodic recall task despite postdictions being more accurate. It is possible that episodic recall predictions and actual task performance were both capturing age-related variance given that children’s episodic recall performance did increase with age. Thus, children with higher predictions were also children with better episodic recall scores despite the absolute difference between predictions and actual performance being high (inaccurate). Thus, although it seems postdictions of RM overall are more accurate, individual predictions accounted for more variance in episodic recall performance. This is supported by the adult literature, such as Hertzog, Saylor, Fleece, and Dixon (1994) who found that across four different RM tasks in which adults and older adults made predictions and postdictions before and after the task, postdiction accuracy was consistent across the tasks. However, the accuracy of participants’ predictions was significantly impacted by individual differences and task type. This supports our finding that postdictions were more accurate than predictions, but individual differences in predictions accounted for more variance is RM performance. This is consistent with the theory that predictions might be impacted more by individual differences but postdiction accuracy might be more consistent across the lifespan.

Children’s optimism in their predictions and postdictions surrounding their episodic recall task is in line with past literature (Kvavilashvili & Ford, 2014). Similar to our findings,
Kvavilashvili and Ford (2014) found that 5-year-old children’s predictions of their RM performance were extremely optimistic, despite their actual performance being quite limited. Unlike predictions, however, several other studies have found that children’s postdictions were significantly related to children’s actual RM performance. For example, Schneider (1998) compared 4- and 6-year-old children’s predictions and postdictions of two separate episodic recall tasks. He found that children’s postdictions were significantly more accurate compared to their predictions. These findings are logical when one considers that in order to make a postdiction (i.e., reflection of one’s performance in the past) one must rely on episodic memory itself (McDaniel & Einstein, 2007). Thus, the fact that postdictions predicted actual episodic memory performance is expected. Clearly, children’s ability to make predictions of their RM performance is not as well developed during the 4- to 6-year age range as is their ability to reflect on performance after the fact (Maylor & Logie, 2010). Both prediction and postdiction accuracy was higher in older compared to younger children. Six-year-olds were significantly more accurate in their episodic recall predictions than 4-year-olds, and both 5- and 6-year-olds were more accurate in their episodic recall postdictions than 4-year-olds.

Relations among Executive Functioning, Prospective Memory, and Metacognition

This study replicated the finding that PM and executive functioning are significantly related in early childhood (Ford et al., 2012; Mahy & Moses, 2011; Mahy, Moses, & Kliegel, 2014a; Mahy, Moses, & Kliegel, 2014b). In line with our prediction, children’s metacognitive monitoring (measured as children’s ability to evaluate their knowledge of common and rare animals) was positively related to PM and executive function supporting the idea that these cognitive processes are interrelated (e.g., Souchay & Isingrini, 2004; Roebers & Feurer, 2015), and develop in similar trajectories in young childhood (e.g., Ford, Driscoll, Shum, & Macaulay,
2012). However, the fact that there was only a limited, but significant, mediation of metacognitive monitoring on the relation between executive function and PM suggests that the effect of metacognitive ability on the relation between executive functioning and children’s PM performance is not primary. Importantly, the direct effect of executive functioning on PM was sufficiently important that there may not have been much room for the influence of metacognitive monitoring (i.e., given the expansive definition of executive functioning; Banich, 2009). This mediation effect might be stronger later in childhood, when older children rely on their metacognitive ability more so to complete many different cognitive tasks (Kreutzer, Leonard, Flavell, & Hagen, 1975). Overall, it does seem like children with better executive functioning also have better metacognitive monitoring; and both of these abilities contribute to better PM performance.

Limitations and Future Directions

There are some limitations of the current study that warrant discussion. One primary limitation is that the impact of difficulty on children’s PM predictions was only described verbally (i.e., children were told ‘the elephant cards would have a bright yellow background/have the same white background and so they would be easy/hard to notice’). This was perhaps too subtle for it to impact children’s PM predictions given it was mentioned only briefly without visual examples, and could have been part of the reason that there was no significant effect of salience condition on children’s PM predictions. This could be remedied in future studies by showing children in the salient condition examples of salient stimuli to aid in their predictions (e.g. ‘the elephants will be on a bright yellow background like this (with the experimenter showing a bright yellow card without anything on it) unlike the other cards’ (with the experimenter showing a blank white card without anything on it)). It is possible that the verbal
instructions prior to predictions may have been too subtle or children did not understand the relevance of this information in the prediction of their PM performance. Further, it could also be argued that for PM specifically, predictions are often unreliable even into adulthood. Adults tend to have a very high rate of failing to fulfill PM intentions in their daily lives (Terry, 1988), despite better metamemory performance being associated with better PM performance (Dobbs & Rule, 1987; Vasile-Frumos & Iurciuc, 2017). Thus, it is possible that even adults are unaware of their PM performance, and as such are unable to make accurate predictions of how they would do in a PM task, regardless of the difficulty of said task (Begg, Duft, Lalonde, Melnick, & Sanvito, 1989). This implicates the need to implement future studies exploring whether increasing metamemory with respect to PM would result in adults having better ‘everyday’ PM performance. One potential reason metamemory performance is associated with better PM performance is because when people think about their PM performance (such as by making PM performance predictions), they are using mental time travel to imagine themselves doing the task. This mental time travel may make them more likely to monitor for the PM cue when they carry out the actual PM task, as the mental simulation would involve seeing the cue and fulfilling the intention. Thus, they may be more likely to detect a PM cue and subsequently fulfill the PM intention (Kvavilashvili & Ford, 2014).

Another limitation of the PM task is the fact that there were only four PM cues, which was necessary given the limited time provided to conduct the study. This amount of cues is also standard for a PM card sorting task for preschool-aged children (e.g., Mahy, & Moses, 2011) and thus there was limited variability in children’s predictions, postdictions, and actual performance. Regardless, this number of cues could have limited the children’s responses since they had to estimate how many cues they would remember out of 4 contrasted to the 8 item range as in the
episodic recall task. It is important to note that this variability is an improvement from previous studies, however, in which children’s PM prediction and actual PM was measured based on their response to a single trial (Kvavilashvili & Ford, 2014). Children’s predictions and postdictions in the current study approached ceiling levels of performance, illustrating young children’s extreme optimism surrounding their memory performance and indicating that most children were not using the entire scale (0 to 4) in predicting and reflecting on their PM performance. This could be due to Piaget’s ‘wishful thinking’ hypothesis, which is the idea that children may be optimistic in predicting their performance on tasks because they are unable to differentiate the difference between effort and ability (Piaget, 1930). In other words, they think that as long as they try to perform well, they will, even in difficult cognitive tasks. This has been supported in the literature. For example, Schneider (1998) randomly assigned 4 and 6-year-olds into two groups who were either told to predict how well they would actually do on two RM tasks, or to make a ‘wish’ of how well they wanted to do on the RM tasks. It was found that not only did both age groups overestimate their performance, but there was no significant difference in condition, such that children’s predictions were the same as other children’s wishes. It should be noted that this study relied heavily on children’s verbal ability in order to understand the difference between the words ‘wish’ versus ‘predict’, and make a cognitive decision based on that. This is also a limitation to the current study, as there was a reliance on children’s verbal responses as well as understanding of subtle verbal differences in several of the tasks. Despite this, for the sake of time a measure of verbal ability was not included. If time permitted, a measure of verbal ability could have been included as an important control measure. However, in all of the predictions and postdictions for both prospective and RM tasks children were given visual scales that they could point to which decreased the verbal requirements to complete the tasks. Future studies should
include measures of verbal ability to help control for the impact of verbal ability in children’s memory predictions and postdictions in understanding task instructions as well as producing a verbal response.

Future studies should attempt to examine children’s ability to predict and postdict their PM and RM performance in a wider age range of children. This study was the first study to examine predictions and postdictions of PM and RM in young children, but it is possible that 4- to 6-year olds do not yet have the ability to make accurate predictions or reflections on their memory performance (e.g., Schneider, 1998). The literature would also benefit from including longitudinal research that examines how PM and RM predictions and postdictions improve or change over time. This is because it would allow us to identify if early optimistic judgments in children was associated with continued optimism bias in predictions and postdictions later in life (and thus is an individual difference) or if children become more realistic with age (which our exploratory age related findings would suggest to be true).

Conclusion

In conclusion, although children are optimistic about their PM and RM performance, children’s memory postdictions are generally more accurate than their predictions. For RM, it seems that individual differences in predictions best predict actual RM performance. Interestingly, it seems that postdictions for PM tasks are influenced by cue salience - children can incorporate their actual PM performance into their reflection on their performance. Future studies should continue to examine children’s predictions and postdictions on both PM and RM, as one’s awareness of memory performance is critical in order to know when to use reminders or memory strategies to improve memory performance.
References


Appendices

Appendix A

Rating Scale for Prospective Memory Predictions and Postdictions

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<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</table>

Elephant illustrations for each rating level.
Appendix B

Rating Scale for Retrospective Memory Predictions and Postdictions
Appendix C

Confidence Rating Scale for Metamemory Judgments
Appendix D:
Certificate of Ethics Clearance from the Brock University Social Science Research Ethics Board

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<th>9/27/2018</th>
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<tr>
<td>FILE:</td>
<td>18-070 - MAHY</td>
</tr>
<tr>
<td>TYPE:</td>
<td>Faculty Research</td>
</tr>
<tr>
<td>STUDENT:</td>
<td>Lydia Lavis</td>
</tr>
<tr>
<td>SUPERVISOR:</td>
<td>Caitlin Mahy</td>
</tr>
<tr>
<td>TITLE:</td>
<td>The Relation Between Young Children’s Memory and Metacognition</td>
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**ETHICS CLEARANCE GRANTED**

| Type of Clearance | NEW | Expiry Date: | 9/1/2019 |

The Brock University Social Science Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University’s ethical standards and the Tri-Council Policy Statement. Clearance granted from 9/27/2018 to 9/1/2019.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 9/1/2016. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at [http://www.brocku.ca/research/policies-and-forms/research-forms](http://www.brocku.ca/research/policies-and-forms/research-forms).

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;

b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;

c) New information that may adversely affect the safety of the participants or the conduct of the study;

d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Lynn Dempsey, Chair
Social Science Research Ethics Board

Robert Steinbauer, Chair
Social Science Research Ethics Board

**Note:** Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.
Appendix E

Parent Consent Form

Consent Form

Date: 2019

Project Title: The Relation Between Young Children’s Memory and Metacognition

Principal Investigator (PI): Dr. Caitlin Mahy, Department of Psychology, Brock University 905-668-5550 ext. 6151 caitlin.mahy@brocku.ca

INVITATION

You and your child are invited to participate in a study that involves research. The purpose of this study is to examine 4- to 6-year-old children’s ability to remember to carry out their future intentions and to examine their accuracy in predicting their ability to remember to carry out a future intention.

WHAT’S INVOLVED

As a participant, you will be asked to fill out a demographics form that will take less than 5 minutes to complete. Your child will play several interactive games with a researcher that requires your child to follow instructions to complete an action or make a verbal response (e.g., a card sorting game, a memory game, playing Simon Says). Your child’s performance will be video- and audio-recorded and the session will take approximately 15 minutes.

POTENTIAL BENEFITS AND RISKS

In appreciation of participation, your child will receive a small toy and we will pay for parking at Brock University. If your child participates at their daycare, they will receive a small toy and the daycare will receive a children’s book as a token of our appreciation. Research on how remember to carry out their future intentions will improve our understanding of child development, and help to inform parents and teachers of strategies to help improve encourage children’s memory development. There are no known or anticipated risks associated with participation in this study.

CONFIDENTIALITY

All information you provide is considered confidential; neither your name nor your child’s will be included with your data. We will use a code number to match your child’s audio-visual tape to the measures that they complete and to the demographics information you provide on the consent form. Children’s audio-visual recording will not be seen by anyone outside of the research team. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research. We will keep a list of participants in order to ensure that each participant does not take part in the study more than once which will be kept for 5 years after publication, and we will keep a list of participants who are interested in being contacted for future studies, however this information will not be connected to your child’s responses in the study.
Data collected during this study will be stored in the laboratory of Dr. Caitlin Mahy, which will be secured at all times. Data will be kept for five years following publication in an academic journal, after which time all data will be destroyed by shredding paper records, or by deleting electronic records and audio and videotapes. Data may be available to publishers for verification purposes only, but access to this data will otherwise be restricted to Dr. Caitlin Mahy and research assistants in Dr. Mahy’s laboratory (all of whom will agree to maintain confidentiality). Only in rare cases will it not be possible to ensure confidentiality because of mandatory reporting laws (e.g. suspected child abuse).

**VOLUNTARY PARTICIPATION**

Participation in this study is voluntary and participants have the right to request the withdrawal of their data. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time. If you chose to withdraw and data has been collected from your child, the data will be destroyed. If your child decides not to participate on the day of the research session, either at the start of the session or during the session, he or she will not be penalized and will still receive the small gift. If your child chooses to withdraw after some data have been collected, acquired data will be retained and used in the analysis.

**PUBLICATION OF RESULTS**

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available as soon as data collection is complete in approximately one year. If you are interested in receiving feedback about the results of the study please indicate below and Dr. Caitlin Mahy will send you a copy of the findings.

**CONTACT INFORMATION AND ETHICS CLEARANCE**

If you have any questions about this study or require further information, please contact Dr. Caitlin Mahy using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University [18-070-MAHY]. If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

Thank you for your assistance in this project. Please sign this form and return to the researcher or Daycare Supervisor/Teacher.

**CONSENT FORM**

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Child’s Name: ______________________  Child’s Date of Birth: ______________________

Your Name: ___________________________________________________________________

Your Signature: ___________________________________  Date: ______________________

If you are interested, in receiving feedback about the overall results of the study please provide your contact information
Phone Number: ____________________     Email Address: ________________________________

Address:

_________________________________________________________________________

☐ I would like to learn more about future research participation opportunities at the Lifespan Centre by joining Growing with Brock.

☐ I am already a member of growing with Brock

Phone Number: ____________________     Email Address: ________________________________
Appendix F
Demographics Questionnaire

PLEASE FEEL FREE TO LEAVE ANY OF THE BELOW ITEMS BLANK.

Please fill out following information about yourself:

1. Sex ___ male ___ female

2. Age _________

3. Your relationship to child:
   ______ Mother
   ______ Father
   ______ Other (please indicate the relationship) __________________________

4. Education level (please check highest level attained):
   ___ No formal education
   ___ Grade school
   ___ Some high school
   ___ Some college or 2-year degree
   ___ Bachelor’s degree (Major: ________________)
   ___ Graduate degree (Please specify) ___________________________________
   ___ Other (Please specify) __________________________________________

5. Occupation (self)____________________
   Occupation (spouse, if applicable)____________________

6. Which category best describes your total annual income?
7. What is (are) the age and gender of your child(ren) including the child participating in this study?

(M/F) ____________  (M/F) ____________
(M/F) ____________  (M/F) ____________

8. Does your child currently attend school?

_______________ Daycare number of hours per week _____________
_______________ Preschool number of hours per week _____________
_______________ Kindergarten number of hours per week _____________
_______________ Other (please specify): _____________________________________

9. Who looks after your child(ren) when they are not in school? ____________  Please turn over  

10. Your cultural background/ Race-Ethnicity (please check all that apply):

___ White
___ Black or African American
___ Hispanic, Latino, or Spanish
___ Asian
___ Asian Indian
___ Hawaiian Native
___ Pacific Islander
___ Middle Eastern
___ First Nations, Inuit, or Metis
___ Other group (Please specify): _____________________________________
Part II: Child Information Questionnaire

Please fill out following information about **YOUR CHILD**:

1. Your child’s sex   ___ male   ___ female

2. Your child’s date of birth _____________

3. Your child’s age in years and months: ___________

4. Does your child have any major health problems?

________________________________________________________________________

5. Your child’s cultural background/ Race-Ethnicity (please check all that apply):
   ___ White
   ___ Black or African American
   ___ Hispanic, Latino, or Spanish
   ___ Asian
   ___ Asian Indian
   ___ Hawaiian Native
   ___ Pacific Islander
   ___ Middle Eastern
   ___ First Nations, Inuit, or Metis
   ___ Other group (Please specify):______________________________