Event-Based Prospective Memory and Executive Functioning:
The Effects of Motivation and Goal Maintenance Support

by

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Abstract

This study examined the effects of motivation and goal maintenance on 3- and 4-year-olds' prospective memory (PM), as well as the relation between executive functioning (EF) and PM. Children sorted picture cards into two boxes (ongoing task) but sorted target cards into a third box (PM task). Motivation was manipulated such that half the children engaged in a highly interesting activity when they successfully sorted target cards while the others did not. Goal maintenance was manipulated such that half the children received more target cards early in the ongoing task while the remaining children received them later. Four-year-olds outperformed 3-year-olds on the PM task and 3-year-olds sorted fewer target cards in the high-motivation condition than the low-motivation condition. Early exposure to target cards did not result in higher PM performance. EF predicted PM performance (controlling for age and language ability) and fully mediated the effect of age on PM performance.

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Event-Based Prospective Memory and Executive Functioning:

The Effects of Motivation and Goal Maintenance Support

The ability to think about the future allows humans to plan their time effectively and become autonomous (Walter & Meier, 2014). A vital aspect of future orientation is prospective memory (PM), namely the ability to remember to perform an intended action in the future (Guajardo & Best, 2000). PM is paramount to success in various facets throughout the lifespan, such as academics (e.g., remembering to return a permission slip), social relations (e.g., remembering your spouse's birthday) and safety (e.g., remembering to turn off the oven; Mahy, 2012).

PM is employed when a predetermined target stimulus (e.g., the end of a TV program or after a certain amount of time has elapsed) cues a self-initiated action (e.g., change the laundry; Einstein & McDaniel, 2005). PM is contrasted with retrospective memory (RM), which is defined as the retrieval of information in response to an external cue, such as the retrieval of a sum from memory in response to an addition question (Wang, Kliegel, Liu, & Yang, 2008). Though PM requires RM (as one must remember the required action), it can nonetheless be distinguished from RM in five ways: (a) PM implicates self-initiated monitoring processes (e.g., monitoring the environment for cues; Einstein & McDaniel, 2005); (b) PM involves time-sensitive actions (Einstein & McDaniel, 1990); (c) PM actions typically require one to interrupt their current activity; (d) PM actions contain a moral and social aspect such that failing to complete them can result in negative consequences; and (e) "PM involves *spontaneously* remembering in response to a cue in the environment (whereas RM often involves *explicitly cued* remembering)" (Mahy, 2012, p. 2).

Einstein and McDaniel (1990) differentiated between two types of PM: event-based PM involves the completion of an action in response to a particular target event (e.g., walking the dog once dinner is done) and time-based PM involves the completion of an action at a particular time or after the lapse of a specific amount of time (e.g., making a phone call at 7:00 pm or in 10 minutes). The present study is designed to examine preschoolers' PM and thus this paper focuses on event-based PM due to the limited time-telling abilities of this target sample (Mahy & Moses, 2011). For the remainder of this document, PM will be used to refer to event-based PM.

In a typical PM paradigm (e.g., Harrison, Mullet, Whiffen, Ousterhout, & Einstein, 2014; Ceci & Bronfenbrenner, 1985; Mahy & Moses, 2011), adult or child participants are given instructions on how to act in response to a particular target cue. This PM task is embedded into an ongoing task which has its own set of rules that are distinct from the PM task. This design requires participants to: disengage from the ongoing task upon seeing the target cue, recall the PM instructions and perform the PM action. In other words, participants are told that when they see a target cue, they should not act in accordance with the ongoing task but instead perform the specific PM action. In order to ensure that this target cue induces *spontaneous* remembering, a short delay (1 to 5 minutes) between the task instructions and the ongoing task is used to allow for some 'forgetting'.

Research on PM and factors that affect its performance has predominantly focused on adult and older adult populations (e.g., Harrison et al., 2014; Marsh, Hancock, & Hicks, 2002; West, Scolari, & Bailey, 2011). While some developmental research exists, it chiefly focuses on school-aged samples (e.g., Ceci & Bronfenbrenner, 1985; Kerns, 2000;

Mackinlay, Kliegel, & Mantyla, 2009). For these two samples, the most commonly adopted PM paradigm is the lexical decision task (e.g., Harrison et al., 2014; Meiser & Schult, 2008; Neely, Keefe, & Ross, 1989). In this computer-based ongoing task, participants are shown a series of letter strings one by one and are instructed to press one key if the letter string is a word and to press another key if the letter string is not a word. For the PM task, participants are given unique instructions for a particular target word (e.g., 'Issue'); they are instructed not to categorize the letter string but instead to press a novel third key. Other PM paradigms utilized for this age group require participants to decipher whether word pairs are semantically related and to press a unique key when the words appear in a particular font format (e.g., green font; West & Craik, 1999). Similarly, another PM paradigm requires participants to read letters aloud and press a unique key when a dot appears on the screen (Duncan, Emslie, Williams, Johnson, & Freer, 1996).

The onset of PM in preschool-aged children has gained considerable attention over the last two decades (e.g., Kliegel, Mackinlay, & Jäger, 2008; Kvavilashvili, Messer, & Ebdon, 2001; Wang, Kliegel, Yang, & Liu, 2006). Researchers are interested in studying PM in this age group because PM memory failures are the most common memory errors among preschool-aged children (Winograd, 1988, as cited in Causey, 2011). PM is also central to young children's development of independence (Kvavilashvili et al., 2001) since remembering to perform certain actions without being reminded enables them to be less reliant on adults.

Studying PM in preschool-aged children is particularly informative because this developmental period is marked by substantial cognitive development, thereby allowing

researchers to examine the cognitive processes (e.g., executive functioning) associated with the emergence and growth of PM (Mahy & Moses, 2011). Doing so also enables researchers to pinpoint the cognitive processes associated with PM memory failure. This research can then be applied to develop and implement tools (e.g., memory aids, such as chore charts) to reduce the occurrences of these failures (Kvavilashvili et al., 2001), as well as help children avoid wasteful (e.g., forgetting to turn off the tap), dangerous (e.g., forgetting to lock the door) and socially distressing situations (e.g., forgetting to return a borrowed toy to a friend). Finally, this research can provide further insight into the adult literature by examining the parallels and distinctions between the cognitive mechanisms involved in PM performance across the lifespan.

Given the limited reading abilities of this youngest age group, the tasks utilized with adult and school-aged samples are not appropriate. Thus, alternate tasks are employed. In one PM paradigm designed for preschool-aged children, participants complete an ongoing task in which they are asked to help a family that is moving homes (Mahy, Moses, & Kliegel, 2014). They are instructed to sort (without naming) picture cards into two piles, one with small items (e.g., a dress) and one with large items (e.g., chest of drawers). To resemble their real world size, larger items take up more surface area on the cards than smaller items. In addition to card sorting, children are also told that the family is looking for their pet animals. For the PM task, they are instructed to ring a bell behind them if they come across a picture card depicting an animal (target card; e.g., a hamster). Accuracy in correctly noticing the animal and ringing the bell is taken as evidence of PM skills. This card-sorting paradigm has been used in other studies as well (e.g., Mahy & Moses, 2011)

In some experimental studies, the ongoing task requires preschoolers to name (as opposed to sort) the picture cards (e.g., Ford, Driscoll, Shum, & Macaulay, 2012; Kliegel & Jager, 2007; Kvavilashvili et al., 2001). For example, in Kvavilashvili et al.'s (2001) design, children are introduced to a stuffed-animal mole that had poor daytime vision. Children are asked to name the pictures on the cards for the mole (ongoing task) as well as to withhold naming and hide pictures of animals (PM task), ostensibly because the mole is afraid of animals. These experimental PM tasks have also been adapted for use on a computer (e.g., images on a screen; Guajardo & Best, 2000; Leigh & Marcovitch, 2014). For example, in Guajardo and Best's (2000) design, preschool-aged children play a computer game in which they are shown a series of pictures one by one. Children are told to memorize the pictures for an impending recall task (ongoing task) and to press the space bar when they see a picture of an animal (PM task). Finally, the PM paradigm has also been modified to accommodate naturalistic study designs (e.g., Guajardo & Best, 2000; Slusarczyk & Niedzwienska, 2013; Somerville, Wellman, & Cultice, 1983). In this design, preschool-aged children are instructed to perform a target action in response to a cue in their natural environment. For example, in Slusarczyk and Niedzwienska's (2013) study, children are instructed to ask the experimenter for a candy when they see her enter their classroom.

Prior research indicates that PM emerges in the early preschool years and continues to develop throughout childhood (e.g., Kerns, 2000) and adolescence (e.g., Wang et al., 2006). It reaches its peak in young adulthood and remains relatively stable (e.g., Kliegel et al., 2008) before gradually declining in old age (e.g., Kliegel & Jager, 2007). However, the specific age at which children show the first signs of PM has not been

clearly established. Experimental studies converge to indicate that PM begins to emerge at 3 years of age (e.g., Guajardo & Best, 2000; Kliegel & Jager, 2007; Wang et al., 2008) while naturalistic studies suggest that there is evidence of PM as early as 2 years of age (Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). Guajardo and Best (2000) speculated that naturalistic studies bolster children's PM performance by employing tasks that mimic familiar, everyday situations, thereby enabling them to utilize existing memory scripts to reduce the cognitive demand. This hypothesis is supported by Kliegel and Jager's (2007) experimental study in which the majority of 2-year-olds were unable to recall the PM instructions, suggesting the RM demands were too overwhelming.

The vast majority of the literature indicates that PM steadily improves throughout the preschool years (e.g., Guajardo & Best, 2000; Kliegel & Jager, 2008; Kvavilashvili et al., 2001; Wang et al., 2008). An extensive literature search exposed Somerville et al.'s (1983) naturalistic study as the only one that did not report significant improvements in PM across the preschool years. However, the validity of Somerville et al.'s finding is questionable given the small sample size ($N = 30$) and lack of experimental control associated with naturalistic studies.

Recent research on the development of PM abilities in preschoolers has also examined the role of executive functioning (EF) skills in PM development (i.e., cognitive skills involved in the conscious regulation of thought and action [e.g., Zelazo, Carlson, & Kesek, 2008]; e.g., Ford et al., 2012; Mahy, 2012; Mahy & Moses, 2011). In the context of the PM paradigm, EF is thought to contribute to children's ability to hold all the relevant information in mind as well as to switch their attention from the ongoing task to the PM task. These skills develop quickly during the preschool years (e.g., Carlson 2005;

Frye, Zelazo, & Palfai, 1995) and have therefore been viewed as potential mechanisms of PM performance.

There are two models that implicate EF skills in the development of PM: the preparatory attentional and memory processes (PAM) model and the multiprocess model. While the present study does not investigate either of these models, they are presented here to provide a more complete framework of the relation between EF and PM. The PAM model argues that controlled processes that are activated throughout the ongoing task enable children to actively monitor their environment for target cards and that these processes are therefore necessary for successful PM performance (Smith, 2003; Smith & Bayen, 2004). Contrarily, the multiprocess model argues that controlled processes are only required under certain circumstances, such as when PM paradigm is more engaging or demanding (Guynn, McDaniel, & Einstein, 2001; McDaniel, Robinson-Riegler, & Einstein, 1998). Consistent with either model, prior research suggests that EF skills do contribute to the development of PM but methodological limitations reduce the power of these findings (e.g. only using one measure of a particular EF skill). Thus, the first aim of this thesis was to further examine the effects of two EF skills (working memory and inhibitory control) on preschool-aged children's PM performance.

Prior researchers have also adapted the PM paradigm to incorporate numerous manipulations. For example, prior studies have demonstrated that increasing the salience of the target card (Mahy et al., 2014) or decreasing the difficulty of the ongoing task (Mahy et al., 2014; Wang et al., 2008) can bolster young children's PM performance. One manipulation that is of particular interest in this thesis is the motivation of the PM task. Researchers are interested in the effect of motivation on PM performance because

of its applicability to real-world situations; young children's PM can be improved by giving them additional incentives to perform the future actions or by assigning them tasks that are interesting or exciting to them. While the majority of prior studies have demonstrated that young children exhibit greater PM performance when the PM task is highly motivating (e.g., picking out a chocolate bar as opposed to broccoli at the store in the near future; Causey & Bjorklund, 2014; Kliegel, Brandenberger, & Aberle, 2010; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983), there are several methodological limitations that warrant further research (e.g., not including memory control questions to verify children's recollection of the PM task instructions). Moreover, prior researchers have manipulated task motivation in two different ways, one of which has only been employed in one study and therefore needs further investigation. Therefore, the second aim of this study was to further examine the effect of this task manipulation on preschool-aged children's PM performance.

Another manipulation that has yet to be thoroughly examined is goal maintenance, namely children's ability to maintain a goal in mind over time (Marcovitch, Boseovski, & Knapp, 2007). Taken in the context of the PM paradigm, this construct likely contributes to children's ability to maintain the PM instructions in mind throughout the ongoing task. Examining this manipulation is important because it can be applied to improve PM performance in real-life settings by designing situations that help children maintain the PM goal over an extended period of time. It is possible that the ease with which children can maintain a PM goal can be manipulated by altering the proportion of target cues to non-target cues or by altering the position of the target cues within the ongoing task. Both of these variables vary substantially in the literature and their effect on PM

performance has yet to be examined. Thus, the third aim of this thesis was to evaluate how the proportion and placement of target cues within the ongoing task effect young children's PM performance.

The fourth aim of this study was to examine whether there are additive effects of motivation and goal maintenance on children's PM performance (no prior study has examined these two manipulations together). The final aim of the present study was to examine whether EF skills differentially contribute to children's PM performance in these conditions. Currently, only one study has examined the relation between preschoolers' EF skills and PM performance in highly motivating tasks (Causey & Bjorklund, 2014). Similarly, only one study has examined the relation between preschoolers' EF skills and PM performance when goal maintenance is manipulated.

In the remainder of this introduction, I will first explain the role of EF skills on the development of PM, discuss the limitations in this research area and explain how the present study aimed to address these limitations. Second, I will briefly outline the factors that have been found to effect PM performance. Third, I will summarize and critically analyze the literature on the two aforementioned manipulations (motivation and goal maintenance) and explain how the present study aimed to fill the gaps in the current literature. Finally, I will outline the goals and hypotheses of the present study.

Following the introduction, I will describe the methodology of the present study, present the results and discuss the implications and applications of the findings.

Executive Functioning and Prospective Memory

Executive functioning (EF) abilities have been posited as mechanisms of the development of PM performance (e.g., Causey & Bjorklund, 2014; Ford et al., 2012;

Mahy & Moses, 2011). EF is a set of domain-general cognitive skills involved in the conscious regulation of thought and action (e.g., Zelazo et al., 2008). EF skills develop quickly during the preschool years; while 3-year-olds demonstrate substantial difficulty on many EF tasks, 5-year-olds perform at ceiling on some measures (e.g., Carlson 2005; Frye et al., 1995). This growth is directly correlated to the development of the prefrontal cortex (e.g., Bunge & Zelazo, 2006).

There is no clear consensus as to which particular skills encompass EF. However, there is a fair bit of agreement among researchers that working memory, inhibitory control and cognitive flexibility should be included in this umbrella term (e.g., Carlson Moses, & Breton, 2002; Diamond, 2006). Working memory involves the temporary storage and manipulation of information (Baddeley, 1986). Inhibitory control involves inhibiting a prepotent (i.e., automatic) response to perform one that is more fitting to the situation (Frye et al., 1995). Cognitive flexibility involves shifting one's attention from one task to another or thinking about two things simultaneously (e.g., Jacques & Zelazo, 2001).

EF is expected to be related to PM performance because the PM paradigm is a dual task procedure: it requires children to divide their attentional resources between performing the ongoing task and detecting the target cues (Mahy et al., 2014). Prior studies have found that 3- to 8-year-old children have considerable difficulty in designating their EF resources between two simultaneous tasks (Halford, Maybery, & Bain, 1986), suggesting that EF abilities may play an important role in the development of PM.

A closer examination of the PM paradigm clearly reveals the importance of EF skills

to PM performance (Mahy et al., 2014). Working memory is needed to hold the task instruction in mind as well as to encode, manipulate and recall one's intentions throughout the ongoing task. Inhibitory control is required to inhibit the prepotent response of acting in accordance with the ongoing task in order to perform the specified PM action. Finally, cognitive flexibility is required to switch one's attention from the ongoing task to the PM task. Only the former two skills are addressed in the PM literature. Thus, they will be the focus for the remainder of this section.

In the forthcoming paragraphs, I will further define inhibitory control (IC) and working memory (WM), discuss how researchers manipulate these skills in PM paradigms and then present research that implicates the contribution of these skills to the development of PM abilities. Finally, I will discuss the limitations in this research area and explain how the present study aimed to address these gaps.

As mentioned, IC involves inhibiting a prepotent response to perform one that is more fitting to the situation (Frye et al., 1995). IC can be further defined as delay-IC or conflict-IC. Delay-IC is required when the desired response is to withhold performing a particular action until a later time and conflict-IC is required when the appropriate response is to perform a different action that is in direct conflict with the prepotent response. Only the latter form of IC is relevant to children's performance on the PM paradigm: when presented with a target cue, children must withhold acting in accordance with the ongoing task instructions and instead perform the unique PM action. Thus, this thesis solely focuses on the role of conflict-IC in the development of PM performance and the term IC will now refer only to conflict-IC.

An example of a task designed to measure conflict-IC in preschool-aged children is

Simon Says (Carlson, 2005). In this task, children are instructed to perform some ‘silly’ actions (e.g., “touch your nose”) but only when the command is preceded with “Simon says...”. Otherwise, children are told to ignore the command and remain as still as possible. Prior research has demonstrated substantial improvement on this task throughout the preschool years such that 5.5-year-olds perform much better on this task than 3-year-olds (Strommen, 1973).

As stated, WM involves the temporary storage and manipulation of information (Baddeley, 1986). According to Baddeley’s (1986) model, WM is comprised of the central executive system and two secondary slave systems, namely the phonological loop and the visuo-spatial sketchpad. The central executive system regulates cognitive thought by controlling the flow of information to and from the secondary slave systems. The phonological loop interprets and stores language input and allows such information to be transferred to storage. Similarly, the visuo-spatial sketchpad interprets and stores visual-spatial information and allows this input to be transferred to storage. These systems are categorized as two unique forms of WM, namely phonological WM and visuo-spatial WM.

Phonological WM is implicated in PM tasks since it is required to interpret and store the task instructions, as well as transfer this information into storage for later use. However, the PM paradigm places very little demand on visual-spatial abilities. As a result, this thesis investigated the role of phonological and not visual-spatial, WM in the development of PM performance. Thus, the term WM will now refer only to phonological WM.

A common task used to measure phonological WM in preschool-aged children is the

Auditory Backward Digit Span (Carlson et al., 2002). In this task, children hear a series of numbers and are instructed to repeat them in backwards order. For example, if the child hears '7, 3' they have to say '3, 7'. The task begins with a set of two trials each with two digits and the number of digits in each trial increases by one after each set. Children progress to the next set if they pass at least one trial of a given set and the task ends when children fail both trials in a given set. Young children demonstrate significant improvement on this task between the ages of 4 and 6 years (e.g., Marcovitch, Boseovski, Knapp, & Kane, 2010).

The roles of WM and IC in PM performance can be manipulated by implementing various task modifications. For example, by manipulating the motivation behind the PM task to heighten children's interest in the task, children may require fewer WM resources throughout the ongoing task. Specifically, this manipulation may lead children to encode the PM task instructions more strongly, thereby making this memory more readily available when the target cue arises and utilizing fewer WM resources. Increasing the salience of the target cues to help draw children's attention to them may lessen the IC demands. Specifically, this manipulation may help children dissociate from the ongoing task and shift their attention to the PM task.

A literature search revealed only four studies that utilized WM and IC measures to examine their contributions to the development of PM performance in preschool-aged children. In the forthcoming paragraphs, these studies will be summarized and critically analyzed and the ways in which the present study aimed to address the limitations in the current literature will be presented.

Mahy and Moses (2011) examined the roles of WM and IC in the PM performance of

4-, 5- and 6-year-olds ($N = 96$). The researchers manipulated the number of distinct target cues (animals or animals and cars) and the length of time between the task instructions and the onset of the ongoing task (1 or 5 minutes). The manipulations were compared across participants. The researchers designed an ongoing card task that required children to name the images depicted on a series of cards. Depending on whether the child was in the condition with one or two distinct target cues, children were either instructed to hide cards depicting an image of an animal or hide cards depicting an image of an animal or a car (PM task). Children were instructed to hide these target cards in a box behind them. Two different boxes (in different locations) were used for children in the condition with two distinct target cards. PM was measured by totaling the number of times children remembered to hide the target cards.

WM was measured using the Digit Backwards Subscale of the Wechsler Intelligence Scale for Children (Wechsler, 1991), a task that very closely resembles the Auditory Backward Digit Span (Carlson et al., 2002; described on page 13). IC was measured using the Day / Night Stroop task (Gerstadt, Hong, & Diamond, 1994), a task that requires children to say “Day” in response to a picture of a moon and stars in a dark sky and “Night” in response to a picture of a sun. The researchers found that performance on the WM task was significantly correlated with PM performance, even after controlling for age, thereby indicating that greater WM abilities are associated with higher PM performance. However, IC was not correlated with PM performance.

Mahy and Moses’s (2011) findings may have been confounded by the child’s language ability. Prior research has demonstrated that children’s language abilities are positively correlated with their PM performance (Ford et al., 2012; Mahy et al., 2014),

demonstrating that this confound should be controlled in analyses. Moreover, their findings may be compromised by their IC measure; recent research has demonstrated that the Day / Night Stroop is not a reliable measure of IC since the instructed responses are not necessarily in direct conflict with children's prepotent responses (see Vendetti, Kamawar, Podjarny, & Astle, 2015). For example, some children's prepotent response to a picture of a moon and stars in a dark sky may be "dark", "moon" or "bedtime" as opposed to "night" which is the response treated as if it were the prepotent response. Thus, Vendetti et al. (2015) argued that the Black / White Stroop, a version in which children say "black" to a white card and "white" to a black card, is a more reliable measure of IC and demonstrated that it is more strongly related to other measures of IC in young children. While other relevant studies (described below) have also used the Day / Night Stroop, this limitation may be particularly evident in Mahy and Moses's (2011) study since this was the sole measure of IC.

Finally, Mahy and Moses's (2011) findings may be compromised if children struggled to recognize the target cards *as* the target cards; while they were instructed to hide cards depicting an 'animal', for example, the ongoing task required children to name the images more specifically, such as 'dog' or 'tree'. Thus, when naming the target cues, the level of classification was higher than that of the task instructions. This methodological limitation may have negatively impacted children's PM performance and masked a possible relation with EF abilities. The present study equated this level of classification such that the target cues were labeled at the same level of specificity as was stated in the task instructions. This modification also aligns the methodology with that of the literature on PM performance among adult samples, in which the ongoing task requires

participants to sort strings of letters into ‘word’ and ‘non-word’ and the PM task requires participants to look for one particular word (e.g., Harrison et al., 2014; Miser & Schult, 2008; Neely et al., 1989). In this paradigm, the instructions specify the exact target word, thus the level of classification between the instructions and the target cue is matched.

Ford et al. (2012) also examined the effects of WM and IC on 4-, 5- and 6-year-olds’ PM performance ($N = 59$). They manipulated the position of the target cards within the ongoing task by placing them either in the middle or at the end of the card stack. This manipulation was examined within subjects such that children completed two trials in which the target card was placed in the middle of the stack and two trials in which the target card was placed at the end of the stack. The ongoing task required children to name images depicted on a series of cards and the PM task required children to withhold naming target cards and place them on a stool behind them. PM performance was measured by totaling the number of times children remembered to withhold naming the target cards as well as by totaling the number of times children remembered to hide these target cards.

WM was assessed with the Auditory Backward Word Span (Carlson et al., 2002), a task that is identical to the Auditory Backward Digit Span (Carlson et al., 2002, described on page 13) except that children listen to a series of monosyllabic words instead of numbers. IC was assessed with a battery of tasks including the Day / Night Stroop (Gerstadt et al., 1994; described on page 14), Luria’s Hand Game (Luria, Pribram, & Homskaya, 1964), the Tapping Game (Luria et al., 1964) and the Pig/Wolf Test (Ford et al., 2012). In Luria’s Hand Game, children were instructed to form a fist when the experimenter pointed their finger and point their finger when the experimenter formed a

fist. In the Tapping Game, children were asked to tap once on a drum when the experimenter tapped twice and tap twice when the experimenter tapped once. The Pig/Wolf Test is an adaptation of Simon Says (Carlson, 2005; described on page 12) in which children are told to perform actions when commanded by a pig finger puppet but ignore commands from a wolf finger puppet. An aggregate IC score was created by transforming children's scores on each task into a z-score and averaging them.

Ford et al. (2012) conducted a series of regression analyses and controlled for both age and language ability (as measured by the Receptive Vocabulary Subscale of the Wechsler Preschool and Primary Scale of Intelligence; Wechsler, 2012). IC was found to significantly predict children's success at withholding naming the target card, suggesting that IC scores contribute to children's performance on this PM action. WM was also found to predict children's abilities to withhold naming, suggesting WM scores contribute to their ability to inhibiting this response. These effects were found regardless of the position of the target card and suggest that children with higher IC and WM abilities are more successful at completing these two PM actions. However, the effect of WM was only found when IC was excluded from the regression model, suggesting that WM and IC share variance. Neither IC nor WM predicted children's performance with respect to placing the target cards on the stool behind them, suggesting that these skills do not contribute to children's ability to perform this PM action. This may be explained by the fact that children were more successful at hiding the target cards than refraining to name them, suggesting that the former task was easier for children and required fewer EF resources.

In a subsequent study, Mahy et al. (2014) examined the role of IC and WM in 4- and

5-year-olds' PM performance ($N = 119$). In the ongoing task, children were asked to label the images on a set of cards as either small or large and then sort the cards into these categories by placing them into one of two boxes. The boxes were clearly labelled with example cards. The researchers manipulated the difficulty of this task (between subjects) by having children either sort the cards into the corresponding box or into the opposing box. Specifically, children in the easy condition were instructed to place small items into the box designated for small items and large items into the box designated for large item. Children in the hard condition were instructed to place small items into the box designated for large items and large items into the box designated for small items. In addition, children were given unique instructions for cards depicting an animal (PM task); children were told to name the image depicted on the card and then to ring a bell on the table behind them (instead of sorting the card into one of the boxes).

The salience of the target cards was also manipulated within subjects such that the target cards were outlined with a bright red boarder for half of the children. This was expected to draw their attention to these cards as being distinct from the rest in the stack, thereby increasing children's chances of noticing the target card. PM performance was measured by totalling the number of times children remembered to ring the bell in response to target cues. WM was measured with the Digit Backwards Subscale of the Wechsler Intelligence Scale for Children (Wechsler, 1991; described on page 14) and IC was measured with the Simon Says task (Carlson, 2005; described on page 11).

Regression analyses revealed that, after controlling for age and language ability (as measured by the PPVT-III; Dunn & Dunn, 1997), only IC abilities predicted children's PM performance. Specifically, IC only predicted children's performance when cues were

not highly salient, suggesting that children's IC abilities only contributed to their ability to ring the bell when the cues were less salient. Mediation analyses revealed that IC mediated the relation between age and PM performance, demonstrating that age alone does not predict PM performance. However, like Mahy and Moses (2011), Mahy et al. (2014) may have underestimated PM if children struggled to recognize the target cards as such (see a discussion of this point above). This issue has been addressed in the current study by equating the level of classification used in the target cards and the task instructions.

In the final relevant study, Causey and Bjorklund (2014) developed a PM paradigm to manipulate agency and motivation and examine the contribution of EF (using a composite measure) to 3- to 4.5-year-olds' PM performance ($N = 31$). Both manipulations were examined within subjects. To alter agency, children were either asked to perform the PM action themselves or remind the experimenter to perform it. In the high-motivation condition, children were instructed to take (or ask the experimenter to give them) a sticker at the end of the testing session. In the low-motivation condition, children were instructed to flip (or ask the experimenter to flip) a sign on the door at the end of the testing session. PM performance was measured by totaling the total number of PM actions children performed.

To measure WM, the researchers used the Digit Backwards Subscale of the Wechsler Adult Intelligence Scale (Wechsler, 1981), the Forward Trail-Making task (Salthouse et al., 2000), the Backward Trail-Making Task (Salthouse et al., 2000) and a 1-Back task (Mäntylä, Carelli, & Forman, 2007). The Digits Backwards Subscale is very similar to the Auditory Backwards Digit Span (Carlson et al., 2002; described on page 13). In the

Forward Trail-Making task, children watched as the experimenter pointed to a series of picture cards one by one and then were instructed to point to the same cards in the same order. The task begins with a set of two trials each with two cards and the number of cards in each set increases by one. Children progress to the next set if they pass at least one trial in a given set and the task ends when the child does not pass either trial in a given set. The Backward Trail-Making Task is identical to the Forward Trail-Making task except that children are told to point to the same cards in backwards order. In the 1-back task, children were shown a 38-page book with one of eight shapes on each page. Children are instructed to name each shape and inform the experimenter when a shape is shown on two consecutive pages.

To measure IC, the researchers used the Day / Night Stroop Task (Gerstadt et al., 1994; described on page 14), a modified Simon Says task (Strommen, 1973) and the Dimensional Change Card Sort task (Zelazo, 2006). The modified Simon Says task very closely resembles the Pig/Wolf Test used by Ford et al. (2012), in which two finger puppets are used (See page 17). In the Dimensional Change Card Sort task, children are shown cards that vary along two dimensions, colour and shape (e.g., red rabbits and blue boats), and are instructed to sort them into two boxes. Example cards, which are red boats and blue rabbits, are each affixed to a box. The test cards are presented one by one with each test card matching the example cards on a different dimension (i.e., colour or shape). First, children are instructed to sort the cards into the boxes based on one of the dimensions (e.g., colour). After six trials, a switch in sorting rules is announced and children are instructed to sort six more target cards by the second, previously irrelevant dimension (e.g., shape). On every trial, before placing the target card into a box, the card

is labeled on the relevant dimension and the sorting rules are repeated.

Causey and Bjorklund (2014) created a single composite EF score by averaging children's z-scores across all of the EF measures. The researchers collapsed across the agency variable since it was not found to effect PM performance. Analyses revealed that children's performance on both the low- and high-motivation tasks were predicted by their composite EF score. This suggests that, regardless of the motivation manipulation, children's EF skills contributed to their ability to perform the PM actions such that children with better EF (composite score) performed the PM actions more frequently than those with lower EF. However, the power of these findings may be compromised by the fact that the researchers did not control for age or language ability in their regression analyses. It is important to control for these variables since they account for a substantial proportion of individual differences in PM performance (Ford et al., 2012; Mahy et al., 2014).

Overall, the abovementioned studies demonstrate that WM and IC are somewhat implicated in the development of PM during the preschool years and that the roles of WM and IC in children's PM performance vary depending on the demands of the tasks. However, the power of these findings are reduced by the studies' methodological limitations. Specifically, Mahy and Moses (2011), Ford et al. (2012) and Mahy et al.'s (2014) findings are limited by the researchers' use of only one measure of WM and/or IC. There is substantial overlap between these two skills making it difficult to develop measures that assess only one particular skill (Brocki & Bohlin, 2014). As a result, a more accurate depiction of that skill can be obtained by employing a battery of tasks and performing a principal component analysis. This method is preferred since it removes

much of the variance that is accounted for by other extraneous skills, thereby resulting in a more valid measure of that skill which can then be used in the analyses.

Although Causey and Bjorklund (2014) utilized multiple measures of both WM and IC, their findings are also limited by methodological problems. The researchers created a composite EF score by averaging children's z-scores across seven EF measures despite not finding all seven variables to be inter-correlated. This is not statistically appropriate since measures that are combined to create a composite score should be statistically related. Moreover, this approach does not provide any indication as to which particular EF skill (WM, IC or both) effects PM performance. Again, conducting two separate principal component analyses would be a more appropriate way to examine the unique effect of these two skills on PM performance since it would not only remove much of the variance that is accounted for by other extraneous skills but would also differentiate which particular EF skill(s) effects PM performance. The present study aimed to expand on the present literature by adopting three measures of each WM and IC and performing two principal component analyses (one for each skill).

Prospective Memory Task Manipulations

The PM paradigm has been adapted to incorporate a broad array of task manipulations. In this section, the manipulations that have been examined in the literature will be briefly outlined. Mahy et al. (2014) examined whether the salience of the target cue impacts 4- and 5-year-olds' PM performance. The researchers were interested in this particular manipulation because it can be applied to real-world PM scenarios to enhance the salience of the target cues in children's environment and thereby bolster their PM performance. Mahy et al. (2014) demonstrated that the salience of the

target cue does effect PM performance; participants remembered to perform the PM action more frequently when the target cue (a picture card) was outlined with a bright red border as opposed to no border.

Kliegel and Jager (2007) examined whether the presence of an external memory aid effected the PM performance of 2- to 6-year-olds. This research is valuable because it can indicate whether children's PM performance can be enhanced by the presence of related perceptual cues and can be applied to scaffold the PM of children in real-world situations. In this study, participants were instructed to name the pictures on a series of cards (ongoing task) and place a target card (an apple) into a box placed either in front of them (memory aid condition) or behind them (no memory aid condition). An actual apple was also placed in front of the child in the memory aid condition. The memory aids proved helpful in improving children's PM performance such that children with the aids remembered to perform the PM action more frequently than those without the aids.

The length of time elapsed between the presentation of PM task instructions and the beginning of the ongoing task has also been examined (Mahy & Moses, 2011; Somerville et al., 1983). Researchers are interested in this manipulation because it is indicative of how long children can successfully maintain a memory about a future action and can be applied improve children's PM in real-world situations by adjusting the time lapse to match their developmental ability. Somerville et al. (1983) subjected 2- to 4-year-olds to either a short delay (1 to 5 minutes) or a long delay (several hours or over night) and found that children remembered to perform the PM actions more frequently in the short delay condition. In a subsequent study, Mahy and Moses (2011) disassembled the former short delay condition and subjected 4- to 6-year-olds to either a 1-minute or 5-minute

delay. The researchers found that 5-year-olds remembered to perform the PM actions more frequently in the long delay condition (4- and 6-year-olds performed comparably in both conditions) and speculated that it enabled them to reflect on the task instructions and develop strategies to remember to perform the PM action.

The positions of the target cues within the ongoing task and the motivation behind the PM task have also been manipulated. The applications and findings pertaining to these two manipulations will be discussed in the next two sections of this literature review. Other task manipulations that have been examined but were not found to significantly affect children's PM performance include: the number of distinct target cues (Mahy & Moses, 2011), the difficulty of the ongoing task (i.e., altering the RM load; Mahy et al., 2014; Kvavilashvili et al., 2001) and agency (i.e., whether children perform the PM action themselves or remind someone else to do it; Causey & Bjorklund, 2014).

Motivation and Prospective Memory

One task manipulation that is of particular interest in this thesis is the effect of motivation on preschoolers' PM performance. As mentioned, researchers are interested in this manipulation because of its applicability to the real world; young children's PM may be improved by giving them additional incentives to perform the future actions or by only assigning them tasks that are interesting or exciting to them. To the best of my knowledge, there are five published studies that examine this relation. The majority of these studies demonstrated that young children exhibit greater PM performance when the PM task is highly motivating (e.g., picking out a chocolate bar as opposed to broccoli at the store in the near future; Causey & Bjorklund, 2014; Kliegel et al., 2010; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). However, one study found equal

performance regardless of task motivation (Guajardo & Best, 2000). Causey and Bjorklund (2014) argue that this may be attributable to the differential way in which the former and latter researchers manipulated the motivation of their PM task.

Across the five studies, there are also several methodological limitations that need further investigation (e.g., not including a memory control questions to verify children's recollection of the PM task instructions) and only one study examined the effect of EF abilities on preschoolers' PM performance. This section summarizes and critically analyzes these five studies as well as discusses how the methodological limitations and gaps in the literature are addressed in the present study.

Somerville et al. (1983) employed a naturalistic design to examine the PM abilities of 2-, 3- and 4-year-olds ($N = 30$). The experimenters designed situations that were familiar to the children. Specifically, caregivers were instructed to ask the child to remind them to do something in the near future. The experimenters manipulated two factors within subjects: the motivation of the PM action and the length of the delay between the task instructions and the PM action. Children completed two of each factor combination, resulting in a total of eight tasks. In the low-motivation condition, children were asked to remind their caregiver of something that was of low interest to them, such as bringing in the laundry, taking out the trash or giving them medicine. In the high-motivation condition, children were asked to remind their caregiver to do something that was of high interest to them, such as buying them candy at the store, taking them to the zoo or baking with them. In the short delay condition, the target cue was presented 1- to 5-minutes after the task instructions. In the long delay condition, the target cue was presented several hours later or the next day. The target cues were event-based; for example, children were

instructed to remind their caregiver “when daddy gets home” or “when we go to the store tomorrow” (p. 89).

Somerville and colleagues (1983) found a main effect of motivation on PM performance such that high-motivation tasks were successfully completed 63% of the time while low-motivation tasks were only completed 20% of the time. I speculate that motivation likely bolsters children’s PM performance by increasing their interest in the task and thereby strengthening their encoding of the PM instructions. This makes the PM instructions more readily available when children are presented with a target cue and likely frees up more cognitive resources to enable children to overcome any subsequent tasks that tax WM or IC.

A main effect of time delay was also found such that children remembered to perform the short-delay PM tasks 48% of the time but only remembered to perform the long-delay tasks 35% of the time. No age effects or interactions were found.

Somerville and colleagues (1983) demonstrated that motivation can improve children’s PM. However, these results should be interpreted with caution due to the study’s methodological limitations. First, the lack of experimental control associated with naturalistic designs and the small sample size may have compromised the validity of the findings. As a result, the present study employed an experimental design with a larger sample. Second, while Somerville et al. (1983) did ask memory control questions (at the end of the PM paradigm) to verify children’s recollection of the PM task instructions, they did not exclude children who failed to answer these questions adequately. The present study asked memory control questions at the end of the PM paradigm and screened out children who demonstrated poor recollection from the

analyses.

Finally, it is also possible that the high-motivation tasks used in Somerville et al.'s (1938) study were more familiar to the children than the low-motivation tasks. While young children are often exposed to tasks that are not interesting to them (e.g., brushing their teeth or washing their hands), some of the low-motivation tasks used in this study are not commonly encountered by this age group. For example, preschool-aged children are rarely asked to remind their caregivers to bring in the laundry or to take their own medicine. As a result, children may have had more detailed scripts pertaining to the more familiar and highly motivating tasks, thereby reducing the RM load and the EF load in that they may not require as much IC. Further, some of the highly motivating actions may not have even been due the PM task, as many children are likely to ask for candy at the store even if they have not been told to do so in advance. The present study addressed this confound by utilizing tasks that are novel to the children in both the low- and high-motivation conditions.

In a subsequent experimental study, Guajardo and Best (2000) employed a larger sample of 3- and 5-year-olds ($N = 80$). In their ongoing task, children played a computer game in which they were shown a series of pictures (e.g., dog, turtle, tree) one by one and were informed that they had to recall the named images at the end of the task. Children were also instructed to press the spacebar when they saw a specified target picture. The task was split into two sessions and a total of six target pictures (duck or house, depending on the session) were included in each set of 60 trials.

The researchers manipulated two factors: motivation and the presence of an external memory cue. The presence of an external memory cue was measured within subjects

across two sessions. In one of the two sessions, children were given a small picture of the target cue and were instructed to place it somewhere that would facilitate their memory to press the spacebar. Children were guided as to where to place the picture, if necessary. No external cue was provided in the second session. Motivation was manipulated between subjects such that half of the children immediately received a small reward every time they pressed the spacebar while the others did not. Children in the high-motivation condition chose one of four possible rewards (i.e., goldfish cracker, goldfish pretzel, pennies or fruit chews) at the outset of the study and were therefore aware that they could receive it.

Guajardo and Best (2000) only found a main effect of age such that 5-year-olds remembered to press the space bar more frequently than 3-year-olds (89% and 59% of the time, respectively). There were no effects of motivation or external memory cue, nor any interactions. To examine whether the lack of any effects resulted from 5-year-olds performing at ceiling, the researchers repeated their analysis with only 3-year-olds and again found no significant effects. These results suggest that neither motivation nor the external memory aid were beneficial to children's PM. The fact that motivation did not facilitate PM is surprising given that the reward should have been highly motivating to the child since they chose it at the outset of the testing session.

While it is highly plausible that motivation did not improve 5-year-olds' PM performance because they performed at ceiling even in the low-motivation condition (90%), it is unclear why motivation did not improve 3-year-olds' PM performance. In the forthcoming paragraphs, four hypotheses will be proposed to explain this latter finding.

First, the researchers speculated that the absence of this effect might be a result of the ongoing task being too difficult for this younger age group compared to their older counterparts. Three-year-olds performed significantly worse on the ongoing task than 5-year-olds; overall, 5-year-olds recalled 64% of the pictures while 3-year-olds only recalled 40%. This may suggest that 3-year-olds had to allocate a greater proportion of their EF resources to the ongoing task than 5-year-olds, thereby leaving them with fewer resources for the PM task. This, in turn, may explain why 3-year-olds performed only slightly above chance (57%) even on the highly motivating PM task while 5-year-olds performed at ceiling (90%) on the less motivating PM task. The researchers were unable to examine this EF claim since they did not employ measures to assess this skill set.

This task may also have been more difficult for 3-year-olds than other ongoing tasks employed in the literature. Ongoing tasks with similar procedures and stimuli typically ask children to name (and sometimes sort) the images but not recall them. The ongoing task employed by Guajardo & Best (2000) may therefore have been especially difficult for 3-year-olds since it also employs short-term memory, a cognitive skill that is much less developed among 3-year-olds than 5-year-olds. While the present study cannot guarantee that the ongoing task was equated in difficulty across age groups, children's performance on the ongoing task was measured and considered when interpreting children's PM performance.

Second, motivation may not have improved 3-year-olds' PM performance because of their underdeveloped IC abilities; in order to succeed on this task, children had to disengage from the ongoing task in order to perform the PM action. It is possible that even if the children found the PM task motivating, they lacked the necessary IC skills to

perform it. Again, the researchers were unable to examine this claim since they did not employ measures to assess this skill.

Third, another reason why motivation may have not improved 3-year-olds' performance relates to the timing of the reward; perhaps receiving it immediately after the successful completion of the PM task and leaving it in the child's field of vision distracted them on the proceeding trials. This may have impeded the reward's ability to improve children's PM performance beyond their score in the low-motivation condition. While the present study also rewarded children immediately after the successful completion of the PM action, the reward token was used immediately and thus was not left in plain sight. This should reduce the extent to which children are distracted by prior rewards on subsequent trials.

Finally, motivation may not have improved 3-year-olds' performance if they were unable to adequately remember the PM instructions. Like Somerville et al. (1983), Guajardo and Best (2000) asked memory control questions (at the end of the PM paradigm) to verify children's recollection of the PM task instructions but did not exclude children who failed to answer these questions from the analyses. Follow-up analyses revealed that 3-year-olds were less likely to accurately recall the PM task instructions than 5-year-olds. With an inadequate recollection of how to attain the reward, perhaps this youngest group could not apply their heightened motivation to improve their performance. As mentioned, the present study employed a memory check question at the end of the PM paradigm and screened out children who failed to demonstrate a thorough recollection of the PM task instructions.

The present study also aimed to make one additional adjustment to Guajardo and

Best's (2000) methodology with respect to the selection of the target cues. The researchers' description of their methodology implies that the six target cues (duck or house) in each session utilized the same picture. The present study employed multiple target cues that depict the same object but through different images (i.e., multiple unique pictures of a banana[s]), to preclude the comment that once children see the cue and perform the PM action they begin to act on the basis of pattern recognition as opposed to reactivating the rule.

A subsequent experimental study conducted by Kliegel et al. (2010) corrected three of these limitations in their examination of the PM abilities of 3- and 5-year-olds ($N = 40$). Specifically, the researchers verified children's RM of the PM task instructions, only presented children with their reward at the end of the ongoing task and equated the difficulty of the ongoing task across the age groups. The latter modification was accomplished by adopting the Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kamphaus, 1984), a measure that contains age-appropriate measures of cognitive development. Children performed three separate ongoing tasks from the K-ABC and two PM tasks. Kliegel et al. (2010) only manipulated the motivation of the PM task. This manipulation was performed within subjects. In the high-motivation condition, children were instructed to remind the experimenter to give them a gift after the completion of the next task. In the low-motivation condition, children were instructed to remind the experimenter to write their name on the front of the testing booklet for the next task.

The analyses did not reveal a main effect of motivation. However, a significant age by motivation interaction was found; while 5-year-olds performed comparably in both

conditions (30% on high-motivation vs. 35% on low-motivation), 3-year-olds performed significantly better on the high-motivation tasks than the low-motivation tasks.

Specifically, 25% of 3-year-olds remembered to perform the PM action in the high-motivation condition while only 5% of 3-year-olds remembered to perform the PM action in the low-motivation condition. In comparison to the other studies discussed in this section, 5-year-olds performed uncharacteristically poor on this PM task but the reasons for this are unclear.

The researchers interpret this finding as resulting from children's underdeveloped IC abilities. Specifically, they suggest that limited IC resources impeded 3-year-olds' performance on the low-motivation task. It is possible that the high-motivation tasks led children to encode the task instructions more strongly and thereby freed up enough cognitive resources to allow them to overcome any IC limitations that hindered their performance in the low-motivation condition. However, the researchers did not employ measures of IC and therefore could not examine this claim. I speculate that a similar argument may stand with respect to WM abilities. Specifically, if limited WM abilities impeded 3-year-olds' performance on the low-motivation task, it is possible that the high-motivation task freed up enough cognitive resources to allow children to overcome this limitation.

More recently, Slusarczyk and Niedzwienska (2013) conducted a naturalistic study with a sample of 2- to 6-year-olds ($N = 143$). The researchers manipulated two factors: motivation and task interruption. The latter manipulation aimed to examine how PM performance is affected by the need to interrupt the ongoing task to perform the PM action. The researchers speculated that eliminating this interruption would reduce the IC

demands of the PM task and may improve young children's performance.

Motivation and task interruption were manipulated within subjects, creating four PM tasks. These tasks were split into two counterbalanced sessions. In the one session, children were instructed to place their pencil crayons on the windowsill (PM action) after they finished colouring (ongoing task; no-interruption, low-motivation condition). Children then coloured for 10 minutes before being told, "We are now finished with drawing" (p. 182-183). Children were given one minute to complete the PM action after which prompting began. Next, children were taken back to their classroom and instructed to tell the experimenter who would be picking them up later that day when they saw her next (PM action; interruption, low-motivation condition). Children then played with a puzzle of their choice for 10 minutes (ongoing task) before the experimenter re-entered the room and stood close by. Again, children were given one minute to complete the PM action after which prompting began.

In the other session, children were instructed to take a sticker from the shelf (PM action) when they finished playing with blocks (ongoing task; no-interruption, high-motivation condition). Children played with blocks for 10 minutes before being told, "We are now finished building" (p. 183). Children were given one minute to complete the PM action, after which prompting began. Next, children were taken back to their classroom and instructed to ask the experimenter for a candy when they saw her next (PM action; interruption, high-motivation condition). Children then played with a puzzle of their choice for 10 minutes (ongoing task) before the experimenter re-entered the room and stood close by. Again, children were given one minute to complete the PM action, after which prompting began.

Consistent with the requirements of successful PM, analyses only included children who successfully completed the PM tasks without prompting. Motivation was found to significantly improve PM performance such that children were more likely to remember to perform the high-motivation tasks than the low-motivation tasks. Overall, 47% of children remembered to perform a PM action in the high-motivation condition while only 22% remembered in the low-motivation condition. A closer look at the results revealed that 2-year-olds can successfully perform PM tasks but only when the task is motivating to them; 26% of 2-year-olds remembered to perform a motivating PM action while only 5% of 2-year-olds remembered to perform a non-motivation PM action.

No age by motivation interaction was found, indicating that all children performed better on the highly motivating tasks regardless of age. A main effect of task interruption was also found such that children were more likely to remember to perform the PM action when the cue was presented at the end of the ongoing task as opposed to during the ongoing task. Specifically, 47% of children remembered to perform a PM action in the no-interruption condition while only 22% of children remembered to perform a PM action in the interruption condition. This suggests that children can demonstrate more advanced PM abilities when they are not distracted by an ongoing task. This may also indicate that children's underdeveloped IC abilities contributed to their failure in the interruption condition, however, without an independent measure of IC the researchers could not examine this conjecture.

Collapsing across methods, Somerville et al. (1983), Kliegel et al. (2010) and Slusarczyk and Niedzwienska's (2013) studies unanimously demonstrate that children younger than 5 years of age perform significantly worse on low-motivation tasks than

high-motivation tasks. In these studies, the PM action required children to remind their caregiver or the experimenter to perform an action. As a result, poor performance on the low-motivation tasks may be attributable to young children's underdeveloped ability to consider another's mental states (theory of mind; Somerville et al., 1983). While both the high- and low-motivation tasks require children to understand that their caregiver (or the experimenter) does not remember the necessary action and needs to be reminded, the low-motivation tasks also require children to understand that their caregiver's desires differ from their own. Specifically, to successfully perform the low-motivation tasks, children must realize that the PM action is important to their caregiver even if it is not pertinent to their own interests. This skill is much more mature among 5-year-olds (e.g., Wellman & Woolley, 1990) and may have enabled them to outperform the 3-year-olds on the low-motivation task. Thus, further research is warranted to examine the relationship between motivation and PM when controlling for theory of mind. The present study aimed to eliminate this potential confound by having children perform the PM action themselves (e.g., placing a card in a box) as opposed to reminding someone else to perform an action (e.g., reminding an experimenter to place a card in a box). The following study demonstrates the importance of this adaptation by demonstrating the relation between theory of mind and PM performance.

In the final relevant study, Causey and Bjorklund (2014) adopted an experimental design to examine the effect of two task manipulations on PM: motivation and agency. Both of these variables were manipulated within subjects. The researchers also controlled for individual differences in theory of mind and EF (composite EF score from 4 WM measures and 3 IC measures). The researchers recruited a sample of 3- to 4.5-

year-olds ($N = 31$). For a detailed description of their methodology, refer to pages 19 - 21. Analyses revealed a main effect of motivation such that children remembered to perform the PM tasks more frequently in the high-motivation condition (87%) than in the low-motivation condition (40%). No effect of agency or interactions were found.

A follow-up regression model (collapsed across agency) demonstrated that theory of mind performance only predicted children's performance on the low-motivation task. This indicates that children's theory of mind scores only contributed to their PM performance when the tasks were less motivating. This is consistent with the abovementioned speculation that low-motivation tasks that require children to remind their caregiver to perform an action place a greater demand on theory of mind abilities. In these tasks, children must realize that although they may not be interested in the PM action, the experimenter is.

The regression model also revealed that children's performance on both the low- and high-motivation tasks were predicted by their composite EF score. This indicates that, regardless of the motivation manipulation, children's EF abilities contributed to their PM performance, thereby suggesting that increased EF abilities are associated with increased PM abilities. However, the power of these findings may be compromised by the fact that the researchers did not control for age or language ability in their regression analyses. It is important to control for these variables since they account for a substantial proportion of individual differences in PM performance (Ford et al., 2012; Mahy et al., 2014).

Moreover, the power of these findings is also limited by the researchers' decision to create a composite EF score by averaging children's scores across seven EF measures despite not finding all seven variables to be inter-correlated. This is not statistically

appropriate since measures that are combined to create a composite score should be statistically related. Moreover, this approach does not provide any indication as to which particular EF skill (i.e., WM, IC or both) effects PM performance.

In summary, the majority of the abovementioned studies demonstrate that preschool-aged children exhibit greater PM performance when tasks are highly motivating (Causey & Bjorklund, 2014; Kliegel et al., 2010; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). Guajardo and Best (2000) were the only researchers that did not find motivation to significantly improve PM performance. This discrepancy may be attributable to the way in which the latter researchers manipulated motivation. The former studies manipulated motivation intrinsically while the Guajardo and Best (2000) manipulated motivation extrinsically. Specifically, in intrinsically motivating tasks, both the PM action (e.g., asking for a sticker) and the PM outcome (e.g., receiving a sticker) are motivating. However, in extrinsically motivating tasks, the PM action is mundane (e.g., pressing a computer key) and only the PM outcome is motivating (e.g., receiving a reward).

Causey and Bjorklund (2014) postulate that manipulating motivation intrinsically may inaccurately represent a true PM scenario. Intrinsically motivating tasks may lead children to become consumed by their excitement to perform the PM action, potentially leading them to mentally rehearse the PM action throughout the ongoing task. Clearly, this does not match the definition of PM which is characterized by *spontaneous* remembering. However, given that only one study examined extrinsically motivating PM tasks, further research is required to truly understand the differential nature of intrinsic and extrinsic motivation. To follow-up on Guajardo and Best's (2000) approach, the

present study employed an extrinsically motivating PM scenario in order to more closely resemble a naturalistic PM scenario.

This section also demonstrates the lack of literature examining the role of WM and IC in relation to PM tasks involving the manipulation of motivation. Based on an extensive literature search, Causey and Bjorklund (2014) are the only researchers who have examined these variables in conjunction with one another and, as discussed, there are some substantial methodological limitations that limit the power of their findings. Thus, the present study aimed to expand on the present literature by adopting three measures of each WM and IC and performing two principal component analyses (one for each skill). This approach is more appropriate since it not only removes much of the variance that is accounted for by other extraneous skills but also differentiates which particular EF skill(s) effects PM performance.

Overall, the present study also aimed to correct numerous limitations that are present in the current literature examining the effect of motivation on preschoolers' PM performance. The present study asked a memory control question (at the end of the PM paradigm) to verify children's memory of the PM task instructions and screened out children who demonstrated insufficient memory. Moreover, the present study considered the effect of ongoing task performance on PM performance and statistically controlled for any differences in age and language ability in regression analyses. Finally, the present study manipulated motivation extrinsically through a procedure that prevents children from collecting rewards throughout the ongoing task.

Goal Maintenance and Prospective Memory

A second task manipulation that is of particular interest in the present study is goal

maintenance, namely the ability to hold a goal in mind over a period of time whilst partaking in other tasks (Marcovitch et al., 2007). Failures in goal maintenance (also referred to as goal neglect) occur when an individual does not perform a task appropriately despite understanding and remembering their intentions. These failures “can result in perseverative responding, the tendency to behave incorrectly in a manner that was previously correct” (Marcovitch et al., 2010, p. 1687).

While very little research exists on the relation between goal maintenance and PM performance, it is likely that goal maintenance contributes to children’s abilities to maintain the PM instructions in mind throughout the ongoing task. In the PM paradigm, failures in goal maintenance occur when the child fails to perform the PM action when presented with the target cue and instead acts in accordance with the ongoing task. These errors are likely related to children’s underdeveloped WM and IC abilities; although young children may recall the PM instructions when prompted, they may be unable to consciously consider these memories independently throughout the ongoing task or may be unable to disengage from the ongoing task to perform the action.

Goal maintenance can be manipulated in two ways: by altering the placement or proportion of target cues within the ongoing task. The placement of the target cues can be manipulated to examine how early exposure to target cues and the temporal proximity of prior target cues effect children’s PM performance. The proportion of the target cues can be manipulated to examine how more frequent repeated exposure effects children’s PM performance. Given the lack of prior research, it remains unclear which of these manipulations is more beneficial to children’s PM performance.

The present study was designed to evaluate both of these manipulations. The ongoing

task consisted of 40 cards which have been conceptualized as two sets of 20 cards. The cues were differentially placed (details below) such that children in each condition received a different proportion of target cards within a set. However, by the end of the ongoing task, all children had received the same number of target cards (six). In the forthcoming sections, these two manipulations will be explained in more detail and the relevant research will be presented when available. Gaps in the literature will also be presented and discussed with respect to the present study's goals.

Target card placement. It may be possible to manipulate goal maintenance by altering the placement of the target cues within the ongoing task. The placement of target cues varies substantially in the literature; the number of non-target stimuli presented before the first target cue ranges from 3 to 19 and the number of non-target stimuli presented between two target cues ranges from 4 to 17 (See Table 1). It is possible that receiving a greater number of target cues near the beginning of the ongoing task (relative to later in the ongoing task) gives children the opportunity to retrieve PM instructions while they are still in the forefront of their memory and thereby helps children solidify and maintain these instructions in memory. This, in turn, may increase their PM performance on subsequent trials. Contrarily, children who experience a delay before receiving the first target cue would not have this opportunity to solidify their memory and may therefore forget the PM instructions and perform more poorly throughout the PM task. This speculation is consistent with the time-window theory of memory consolidation which “suggests that children learn a new concept if they have repeated experiences with the concept that occur in close proximity in time [and] close in time to the first exposure” (Tarlov & Debbink, 2008, p. 77 - 78). This theory further argues that

Table 1

The Proportion and Placement of Target Cues Within the Ongoing Task, as Found in the Present Literature.

	Number of Sets	Total Number of Stimuli (Per Set)	Number of Target cards (Per Set)	Proportion of Target cards (in %)	Position of Target cards Within Set
Kvavilashvili et al. (2001)	4	80 (20)	4 (1)	5	10 th 10 th 20 th 20 th
Mahy et al. (2014)	3	96 (32)	6 (2)	6.3	12 th & 30 th 14 th & 21 st 7 th & 23 rd
Leigh & Marcovitch (2014)	2	30 (15)	2 (1)	6.7	12 th (presented only in 2 nd set)
Wang et al. (2008)	1	12 (12)	1 (1)	8.3	7 th
Guajardo & Best (2000)	6	60 (10)	6 (1)	10	Unknown
Kliegel & Jager (2007)	3	30 (10)	3 (1)	10	8 th 6 th 9 th
Mahy & Moses (2011)	4	52 (13)	8 (2)	15.4	7 th & 12 th 4 th & 10 th 6 th & 11 th 5 th & 10 th

such exposure solidifies children's memory of this new concept and that the developing memory fades without it. Alternatively, it is possible that the temporal proximity of the previously presented target cue to the current target cue is more important. For example, perhaps children perform better on any particular target cue if they have received a target

cue within the last 5 trials as opposed to within the last 10 trials.

Examining this manipulation is important as it can provide insight into how long children can maintain a goal in mind without any reminders as well as determine the timing of reminders that facilitate better remembering, both short-term and long-term. In real-world situations, this can be applied to adjust the PM demands placed on children to meet their goal maintenance abilities.

Very little research has examined the effect of target cue placement on PM performance. While four studies have manipulated this factor, they all examined one particular cue arrangement (Ford et al., 2012; Kvavilashvili et al., 2001; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008). Specifically, the target cue was either placed in the middle or at the end of the ongoing task. In the latter situation, children always knew that they were on the final trial. The researchers were interested in this placement arrangement because it manipulates whether children have to interrupt the ongoing task to complete the PM action. These four studies will now be reviewed in detail.

Kvavilashvili et al. (2001) examined the effect of task interruption on the PM performance of 4-, 5- and 7-year-olds ($N = 120$). They manipulated this variable between subjects. They developed an ongoing task in which children were shown a series of 20 cards and instructed to name the depicted picture. However, if the card depicted an animal, children were instructed not to name the card but to hide it instead (PM task). The analyses only included children who displayed a sufficient understanding of the PM instructions.

Kvavilashvili et al. (2001) found a main effect of age such that 7- and 5-year-olds (76% and 55%, respectively) remembered to perform the PM action more frequently than

4-year-olds (48%). Moreover, 7-year-olds (76%) remembered more often than 5-year-olds (55%). No difference was found between 4- and 5-year-olds. A main effect of task interruption was also found such that children performed the PM task more frequently when the target card was presented in the final position (79%) as opposed to in the middle of the ongoing task (41%). This suggests that children's RM of the PM instructions were intact throughout the ongoing task and that they simply failed to perform the PM action when the cue was presented in the middle of the task.

In a subsequent study, Wang et al. (2008) designed a two-part experiment to examine the effects of task interruption and ongoing task difficulty on the PM performance of 3- to 5-year-olds ($N = 60$ in part 1; $N = 62$ in part 2). In both parts of their study, Wang et al. utilized an ongoing task in which children named the image depicted on a series of 12 balls (one by one). However, when faced with an image of an animal, children were instructed to withhold naming the image and throw the ball into a basket behind them (PM action). To manipulate the ongoing task difficulty, the researchers varied the RM load such that half of the children were told to memorize the images for a subsequent free recall. The two parts of this study were differentiated by the task interruption manipulation; children in the first study received the target card in the 7th position while children in the second study received the target card in the (final) 12th position.

The analyses only included children who displayed a sufficient understanding of the PM instructions. When the target card was placed in the middle of the ongoing task, an age effect was found such that 4- and 5-year-olds (95% and 100%, respectively) were more likely to perform the PM action than 3-year-olds (50%). Moreover, although PM accuracy was not affected by the RM manipulation, children who were subject to the

additional RM recall task were slower to perform the PM action than those who were not subject to this additional task. The results differed when the target card was placed in the final position of the ongoing task; neither age or RM load effected children's PM performance. Although the researchers did not perform any analyses to compare the effect of task interruption, a closer look at the results suggests that 3-year-olds remembered to perform the PM action more often when the target card was presented at the very end of the ongoing task (80%) as opposed to in the middle (50%), while 4- and 5-year-olds' performance did not differ in these two conditions.

More recently, Slusarczyk and Niedzwienska (2013) conducted a naturalistic study with a sample of 2- to 6-year-olds ($N = 143$). The researchers manipulated two factors: motivation and task interruption. For a detailed description of their methodology, refer to pages 32 - 34. A main effect of task interruption was found such that children were more likely to remember to perform the PM action when the cue was presented at the end of the ongoing task (e.g., placing their pencil crayons on the windowsill *after* they had finished drawing) as opposed to during the ongoing task (e.g., stop playing to ask the experimenter for a candy). Specifically, 47% of children remembered to perform a PM action in the no-interruption condition while only 22% of children remembered to perform a PM action in the interruption condition.

In the final relevant study, Ford et al. (2012) examined the PM performance of 4-, 5- and 6-year-olds ($N = 59$). The position of the target cards was examined within subjects such that children completed two trials in which the target card was placed in the middle of the stack and two trials in which the target card was placed at the end of the stack. The ongoing task required children to name images depicted on a series of cards and the PM

task required children to withhold naming target cards and place them on a stool behind them. The researchers also examined the role of WM and IC in children's PM abilities (see pages 16 – 17 for details).

Through a series of series of regression analyses (controlling for both age and language ability [as measured by the Receptive Vocabulary Subscale of the Wechsler Preschool and Primary Scale of Intelligence; Wechsler, 2012]), the researchers demonstrated that children more frequently remembered to withhold naming the target cards when they were not required to interrupt the ongoing task. The rate with which children placed the target card on the stool behind them was not affected by this manipulation. Moreover, regardless of the position of the target card, children with higher IC and WM scores were more successful at withholding naming the target card. Neither IC or WM predicted children's performance with respect to placing the target cards on the stool behind them. This may be explained by the fact that children were more successful at hiding the target cards than refraining to name them, suggesting that the former task was easier for children and required fewer EF resources.

The four abovementioned studies suggest that children can demonstrate more advanced PM abilities when the target card is placed at the end of the ongoing task. The authors of these studies interpret their findings as indicating that children exhibit greater PM abilities when they are not distracted by an ongoing task. In other words, the authors argue that children succeed in the no-interruption condition because there is minimal demand on IC while their underdeveloped IC abilities prevent them from succeeding in the interruption conditions (i.e., the middle position). However, given that children knew that they were on the final card, I argue that children's superior performance in the no-

interruption condition may be explained by their realization that they had not used PM rule yet. Thus, there may have been additional task factors that made children pay special attention to that final card.

The studies by Kvavilashvili et al. (2001), Wang et al. (2008) and Ford et al. (2012) are more methodologically related to the present study than that of Slusarczyk and Niedzwienska (2013) since they employ an experimental design and utilize an ongoing task that requires children to name the images depicted on the stimuli. As a result, the focus will now be refined to these three studies. Children in these studies demonstrated more accurate PM performance when the target cues were presented later (i.e., in the final position) in the ongoing task. While these studies appear to refute the idea that exposure to target cues earlier in the ongoing task is better, it is possible that only receiving the first target cues in the 5th, 7th or 10th position was too late. Specifically, perhaps receiving a cue within the first 4 trials would have helped children solidify their memory of the PM instructions, thereby enabling them to overcome the WM or IC demands in this ‘middle’ positions.

To truly understand how target card placement effects children’s PM performance above and beyond IC abilities, it would be more informative to compare two trials in which children are unaware of the status of their progression in the ongoing task. By comparing target cues placed in the middle and the end of the ongoing task, differential demands are placed on IC. Specifically, when the target cue is placed in the middle of the task, children must employ IC to disengage from the ongoing task and perform the PM action. However, when the target cue is placed in the final position, children no longer have to disengage from the ongoing task since they know it has ended. This

difference makes it very difficult to draw any concrete conclusions about the effect of goal maintenance on children's PM performance. The present study is designed to allow this comparison. Specifically, the placement of the target cards was manipulated to examine how early exposure to target cards and the temporal proximity of prior target cards effect children's PM performance.

The studies reviewed in this section also demonstrate the lack of literature examining the role of WM and IC in relation to PM tasks that manipulate target cue placement. Ford et al. (2012) was the sole researcher to examine this relation and demonstrated that IC and WM do not differentially impact children's PM performance when target cards are placed in the middle or last position. Given that this is the only study to examine this relation, additional research is warranted. Moreover, the validity of the result pertaining to WM is also limited by the researchers' use of only use one measure of this construct. The present study employed three measures of both WM and IC and conduct two principal component analyses to examine how these skills interact with target card placement to effect children's PM performance.

Target card proportion. As mentioned, goal maintenance can also be manipulated by altering the proportion of target cues (to non-target cues) within the ongoing task. This manipulation varies substantially in the literature, ranging from 5% to 15% (See Table 1 on page 41). It is possible that receiving a greater number of target cues throughout the ongoing task facilitates children's PM performance. If this is true, then this would suggest that the number of previously seen target cues is important for any given target cue. Research examining this manipulation is informative because it can indicate the number of reminders that result in enhanced PM performance. In real-world

situations, this can be applied to adjust the PM demands placed on children to meet their goal maintenance abilities.

The effect of this manipulation on children's PM performance has yet to be examined. Although not directly related to PM, Marcovitch et al. (2007) demonstrated that task performance on an ongoing card-sorting task can be affected by manipulating the ease with which the children could maintain the goal. The authors created a modified version of Dimensional Change Card Sort Task (Zelazo, 2006) and recruited a sample of 4- and 5-year-olds ($N = 32$). For a detailed description of the standard version of this task, refer to pages 20 and 21. By 3 years of age, children generally have no difficulty on the pre-switch trials of the Dimensional Change Card Sort Task (Zelazo, 2006). However, children under the age of 4.5 to 5 years typically have some difficulty on the post-switch trials; instead of switching to the new sorting dimension, children persevere on the previously relevant dimension. For example, in the post-switch phase, children continue to sort along the colour dimension and ignore the shape information. To succeed, children would have to inhibit responding on the basis of the previously relevant dimension and remember the relevant dimension (maintain the goal of sorting by the relevant dimension).

One reason to account for this difficulty may be that the goal maintenance requirements exceed the child's ability. To examine this claim, Marcovitch et al. (2007) used the traditional pre-switch trials and adapted the post-switch trials to include two card types: (a) redundant cards which match one of the example cards on both dimensions (e.g., blue boats and red rabbits) and (b) conflict cards which match each example card on one dimension (as in the standard version of the card sort task). In the redundant

condition, 80% of the post-switch cards were redundant cards, meaning that the majority of the cards matched one of the example cards perfectly. As a result, this condition does not require children to actively maintain the post-switch instructions because they do not have to apply them very often. However, in the conflict condition, 80% of the post-switch cards were conflict cards, meaning that the majority of the cards matched both boxes on one dimension. As a result, this condition does require children to actively maintain the post-switch instructions.

Analyses revealed a main effect of condition such that children in the redundant condition correctly sorted a lower proportion of conflict cards (37%) than children in the conflict condition (69%). Children's poor performance in the redundant condition reveals that children struggle to maintain the task instructions when they are not regularly applying them. Marcovitch and colleagues (2007) speculated that this is indicative of the age group's underdeveloped WM abilities.

Thus, in a subsequent study, Marcovitch et al. (2010) examined the relation between goal maintenance and WM. The researchers used the same conditions from their 2007 study and recruited a sample of 4- and 6-year-olds ($N = 65$). Regression analyses revealed that, in the redundant condition, children with higher WM capacity correctly sorted a greater proportion of conflict cards than children with lower WM capacity. This demonstrates that when the goal is not activated frequently, children require a certain threshold of WM to maintain it. However, in the conflict condition, WM capacity only predicted the performance of 4-year-olds; 4-year-olds with higher WM capacity correctly sorted a greater proportion of conflict cards than children with lower WM capacity. The researchers speculate that despite the repetitious execution of the goal, 4-year-olds still

struggle to maintain it and thus require additional WM capacity. Contrarily, 6-year-olds are sufficiently scaffolded by the repetitious execution and therefore do not employ their WM.

Marcovitch et al.'s (2007) study clearly demonstrate that the ease with which children can maintain a goal can be manipulated by altering proportion. To examine how this can be applied to the PM paradigm, the present study aimed to examine how the proportion of target cues within the ongoing task effects children's PM performance. To follow-up on the findings of Marcovitch et al. (2010), the present study examined the relation between proportion and WM in the context of a PM paradigm. As demonstrated by this prior study, children employ more WM resources when the proportion is less supportive of goal maintenance. Thus, I speculate that supporting children's ability to maintain the PM goal will reduce their employment of WM. Evidence of this effect would consist of a weaker correlation between PM and WM. Specifically, WM will be less predictive of children's PM performance when goal maintenance is supported because frequent execution of the PM goal will result in the goal being more strongly encoded. This, in turn, will enable children to recall the goal more readily and perform more favourably on PM task without utilizing as many WM resources. I speculate that a similar relation will exist between goal maintenance, PM and IC. Specifically, the more strongly encoded PM goal will enable children to more easily disengage from the ongoing task to recall and act on the PM goal. This, in turn, will enable children to perform more favourably on the PM task without utilizing as many IC resources.

Present Study

The first aim of this study was to further examine the effects of age on preschoolers' PM performance. The study was originally designed to compare 4- and 5-year-olds' performance. However, the first 12 five-year-olds performed at ceiling on the PM task (98% correctly sorted all 6 target cards, on average), thereby rendering nearly all of the planned analyses futile. Therefore, in order to obtain a more varied performance on the main task (PM performance), the age range was revised to include 3- and 4-year-olds and the hypotheses were updated to reflect this change.

The second aim of the present study was to examine the effect of motivation on preschoolers' PM performance. Motivation was manipulated between subjects with half of the participants being assigned to the high-motivation condition and half to the low-motivation condition. This study addressed numerous limitations in the current literature (as discussed in the motivation and PM section of this paper) and employed an extrinsically motivating task, meaning that only the PM outcome was motivating as opposed to the PM action. This method was chosen based on Causey and Bjorklund's (2014) argument that extrinsically motivating tasks more accurately represent real-world PM scenarios than internally motivating tasks (i.e., both the task and outcome are motivating). Further examining this methodological approach is important since only one prior study manipulated motivation extrinsically (Guajardo & Best, 2000) and the results of this study are in conflict with the remainder of the literature.

The third aim of this study was to examine the effect of goal maintenance support on preschoolers' PM performance. Although the placement of the target cards within the ongoing task has been examined in the literature, the ability to make any clear conclusion

about the effect of this manipulation on PM performance is hindered by the task design (Ford et al., 2012; Kvavilashvili et al., 2001; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008). No prior research has examined how the proportion of ongoing cards within the ongoing task affects children's PM performance. Thus, this thesis aimed to fill this research gap by examining how the placement and proportion of target cards affects later performance. Goal maintenance was manipulated between subjects with half of the children assigned to the early-placement condition and half the children to the late-placement condition. While the specific task procedures are typically outlined in the methods section, the placement of the target cards is outlined in the forthcoming paragraphs since this information is required to interpret the hypotheses.

The ongoing task consisted of 40 cards, 34 of which were non-target cards. The remaining six cards were target cards. In the early-placement condition, the target cards were placed in the 2nd, 5th, 10th, 13th, 32nd and 40th positions (See Figure 1). In the late-placement condition, the target cards were placed in the 10th, 13th, 18th, 21st, 32nd and 40th positions. The positions of the target cards were picked such that children in the early-placement condition received target cards much earlier in the ongoing task than children in the late-placement condition. The distances between two target cards varied from one to eighteen (See Figure 1) which is consistent with the literature (see Table 1 on page 41). These distances were made as consistent as possible across the two goal maintenance conditions. Regardless of condition, the distance between the 1st and 2nd target card was three, the distance between the 2nd and 3rd target card was five, the distance between the 3rd and 4th target card was three and the distance between the 5th and 6th target card was eight. The only distances that varied were those before the first target card (one vs. nine)

Figure 1: Placement of the prospective memory target cards within the ongoing card-sorting task.

and between the 4th and 5th target card (eleven vs. nineteen). The target cards were also strategically positioned to create two comparison pairs that are in the same absolute position in both conditions (See Figure 1). Performance on the first comparison pair was compared across conditions to determine whether there is an effect of proportion and performance on the second comparison pair was compared across conditions to determine whether there is an effect of placement. By the time children completed the second comparison pair, they had been exposed to the same number of target cards so there was no difference in terms of the proportion for the two conditions.

The fourth aim of this study was to examine the interactions between age, motivation and goal maintenance. Specifically, this study aimed to replicate previous findings demonstrating no age by motivation interaction (Causey & Bjorklund, 2014; Guajardo & Best, 2000; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). Moreover, this study aimed to examine whether there are additive effects of goal maintenance and age, as well as motivation and goal maintenance, on children's PM performance. No prior study has examined these manipulations together.

The fifth aim¹ of the present study was to further evaluate the contribution of WM and IC to the total PM performance score in 3- and 4-year-old children. Although prior studies have demonstrated a positive relation between these skills and PM (Causey & Bjorklund, 2014; Ford et al., 2012; Mahy et al., 2014; Mahy & Moses, 2011), methodological limitations question the validity of these findings. This study aimed to gain a more precise measurement of WM and IC by utilizing three assessments of each

¹ Note that this aim has been updated to reflect the new age range

and conducting two principal component analyses (one for each skill). The factors from these principal component analyses will then be used in subsequent statistical analyses. This method is preferred since it extracts the common ability across the measures, thereby reducing the effect of extraneous skills.

The final aim of this study was to examine the extent to which individual differences in IC and WM predict PM performance in the context of the two task manipulations. Specifically, the contribution of these skills are examined with respect to motivation (low- vs. high-motivation PM tasks) and goal maintenance (distribution of PM trials during the ongoing task). Only one prior study examined the contribution of EF skills (composite score) to children's PM performance in low- and high-motivation PM tasks (Causey & Bjorklund, 2014) but the unique effects WM and IC remain unknown. Similarly, only one prior study examined the contributions of EF skills to children's PM performance when the placement of target cards is manipulated but the methodological limitations warrant further research. No prior studies have examined the contribution of WM and IC in children's PM performance when the proportion of target cards is manipulated.

Hypotheses

The hypotheses were as follows:

Effects of Age, Motivation and Goal Maintenance on Total Prospective Memory Score (Out of 6).

1. Four-year-olds would outperform 3-year-olds on the PM task (collapsed across motivation and goal maintenance conditions) based on prior research demonstrating improvements in PM abilities across this age range (e.g., Ford et al.,

2012; Mahy & Moses, 2011; Mahy et al., 2014).

2. Children would demonstrate better PM performance in the high-motivation condition than in the low-motivation condition since highly motivating tasks strengthen children's encoding of the PM instructions (Causey & Bjorklund, 2014).
3. Children in the early-placement condition would demonstrate better PM performance than children in the late-placement condition. This hypothesis was based on the speculation that early exposure would strengthen children's encoding of the PM instructions.
4. No age by motivation interaction was predicted; more specifically, I expected that the low-motivation task would result in worse PM performance than the high-motivation task regardless of age. This prediction is consistent with prior studies that also did not find an interaction (Causey & Bjorklund, 2014; Guajardo & Best, 2000; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). This was also based on the established relation between highly motivating PM tasks and lesser EF demands (Causey & Bjorklund, 2014). Specifically, I hypothesized that both 3- and 4-year-olds would benefit from the reduced EF demands of the high-motivation task since neither age group has reached their full developmental potential on this skill.
5. No age by goal maintenance interaction was predicted; more specifically, I predicted that the early-placement goal maintenance condition would result in better PM performance than the late-placement goal maintenance condition regardless of age. This was based on the established relation between goal

maintenance support and lower EF demand (Marcovitch et al., 2010).

Specifically, I hypothesized that both 3- and 4-year-olds would benefit from the reduced WM demands of the early-placement condition since neither age group has reached their full developmental position on this skill.

6. A significant motivation by goal maintenance interaction was predicted; the low-motivation condition, when combined with late-placement, would result in the lowest PM performance compared with the other three conditions because this combination of factors would place a particularly high demand on EF resources.

Effect of Goal Maintenance on Prospective Memory Comparison Pair Scores (Out of 2).

7. Children in the early-placement condition would demonstrate better PM performance on the first comparison pair than children in the late-placement condition. This hypothesis was based on the expectation that early exposure to the target cards would solidify children's memory of the PM instructions. In addition, this hypothesis was based on the fact that those in the early-placement condition would have received a greater proportion of target cards (by this point in the ongoing task) than children in the late-placement condition, a manipulation that has been demonstrated to improve performance in non-PM tasks (Marcovitch et al., 2010).
8. Children in the early-placement condition would demonstrate better PM performance on the second comparison pair than children in the late-placement condition. This hypothesis was based on the speculation that early exposure would strengthen children's encoding of the PM instructions.

Predictors of Total Prospective Memory Performance Score (Out of 6).

9. WM and IC scores would be positively correlated with children's total PM performance score (out of 6). This hypothesis was based on prior studies demonstrating this relation (Causey & Bjorklund, 2014; Ford et al., 2012; Mahy et al., 2014; Mahy & Moses, 2011)
10. IC and WM would predict PM performance across all conditions even after controlling for general language ability and age. This was based on the prior finding by Causey and Bjorklund (2014) demonstrating that EF abilities predicted children's performance regardless of the motivation condition. This was also based on the established relation between goal maintenance support and lower EF demands (Marcovitch et al., 2010).
11. I further hypothesized that IC and WM would be a weaker predictor in the high-motivation condition than in the low-motivation condition because the motivation would make the task easier by reducing the EF requirements. Moreover, I predicted that IC and WM would be a weaker predictor in the early-placement condition than the late-placement condition because the late placement would make it more difficult to retrieve the rule from memory (due to elapsed time). Given that the PM actions had to be done while engaged in the ongoing task, I expected that children with stronger EF abilities would be better able to do it as they would have greater WM resources (to recognize the target card and then retrieve the memory) and greater IC resources (to stop the ongoing task to follow through on the PM requirement).

Method

This study was approved by Carleton University's Research Ethics Board (approval number #16-051; See Appendix A) and the Ottawa-Carleton Research and Evaluation Advisory Committee (See Appendix B).

Participants

This study initially aimed to evaluate the PM abilities of 4- and 5-year-olds since prior research has demonstrated significant development in PM abilities over this period (e.g., Mahy & Moses, 2011; Mahy et al., 2014), as well as substantial growth in EF abilities (e.g., Carlson 2005; Frye et al., 1995). However, preliminary analyses examining 12 5-year-olds ($M = 63.00$, $SD = 2.49$; 7 girls) demonstrated ceiling performance on the PM task regardless of condition², resulting in the decision to exclude this older group and recruit 3-year-olds instead.

Data was then collected from 108 children. Two children were excluded for failing the practice trials in the PM task and 13 children were excluded for failing to correctly answer the memory question in the PM task. The remaining 93 children consisted of 32 3-year-olds ($M = 43.53$, $SD = 3.08$; 18 girls) and 61 4-year-olds ($M = 52.44$, $SD = 3.38$; 27 girls).

The majority of children were recruited from daycares and schools in the Ottawa area. A few children were also recruited by word-of-mouth (i.e., friends and family with appropriately-aged children). Informed consent was obtained from the daycare coordinators/school principals (when applicable; See Appendix C and D) and the

² 11 5-year-olds correctly sorted all six PM target cards and one 5-year-old correctly sorted five PM target cards.

children's parents (See Appendix E and F). Moreover, verbal assent was also attained from the children and they were told that they could withdraw their participation at any time without penalty (this was done using child-friendly language; See Appendix G). Experimenters were also cognisant of the children's emotional state and discontinued testing if the child appeared uncomfortable or upset. Testing took place in a quiet space in the daycare/school, such as a corner of a classroom or an office or in our private lab space at Carleton University. Children were given a sticker to thank them for their participation and the daycare/school teachers were given enough stickers for those children that did not participate. Each participating daycare/school classroom also received an age-appropriate storybook for the room as a small token of our appreciation. Children who completed the study on campus were also given a storybook to take home. All children were given a debriefing letter to take home to their parents (See Appendix H and I) and were read a verbal debrief in child-friendly language (See Appendix J)

Procedure

Motivation and goal maintenance were assessed with a 2x2 between subjects design, creating four conditions (high-motivation, low-motivation, early-placement and late-placement) that were crossed to produce four cells. These conditions were counterbalanced within each age group.

This study was completed in two sessions that lasted approximately 20-25 minutes each. In the first session, children completed the following tasks in a fixed order: Standard Dimensional Change Card Sort, Auditory Backward Digit Span and PM paradigm. In the second session, children completed the following tasks in a fixed order:

Self-Ordered Pointing³, Black / White Stroop, Simon Says, Visual Backward Word Span and Peabody Picture Vocabulary Test. A fixed order is required in order to examine the individual differences in IC and WM; this aims to ensure that practice or fatigue effects are experienced on similar tasks across the sample. For more on the use of fixed-order for individual differences, see Carlson and Moses (2011).

Measures

Prospective memory paradigm. The PM paradigm consisted of an ongoing card-sorting task and an embedded PM task (See Appendix K for task protocol). This task is largely based the methodologies of Mahy and Moses (2011) and Mahy and colleagues (2014), two other studies that examined the role of EF skills in relation to PM (with similar age groups). These methodologies were favoured since they more closely resemble the methodology used in the adult literature. All task instructions were presented in child-friendly language.

Children were shown a series of cards (see Appendix L) one by one depicting either a food item (e.g., carrot) or a non-food item (e.g., toy truck). Children were instructed to name the image on the card aloud and then sort it into the categories of ‘things people eat’ and ‘things people don’t eat’ by placing it into one of two appropriately labeled boxes (by sliding the card through a slit in the box). The boxes were placed on the table in front of the child and were visually distinguished by example cards attached to the top face. To differentiate the example cards from the sorting cards, the example cards

³ This task was initially presented in Session 1 (30 children) but was subsequently moved to the start of Session 2 to equate the duration of the two sessions. This modification did not effect children’s performance on Self-Ordered Pointing or any task presented after its administration (See Appendix U).

depicted an array of four food or non-food items using items that did not appear in the task itself. The use of an array of items (instead of a single one) was also used to prevent children from thinking that the sorting cards should exactly match the example cards.

The cards were approximately 3 by 3 inches and the colour images took up the majority of the space on the card. The researcher demonstrated this naming and sorting procedure with two demonstration trials (one with a food item and one with a non-food item). Children then practiced naming and sorting two cards (one of each type) to check for comprehension. Feedback was given if necessary and children who erred on a first practice trial were given a second practice trial of that type. Only two children could not follow the instructions on the second practice trial and they did not go on to the PM task.

To introduce the embedded PM task, children were told that there was a box just for cards with bananas on them. Children were instructed to name and place any pictures of bananas in this third box which was located behind them (it was not in their line of sight while they are completing the ongoing task) as to not act as a memory aid. This was the extent of the PM task instructions for children in the low-motivation condition.

However, children in the high-motivation condition were then told that they would receive a banana coin (i.e., a coin with a sticker of a banana on it) in exchange for placing the banana card in this box. This coin which was handed to the child by the experimenter was used to operate a special, mechanical piggy bank (See Appendix M) also located behind the child. This is considered a high-motivation task because children utilized their coin to activate the piggy bank and watched as a monkey emerged from inside the concealed box to take the coin (the piggy bank is shown in operation here:

<https://www.youtube.com/watch?v=VW9Z1wiIj08>). It was expected that young children

would enjoy ‘feeding’ the monkey.

After the PM instructions were explained, the researcher performed one demonstration trial with a banana card. Children in the low-motivation condition watched the experimenter name and sort the target card. Children in the high-motivation condition watched the experimenter name and sort the target card, as well as place the banana coin on the piggy bank to initiate its operation. Children were then instructed to draw for 3 minutes while the experimenter ostensibly prepared the task materials. This is consistent with prior work (e.g., Kvavilashvili et al., 2008; Mahy et al., 2014; Wang et al., 2008) as it ensures that children’s subsequent PM actions demonstrate spontaneous remembering. The test trials then commenced and no feedback was given. If children hesitated on a trial, they were prompted with, “Where does that card go?”. As a control, at the end of the ongoing card-sorting task, children were asked a memory question to verify their memory of the PM task instructions. Specifically, they were asked, “What were you supposed to do when you saw a card with any bananas on it?”. This verified that children remembered the PM task instructions and indicates that forgetting to perform the PM action is not related to RM failure. Children who failed to correctly answer this memory question were excluded from the analyses ($n = 13$).

The ongoing task consisted of 40 cards, 34 of which were non-target cards. The placement of the non-target cards was fixed such that the position of food and non-food items was stable. However, two card orders were used such that the specific food or non-food item in each position differed. The placement of the target cards varied by the goal maintenance condition. While the placement of the target cards within the goal maintenance condition was fixed, two card orders were used such that the specific target

card in each position differed. Fifty-nine children received the PM cards in Order 1 and 58 children received the PM cards in Order 2.

Sixteen non-target cards were food items and 18 were non-food items. These numbers were unequal so that the difference between the number of food and non-food items was not too noticeable if children erroneously sorted banana cards as food cards (if children sorted all banana cards as food cards, 22 cards would be placed in the food box and 18 items would be placed in the non-food box). The remaining six cards were target cards (i.e., banana cards). For a detailed description of the placement of the target cards, refer to pages 52 to 54.

Ongoing task performance was measured by assessing children's accuracy in sorting the 34 non-target cards. Children received one point for every non-target card they placed into the appropriate box for a maximum score of 34. PM performance was measured by assessing the number of times children correctly placed the banana cards into the box behind them. One point was awarded for each card for a maximum score of 6. In addition, performance on the 10th and 13th trials were summed out of two (performance on the first comparison pair), as was performance on the 32nd and 40th trials (performance on the second comparison pair). Each of these scores was used but for different analyses.

Working memory tasks. Children received three WM tasks: the Auditory Back Digit Span, the Visual Backward Word Span and the Self-Ordered Pointing task. These specific tasks were selected because they have demonstrated variability among preschool-aged children.

Auditory Backward Digit Span (ABDS; modified from Carlson et al., 2002, as in Vendetti, 2015; See Appendix N). In this task, children were introduced to Willy the pig, a stuffed animal who says everything in backwards order. Children were instructed to repeat a series of numbers stated by the researcher in backwards order. These instructions were explained using a demonstration trial. Children received two practice trials with feedback, each consisting of two numbers. In the test trials, numbers were presented in sets of two, three, four, five or six. Each set comprised of two trials, amounting to a total of 10 trials. Children progressed to the next set if they passed at least one trial of the prior set. The task ended when the child did not pass either trial in a given set or when the child completed both trials with six numbers. Children received one point for each correct test trial for a maximum score of ten.

Visual Backward Word Span (VBWS; Carlson et al., 2002; See Appendix O). In this task, children were shown cards depicting pictures of familiar objects (e.g., car, tree). The experimenter named each item aloud, one at a time and then placed it face down on the table in front of the child. Once all cards in a set had been placed on the table, the child was asked to name the objects in reverse order. These instructions were explained using a demonstration trial. Children then received two practice trials containing two cards and feedback was given when necessary. In the test trials, cards were shown in sets of two, three, four or five. Each set comprised of two trials, amounting to a total of 8 trials. Children progressed to the next set if they passed at least one trial of a given set. The task ended when the child did not pass either trial in a given set or when the child completed both trials with five cards. Children received one point for each correct test trial for a maximum score of eight.

Self-Ordered Pointing (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; See Appendix P). In this task, children were shown arrays depicting pictures of familiar objects (e.g., car, tree) and asked to point to each object just once across multiple presentations of the array. Children received two practice trials consisting of two pages depicting the same two objects but in different spatial locations and feedback was given when necessary. Children were told that they are to point to each picture once but that they have to point to all of the pictures at different times. They were then instructed to point to a picture and then the experimenter turned to the second page and the child was instructed to point to the picture that they did not point to before. In the test trials, children were shown pages with sets of three, four, five, six, seven or eight objects. The number of pages is equivalent to the number of objects. Each set comprised of two trials, amounting to a total of 12 trials. Children progressed to the next set if they passed at least one trial of a given set. The task ended when the child made an error on both trials in a set or when the child completed both trials with eight objects. Children received one point for each correct test trial for a maximum score of twelve.

Inhibitory control tasks. Children received three IC tasks: the Black / White Stroop, Simon Says and the Dimensional Change Card Sort task. These specific tasks were selected because they have demonstrated variability among preschool-aged children.

Black / White Stroop (Vendetti et al., 2015; See Appendix Q). In this task, children were shown solid black and white cards and instructed to name the opposing colour. Specifically, children were asked to say “white” when shown a black card and to say “black” when shown a white card. Children received up to three practice trials with feedback. Twenty-one test trials were administered; children’s first complete response

was recorded and no feedback was provided. One point was awarded for each correct trial for a maximum score of twenty-one.

Simon Says (Carlson, 2005; See Appendix R). In this task, children were told that the experimenter was going to ask them to perform some ‘silly’ actions, such as “touch your nose”. However, they should only perform the actions when the command is preceded with “Simon says...”. Otherwise, children were instructed to ignore the command and remain as still as possible. The experimenter demonstrated the action (or lack of action) in a demonstration trial in which they showed children what they should do if they heard, “Simon says touch your knees”, and if they just heard, “Touch your knees”. Children were then given up to three practice trials to successfully perform the two actions (or lack of action) independently. If children correctly completed a practice trial, a total of 10 test trials (5 of each type) were administered in quick succession, without demonstration or correction. Only non-Simon says trials were scored as indicators of the ability to inhibit. Consistent with Mahy et al. (2014), children’s actions per trial were scored as: 0 = commanded movement; 1 = partial movement; 2 = incorrect movement; and 3 = no movement. This resulted in a maximum score of 15.

Dimensional Change Card Sort (DCCS; modified from Zelazo, 2006, as in Prodjarny, 2015; See Appendix S). In this task, children were shown cards that varied along two dimensions, colour and shape (e.g., red rabbits and blue boats) and were instructed to sort them into two boxes. Example cards, which are red boats and blue rabbits, were each affixed to the box. The test cards were presented one by one with each test card matching one of the example cards on a different dimension (i.e., colour or shape). First, children were instructed to sort the cards into the boxes based on one of the

dimensions (i.e., colour). During the pre-switch phase, the experimenter demonstrated this rule with one example and then the child completed one practice trial (with feedback) and eight test trials (without feedback). Children were reminded of the sorting rule prior to receiving each of the test cards. Then, children were told that they were going to play a new ‘game’ and a switch in sorting-rules was announced. In this post-switch phase, children were instructed to sort eight more test cards by the second, previously irrelevant dimension (i.e., shape). On every trial, before placing the test card into a box, the card was labeled on the relevant dimension and the sorting rules were repeated. One point was awarded for each correctly sorted test card during the post-switch phase (the phase that requires children to inhibit a previously learned rule) for a maximum score of 8. Children were required to correctly sort a minimum of 6 pre-switch trials to be considered performing better than chance and to be included in the analyses.

Language task. One general language task was used as a control measure.

Peabody Picture Vocabulary Test – Third Edition (PPVT-III; Dunn & Dunn, 1997; See Appendix T). In this standardized measure of receptive vocabulary, children were presented with an array of four pictures. The experimenter stated the name of one of the pictures and children were asked to identify which one was named. This task was administered in accordance with the testing manual. The PPVT-III is arranged into blocks of 12 trials and the words stated by the experimenter increase in difficulty as the task goes on. Children began at the block in which they correctly identified at least 11 of 12 pictures and continued through the task until they made at least eight errors in one block. A raw score was calculated by subtracting the total number of errors from the last item administered in the task. This measure was used for control purposes in the

regression analyses.

Results

Participants

There were a number of children who did not complete one or more of the tasks during the testing sessions for various reasons. Three children did not complete the Auditory Backward Digit Span task because they would not speak (one child in Conditions A⁴, B and D; 1 girl), one boy did not complete the Self-Ordered Pointing because he got bored (Condition C) and one boy did not complete the Black/White Stroop because he terminated his participation prior to this task (Condition A). Thirty-five children failed to pass the screener and therefore did not go on to complete Simon Says⁵ (10 in Condition A, 8 in Condition C, 9 in Condition B and 8 in Condition D; 18 girls), three children did not complete the Visual Backward Word Span because they terminated their participation prior to this task or got bored during the task (2 in Condition A and one in Condition B, 2 girls) and two children refused to complete the PPVT due to boredom (1 in Condition C and one in Condition B; 1 girl). Moreover, one girl's DCCS score was excluded because her score on the pre-switch trials fell below the cut-off score of six out of eight (Condition C). These participants were excluded pairwise for each relevant analysis. Given that only 62% of participants completed Simon Says task, I decided to exclude this task from analyses involving the EF measures. This decision was made since including this task in the analyses would substantially reduce the sample size of participants who had completed all EF measures (only 54

⁴ Condition A: High-motivation & Early GM; Condition B: High-motivation & Late GM; Condition C: Low-motivation & Early GM; Condition D: Low-motivation & Late GM

⁵ Test trials were not administered to children who failed to successfully complete at least one of three practice trials as per task instructions (Mahy et al., 2014).

children completed all EF tasks). A total of 84 children completed all tasks (21 in Condition A, 17 in Condition B, 24 in Condition C and 22 in Condition D). The full sample of 93 was used for all other analyses.

Exploratory Data Analysis

Data was entered in SPSS by two coders and inter-rater reliability was consistently above $\alpha = 0.95$. Any discrepancies between the coders were resolved by referring back to the original testing booklet. Analyses were first conducted to determine whether the groups of participants were matched on the non-PM tasks across conditions. Twenty-four children were in Condition A, 21 children were in Condition B, 25 children were in Condition C and 23 children were in Condition D. The four groups of participants did not differ on any of the individual difference measures (i.e., WM, IC, vocabulary). Furthermore, the four groups did not differ in age or sex distribution (See Tables V1 and V2 in Appendix V). As a result, these groups were considered well matched. See Table 2 for descriptive statistics on these measures (see Appendix V, Table V1, for a breakdown of performance by condition).

The effect of card order (there were two) on children's ongoing task performance, $t(91) = 1.20, p = 0.23^6$ and total PM performance score, $t(91) = 0.64, p = 0.53$, was also examined and no significant effects were found. Thus, performance was collapsed across card order. Children's performance on the ongoing task was also examined. Children's accuracy on this task was very close to ceiling (95.9%) and was not significantly related to PM performance, $r(93) = 0.11, p = 0.31$. Similarly, children's ongoing task

⁶ All planned t-test are evaluated with $p = 0.05$. Bonferroni corrections are applied for any post-hoc t-tests.

Table 2.

Sample Size, Means and Standard Deviations for all Measures (Collapsed Across Conditions)

	Total Sample			3-Year-Olds			4-Year-Olds		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Ongoing Task	93	32.61	3.46	32	32.38	3.52	61	32.74	3.45
Prospective Memory									
Total	93	4.61	2.27	32	3.91	2.59	61	4.98	2.00
Comparison Pair 1	93	0.72	0.44	32	0.58	0.49	61	0.80	0.39
Comparison Pair 2	93	0.81	0.39	32	0.70	0.46	61	0.86	0.34
Working Memory									
Auditory Backward Digit Span	90	0.62	1.15	31	0.00	0.00	59	0.95	1.31
Self-Ordered Pointing	92	4.24	3.08	32	4.47	3.32	60	4.12	2.96
Visual Backward Word Span	90	1.20	1.15	32	0.94	1.08	58	1.34	1.18
Inhibitory Control									
Dimensional Change Card Sort	92	5.25	3.60	31	3.55	3.78	61	6.11	3.21
Black/White Stroop	92	13.28	7.13	32	11.63	7.55	60	14.17	6.80
Simon Says	58	4.76	5.55	14	1.36	2.79	44	5.84	5.78
(Removed)									
PPVT-III	91	59.69	17.21	32	52.44	13.65	59	63.63	17.76

Note. Ongoing Task (0-34), Prospective Memory Total (0-6), Prospective Memory Comparison Pair 1 or 2 (0-2), Auditory Backward Digit Span (0-10), Self-Ordered Pointing (0-12), Visual Backward Word Span (0-8), Dimensional Change Card Sort (0-8), Black/White Stroop (0-21), Simon Says (0-15), PPVT-III (20-160).

performance did not differ by condition, $F(3, 93) = 0.94, p = 0.43$.

The distributions of children's performance on the PM, WM, IC and vocabulary measures are presented in Appendix V (Figures V1 to V8). With the exception of the Auditory Backward Digit Span, the skewness and kurtosis statistics of these measures are within the ± 2 range and are therefore considered approximately normal (See Table V3 in Appendix V; Tabachnick & Fidell, 2006). Since the Auditory Backward Digit Span was positively skewed, a square-root transformation was applied and the skewness and

kurtosis fell into the normal range (See Figure V9 and Table V3 in Appendix V). The transformed variable is used in subsequent analyses.

Effects of Age, Motivation and Goal Maintenance

To examine the effects of age (in years), motivation and goal maintenance on children's total PM performance score (out of 6), a 2 (age group: 3-year-olds vs. 4-year-olds) x 2 (motivation: high vs. low) x 2 (goal maintenance: early-placement vs. late-placement) analysis of variance (ANOVA) was conducted. All three variables varied between subjects. Table 3 shows the descriptive statistics for children's total PM performance score at each level of age (in years), motivation and goal maintenance.

Table 3.

Prospective Memory Performance by Condition

	N	Mean	SD
Age (in years)			
3-year-olds	32	3.91	2.59
4-year-olds	61	4.98	2.00
Motivation			
Low	48	5.21	1.73
High	45	3.98	2.60
Goal Maintenance			
Early-Placement	49	4.84	2.19
Late-Placement	44	4.36	2.34

Prior to examining the results, the three assumptions of ANOVA were examined. To examine the presence of outliers, z-scores were created for children's PM scores and compared to the established cut-off value of 2.58 (Iglewicz & Hoaglin, 1993); no outliers emerged. The normality of the children's total PM performance score was further examined via within-cell histograms and normal Q-Q plots. Visual inspection of these graphs demonstrated that children's total PM performance scores were negatively skewed in some conditions while bi-modally distributed in other conditions. However, according

to convention, normality can be assumed since the skew (-1.32) and kurtosis (0.05) are within the ± 2 range (Tabachnick & Fidell, 2006). Finally, homogeneity of variance was evaluated through Levene's test of Homogeneity of Variances. This test was violated, $F(7, 85) = 2.63, p = 0.02$; however, the 2-way ANOVA is robust to this violations since the within-cell sample sizes are approximately equal (Jaccard, 1998).

Consistent with the first hypothesis, a significant main effect of age indicated that the 4-year-olds ($M = 4.98, SD = 2.00$) successfully sorted more PM target cards than did the 3-year-olds ($M = 3.91, SD = 2.59$), $F(1,85) = 7.39, p = 0.01, \eta_p^2 = 0.08$ (See Figure 2). This effect is qualified by an interaction that is described below.

The second hypothesis stated that children in the high-motivation condition would perform better on the PM task than would children in the low-motivation condition. On the contrary, a significant main effect of motivation demonstrated that children in the low-motivation condition ($M = 5.21, SD = 1.73$) successfully sorted *more* target cards than did children in the high-motivation condition ($M = 3.98, SD = 2.60$), $F(1,85) = 12.70, p = 0.001, \eta_p^2 = 0.13$ (See Figure 2). This effect is qualified by an interaction that is described below.

The third hypothesis, which was about the effect of goal maintenance, stated that children in the early-placement condition would perform better on the PM task than children in the late-placement condition. However, no significant difference in PM performance was found between children in the early-placement ($M = 4.84, SD = 2.19$) and late-placement conditions ($M = 4.36, SD = 2.34$), $F(1,85) = 1.64, p = 0.20$ (See Figure 2).

The fourth hypothesis predicted that no age by motivation interaction would be found.

Figure 2: Effects of age, motivation and goal maintenance on total PM performance score (out of 6; error bars represent 1 standard deviation)

This hypothesis was not supported; a significant age by motivation interaction was found, $F(1, 85) = 4.77, p = 0.03, \eta_p^2 = 0.05$ (See Figure 3). Follow-up analyses indicated that 3-year-olds were adversely affected by the high-motivation condition and correctly sorted more target cards in the low-motivation condition ($M = 5.06, SD = 1.73$) than in the high-motivation condition ($M = 2.43, SD = 2.82$), $t(20.39) = 3.07, p = 0.01$, Cohen's $d = 1.12$. In contrast, 4-year-olds' performance did not differ between the low- ($M = 5.30, SD = 1.74$) and high-motivation conditions ($M = 4.68, SD = 2.20$), $t(59) = 1.22, p = 0.23$.

The fifth hypothesis predicted that no age by goal maintenance interaction would be found. This hypothesis was supported; older children correctly sorted more PM target cards than younger children regardless of goal maintenance condition, $F(1, 85) = 0.29, p = 0.59$ (See Figure 4). Further, the sixth hypothesis predicted a motivation by goal maintenance interaction such that the low-motivation and late-placement conditions together would result in the lowest PM performance (compared to the other three

Figure 3: Effect of age by motivation interaction on total PM performance score (out of 6; error bars represent 1 standard deviation)

Figure 4: Effect of age by goal maintenance interaction on total PM performance score (out of 6; error bars represent 1 standard deviation)

conditions). However, this hypothesis was not supported; children correctly sorted a greater number of PM cards in the low-motivation condition than in the high-motivation condition (this effect was carried by the 3-year-olds) regardless of goal maintenance condition, $F(1, 85) = 0.006, p = 0.94$ (See Figure 5).

Figure 5: Effect of motivation by goal maintenance interaction on total PM performance score (out of 6; error bars represent 1 standard deviation)

The seventh and eight hypotheses predicted that children in the early-placement condition would demonstrate better performance on the first and the second comparison pairs than children in the late-placement condition. Recall that at the first comparison pair, children in the early-placement condition had already received one pair of target cards while children in the late-placement condition had not. However, at the second comparison pair, all children had received four prior target cards (See Figure 1 on page 53).

A 4-way mixed-measures ANOVA was conducted to test these hypotheses. This

statistical analysis was chosen since the significant main effects of age and motivation prohibited collapsing across these factors. This analyses compared children's performance on the two comparison pairs as well as investigated how age, motivation and goal maintenance impacted performance. Age (3-year-olds vs. 4-year-olds), motivation (low vs. high) and goal maintenance (early-placement vs. late-placement) were entered as between subjects variables and comparison pair (one vs. two) was entered as a within subjects variable.

Before reporting the results, the assumptions of this particular statistical test are discussed. The absence of outliers, normality and homogeneity of variance were examined with respect to the within-subject variables (i.e., comparison pairs one and two). Using the conventional cut-off value of ± 2.58 (Iglewicz & Hoaglin, 1993), the examination of z-scores revealed no outliers with respect to these variables. Children's PM performance on the first comparison pair ($skew = -0.10$; $kurtosis = -0.95$) and the second comparison pair ($skew = -1.58$; $kurtosis = -0.56$) were deemed normal based on comparing these statistics to the cut-off value of ± 2 (Tabachnick & Fidell, 2006). Levene's test of homogeneity of variances was violated for both the first comparison pair, $F(7, 85) = 5.25, p < 0.001$, and the second comparison pair, $F(7, 85) = 4.54, p < 0.001$. However, the 4-way ANOVA is robust to these violations since the within-cell sample sizes are approximately equal (Jaccard, 1998).

Consistent with the prior ANOVA examining children's total PM performance score (out of 6), there was a statistically significant main effect of age, $F(1, 85) = 7.77, p = 0.01, \eta_p^2 = 0.08$, and motivation, $F(1, 85) = 14.05, p < 0.001, \eta_p^2 = 0.14$, on children's performance on the comparison pairs (See Figure 6). More specifically, 4-year-olds ($M =$

0.83, $SD = 0.37$) performed better on the comparison pairs than did 3-year-olds ($M = 0.64$, $SD = 0.47$) and children in the low-motivation condition ($M = 0.87$, $SD = 0.32$) performed better than children in the high-motivation condition ($M = 0.65$, $SD = 0.47$). Again, no significant main effect of goal maintenance emerged, $F(1, 85) = 2.36$, $p = 0.13$ (See Figure 6).

A statistically significant main effect of comparison pair was also found such that children performed better on the second comparison pair ($M = 0.81$, $SD = 0.39$) than on the first one ($M = 0.72$, $SD = 0.44$), $F(1, 85) = 8.77$, $p = 0.004$, $\eta_p^2 = 0.09$ (See Figure 6). All three significant main effects are qualified by an interaction that is described below.

Figure 6: Effects of age, motivation, goal maintenance and comparison pair on PM performance score (out of 2, averaged across comparison pairs; error bars represent 1 standard deviation)

Congruent with the previous ANOVA analysis, a significant age by motivation interaction was found, $F(1, 85) = 5.45$, $p = 0.02$, $\eta_p^2 = 0.06$ (See Figure 7). Follow-up analyses indicated that 3-year-olds were more successful at sorting the comparison pairs in the low-motivation condition ($M = 0.85$, $SD = 0.29$) than in the high-motivation

conditions ($M = 0.38$, $SD = 0.49$), $t(19.8) = 3.22$, $p = 0.004$, Cohen's $d = 1.17$. In contrast, 4-year-olds' performance on the comparison pairs did not differ between the low ($M = 0.88$, $SD = 0.29$) and high-motivation conditions ($M = 0.77$, $SD = 0.38$), $t(56.2) = 1.26$, $p = 0.21$ (See Figure 7).

Figure 7: Effect of age by motivation interaction on PM performance on comparison pairs (score out of 2, averaged across comparison pairs; error bars represent 1 standard deviation)

A significant interaction was also found between comparison pair and goal maintenance, $F(1,85) = 5.08$, $p = 0.03$, $\eta_p^2 = 0.06$ (See Figure 8). Follow-up analyses demonstrated that children in the early-placement condition ($M = 0.81$, $SD = 0.39$) performed better on the first comparison pair than children in the late-placement condition ($M = 0.63$, $SD = 0.47$), $t(84.1) = 2.00$, $p = 0.049$, Cohen's $d = 0.42$. However, performance on the second comparison pair did not differ by goal maintenance condition; children in the early-placement ($M = 0.82$, $SD = 0.38$) and late-placement conditions ($M = 0.80$, $SD = 0.41$) performed comparably on the second comparison pair, $t(91) = 0.26$, $p = 0.80$.

Figure 8: Effect of comparison pair by goal maintenance interaction on PM performance on comparison pairs (score out of 2, averaged across comparison pairs; error bars represent 1 standard deviation)

No other significant two-way interactions or three-way interactions were found. A significant four-way interaction between comparison pair, age, motivation and goal maintenance was found, $F(1, 85) = 4.60, p = 0.04, \eta_p^2 = 0.05$.

Relation Between PM and Executive Functioning

To test the ninth hypothesis, the correlations between children's total performance on the PM task (score out of 6) and their EF abilities were examined. Zero-order correlations between PM, age, WM, IC and language are displayed in Table 4.

Children's PM performance was correlated with age (in months), $r(91) = 0.32, p = 0.002$, Auditory Backward Digit Span (Transformed), $r(88) = 0.29, p = 0.009$, Dimensional Change Card Sort, $r(90) = 0.26, p = 0.02$, Black / White Stroop, $r(90) = 0.31, p = 0.003$, and PPVT, $r(89) = 0.25, p = 0.02$.

The tenth hypothesis predicted that IC and WM would predict children's total PM performance score collapsed across motivation and goal maintenance. The planned analysis was to perform principal component analyses on the WM and IC measures to

Table 4.

Correlations Among Measures of PM, Age, Working Memory, Inhibitory Control and PPVT

Measure	1	2	3	4	5	6	7	8
1 PM	---	0.32**	0.29**	0.20	0.20	0.26*	0.31**	0.25*
2 Age (in months)		---	0.54**	-0.03	0.21	0.26*	0.21*	0.43**
3 ABDS _T (WM)			---	0.001	0.40**	0.38**	0.37**	0.47**
4 SOP (WM)				---	0.09	0.18	0.13	0.20
5 VBWS (WM)					---	0.35**	0.21*	0.30**
6 DCCS (IC)						---	0.33**	0.38**
7 BW (IC)							---	0.20
8 PPVT								---

Note. PM = Prospective Memory. ABDS_T = Auditory Backward Digit Span (Transformed). SOP = Self-Ordered Pointing. VBWS = Visual Backward Word Span. DCCS = Dimensional Change Card Sort. BW = Black / White Stroop. PPVT = Peabody Picture Vocabulary Test. * $p < 0.05$. ** $p < 0.01$

derive two scores (one per cognitive skill) and then examine the contribution of each of those skills in PM performance. However, once the Simon Says measure was eliminated, there were only two measures of IC remaining. Given that a principal component analysis requires a minimum of three measures per skill, an exploratory factor analysis (EFA) was conducted instead in order to create an overarching EF measure to use in the analyses.

First, the suitability of the EFA was assessed. The overall Kaiser-Meyer-Olkin measure was 0.70 which is classified as 'middling' according to Kaiser (1974). Bartlett's Test of Sphericity was statistically significant, $\chi^2(10) = 48.32, p < .001$, indicating that the data was likely factorizable. The EFA revealed one factor that had an eigenvalue greater than one. This composite EF factor contained all five measures of IC and WM

and explained 40.6% of the total variance. Visual inspection of the scree plot confirmed that only one factor should emerge (Cattell, 1966). The component loadings are displayed in Table W1 in Appendix W.

Age in months was entered in the first step, PPVT-III score was entered in the second step and the EF factor was entered in the third step. Preliminary analyses were conducted to examine the assumptions of linear regression. The examination of the standardized residuals did not reveal any outliers (Iglewicz & Hoaglin, 1993). The Durbin-Watson statistic demonstrated independence of residuals ($d = 1.76$) and visual inspection of plots of standardized residuals versus standardized predicted values demonstrated heteroscedasticity.

The results of the linear regression are presented in Table 5. Age, language and EF accounted for 15.1% of the variance in PM ($R^2_{adjusted} = 0.12$). Moreover, performance on the EF tasks explained a significant amount of variance above and beyond age and language, $F(1, 80) = 6.60$, $p = 0.01$. Specifically, the EF measures accounted for 7.0% of variance in PM.

Table 5.

Regression Analyses for PM Performance (Collapsed Across Conditions)⁷

		B	SE	β
Step 1	Age	.111	.045	.263*
Step 2	PPVT-III	.016	.015	.120
Step 3	Executive Functioning	.907	.353	.327*

* $p < 0.05$.

⁷ A second regression examined the results when PPVT-III is entered in the first step and age is entered in the second step (with PM still in the final step). PPVT-III still did not account for a significant amount of variance in PM performance, $F(1, 82) = 3.676$, $p = 0.06$.

The eleventh and final hypothesis predicted that IC and WM would be a stronger predictor of children's total PM performance score in the low-motivation condition (as opposed to the high-motivation condition) and late-placement goal maintenance condition (as opposed to the early-placement goal maintenance condition). Again, given that the Simon Says measure was dropped and the overarching EF factor was used, the individual contributions of IC and WM could not be examined in this way. Instead, the contribution of the EF factor on children's PM performance were compared across the conditions in a linear regression.

The individual difference measures (i.e., the EF factor and PPVT) were entered in the first step and the three condition manipulations were entered in the second step (i.e., age in years, motivation and goal maintenance). The interactions between the EF factor and the three conditions were entered in the third step along with the two- and three-way interactions between the three conditions⁸. Before examining the result, preliminary analyses were conducted to evaluate the assumptions of linear regression. The examination of the standardized residuals did not reveal any outliers (Iglewicz & Hoaglin, 1993). The Durbin-Watson statistic demonstrated independence of residuals ($d = 2.05$) and visual inspection of plots of standardized residuals versus standardized predicted values revealed heteroscedasticity.

The regression table for this analysis is presented in Table 6. The results of the regression indicated that EF was equally predictive in both motivation conditions, $t(71) = 1.17, p = 0.24$, and goal maintenance conditions, $t(71) = 0.18, p = 0.86$. However, the

⁸ A statistics advisor recommended that the other 3-way interactions and the 4-way interactions be omitted from the model because overcomplicating the model would result in problems.

Table 6.

Regression Analyses for PM Performance (By Condition)

		B	SE	β
Step 1	PPVT-III	0.001	0.02	0.01
	Executive Functioning	1.02	0.34	0.37**
Step 2	Age (in years)	0.42	0.501	.09
	Motivation	-1.28	0.44	-0.29**
	Goal Maintenance	-0.52	0.44	-0.12
Step 3	Age (in years) * Motivation	0.76	1.41	0.16
	Age (in years) * Goal Maintenance	0.93	1.26	0.19
	Motivation * Goal Maintenance	0.95	1.53	0.17
	Age (in years) * Motivation * Goal Maintenance	-1.43	1.89	-0.23
	Executive Functioning * Age (in years)	-1.69	0.81	-0.50*
	Executive Functioning * Motivation	0.78	0.66	0.19
	Executive Functioning * Goal Maintenance	0.12	0.64	0.03

* $p < 0.05$. ** $p < 0.01$.

predictive power of EF on PM performance did differ by age, $t(71) = -2.08$, $p = 0.04$, Cohen's $d = 0.39$, such that EF was a stronger predictor of PM performance for the 3-year-olds than the 4-year-olds.

It is also worth noting that, like the ANOVA reported above, this regression also found a main effect of motivation on children's PM performance. However, the main effect of age and the interaction between age and motivation were no longer significant. This may suggest that these latter two effects are explained by the age related differences in EF abilities. To follow-up on this, a post-hoc mediation analysis was conducted to investigate whether EF mediates the effect of age on PM performance. A Bonferroni corrected alpha was achieved by dividing 0.05 by the number of tests (4) to achieve a p-value of 0.012. Results indicated that age was a significant predictor of EF, $\beta = 0.70$, $t(83) = -3.27$, $p < 0.001$, and that EF was a significant predictor of PM performance,

$\beta = 0.95$, $t(82) = 3.16$, $p = 0.002$. Since both the a-path and b-path were significant, mediation analyses were tested using the bootstrapping method with bias-corrected confidence intervals (Preacher & Hayes, 2004). The 95% confidence interval of the indirect effects was obtained with 5000 bootstrap re-samples (Preacher & Hayes, 2008).

Age was no longer a significant predictor of PM performance after controlling for the mediator, EF, $\beta = 0.23$, $t(82) = 0.44$, $p = 0.66$, consistent with full mediation.

Approximately 14% of the variance in PM performance was accounted for by the predictors ($R^2 = 0.14$). The indirect coefficient was significant, $\beta = 0.66$, $SE = 0.24$, 95% CI = 0.30 to 1.29, $p = 0.004$, indicating that being one year older was associated with approximately 0.66 points higher PM performance scores, as mediated by EF abilities.

*Figure 9: Indirect effect of age (in years) on prospective memory performance through executive functioning performance. ** $p < 0.01$*

Discussion

This study aimed to further evaluate the effects of age, motivation and goal maintenance on children's PM performance. To do so, 3- and 4-year-old children played an ongoing task in which they sorted a series of cards into two boxes placed on the table in front of them, one for 'things people eat' and one for 'things people don't eat'. Children were also told to place cards depicting bananas into a third box located behind them (the PM task). Motivation was manipulated such that half of the children got to operate a fun, interesting mechanical piggy bank if they remembered to place the banana cards in the box behind them, whereas the other half of the children did not receive this motivation (they simply placed the cards in the box and continued the ongoing task). Goal maintenance, which was crossed with motivation, was manipulated such that half of the children received their first pair of banana cards early in the ongoing task while the other half did not receive those cards until later in the ongoing task. This study also investigated how children's IC and WM abilities relate to their performance on the PM task. Children completed a series of IC and WM measures which were subsequently used to create a single EF factor.

Effects of Age, Motivation and Goal Maintenance

The first hypothesis, which predicted that the older children (4-year-olds) would correctly sort a greater number of PM target cards than the younger children (3-year-olds), was supported. This finding is consistent with prior studies that demonstrated improvements in PM performance across the preschool years (e.g., Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). Moreover, the 3-year-olds did not perform at floor (56% correctly sorted all six target cards), further corroborating the notion that 3-

year-olds can successfully demonstrate PM (e.g., Guajardo & Best, 2000; Kliegel et al., 2007; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008). This main effect of age is qualified by an interaction that is described below.

Prior to discussing the remaining findings, I will first address the change made to the planned study in terms of the participants' ages. As mentioned in the methods section, this study initially aimed to compare the PM performance of 4- and 5-year-olds. This age group was chosen since the PM task was largely modelled from two previous studies by Mahy and colleagues (2011; 2014) that found significant improvements in PM performance across this age span. However, the first 12 5-year-olds in the present study performed at ceiling on the PM task, remembering to place the banana card behind them 98% of the time (on average), so the 5-year-olds were replaced with 3-year-olds in order to have some variability in performance. The ceiling performance of the 5-year-olds is contrary to children of the same age in prior studies who only remembered to perform the PM action 86% (Mahy & Moses, 2011) and 47% (Mahy et al., 2014) of the time (on average).

This discrepancy is likely due to differences in how children named the PM target cards. In Mahy and Moses' (2011) study, children were instructed to name a series of picture cards and the PM rule was to hide those depicting animals and/or cars (target cards). A total of eight target cards were included and multiple different animals and cars were used. Similarly, in Mahy et al.'s (2014) study, children were instructed to sort a series of cards into two boxes and ring a bell behind them if a card depicted an animal (target card). A total of six target cards were included and multiple different animals were used. I speculated that this design may cause children to struggle to match the

target cards to the PM rule; while they were instructed to perform a particular action in response to an ‘animal’, for example, the ongoing task required children to name the image more specifically, such as ‘dog’. Thus, when naming the target cards, the level of classification was higher than in the task instructions, thereby requiring children to make an additional step (e.g., ‘a dog is an animal’) in order to be successful on this task.

The current study equated this level of classification such that the target cards were labeled at the same level of specificity as was stated in the task instructions. More specifically, children were instructed to place cards depicting ‘bananas’ behind them and all six target cards depicted bananas (different image each time). This method also aligns with the methodology that is used in adult PM studies where the ongoing task requires participants to sort strings of letters into ‘words’ and ‘non-words’ and the PM task requires participants to look for one particular word (e.g., Harrison et al., 2014; Meiser & Schult, 2008; Neely et al., 1989). In this paradigm, the instructions specify the exact target word and thus the level of classification between the instructions and the target cue is matched.

The results of the present study may suggest that equating the level of classification made the task easier for children, resulting in near ceiling performance among the 5-year-olds. If this is so, it also suggests that prior studies may have underestimated 5-year-olds’ PM abilities as some of their errors may have had more to do with recognizing classification hierarchies and less to do with PM itself. A future study dedicated to investigating whether the matched and unmatched levels of classification differentially impact children’s PM performance is warranted.

The second hypothesis predicted that children in the high-motivation condition would

perform better on the PM task than children in the low-motivation condition. This hypothesis was not supported. Instead, children were *adversely* affected by the high-motivation condition such that they correctly sorted fewer cards than did children in the low-motivation condition. This is surprising given that children were generally very excited to play with the piggy bank and often asked to play with it again during the next session. Subsequent analysis demonstrated that this effect was qualified by an interaction between age and motivation; while the 3-year-olds performed more favourably in the low-motivation condition than the high-motivation condition, the 4-year-olds' performance did not differ across the two conditions. Interestingly, the two age groups performed comparably in the low-motivation condition (84% in the 3-year-olds and 88% in the 4-year-olds, on average) but differed significantly in the high-motivation condition (40% in the 3-year-olds and 84% in the 4-year-olds, on average). This interaction effect does not support the fourth hypothesis that predicted no interaction. This hypothesis was based on prior studies that did not find a significant interaction between age and motivation (Causey & Bjorklund, 2014; Guajardo & Best, 2000; Slusarczyk & Niedzwinska, 2013; Somerville et al., 1983), as well as the postulation that both 4- and 5-year-olds would benefit from the reduced EF demands of the high-motivation tasks since neither age group has reached their full developmental potential on this skill.

A follow-up regression analysis and mediation analysis demonstrated that EF abilities account for the interaction between age and motivation (this will be discussed in greater detail shortly). Prior to turning to that finding, it is worth considering task-related explanations for why the performance of 3- and 4-year-olds differed in the high-motivation condition and not in the low-motivation condition. First, reflecting on the PM

task instructions, it becomes apparent that they were more complex in the high-motivation condition than in the low-motivation condition and this may have impacted 3-year-olds' ability to effectively encode the instructions in the former condition. In order to succeed in the high-motivation condition, children had to successfully encode a three-step process: place the banana card in the box behind them, receive a banana coin and operate the piggy bank. However, in the low-motivation condition, children simply had to encode the first step of this process. Recall that to be included in the study, children had to successfully answer the comprehension question at the end of the task, clearly demonstrating that children in the high-motivation condition knew where to place the banana cards. However, anecdotal evidence suggests that some may have failed to encode all three steps of the process; several children interrupted the ongoing task to ask the researcher *when* they could use the piggy bank (some children even pointed to the piggy bank while asking this question), clearly indicating that they recalled that the piggy bank had been placed behind them during the task instructions. But, they had not fully connected the PM task (banana cards) to using the piggy bank. This suggests that at least some 3-year-olds may have not fully understood the way in which the end goal (receiving a coin and using the piggy bank) was related to the PM task (placing the banana card behind them) even though they correctly stated where the banana cards should go after the task was over. Future studies could implement a practice trial to allow children to perform this three-step process prior to beginning the test trials as well as ask a memory question at the end of the task to verify children's comprehension of this more complex three-step process.

Second, it is possible that the 3-year-olds struggled to retain this three-step process in

mind while also performing the ongoing task due to less developed WM skills. Finally, it is possible that the piggy bank was too exciting and served as a distraction to the 3-year-olds. This younger group may have been consumed by their anticipation to operate the piggy bank, thereby leaving them with insufficient EF resources to effectively perform the PM task even though they were able to later recall the PM rule. If this is true, then children's WM resources could have been consumed by thoughts about utilizing the piggy bank and their IC could have been over powered by their excitement. The anecdotal evidence stated above is consistent with this claim by indicating that at least some children were thinking about their desire to use the piggy bank throughout the ongoing task. Future studies could implement a practice trial to allow children to use to piggy bank prior to test trials. This could allow children to 'release' some of their excitement and may improve their focus throughout the test trials. Further, future studies may consider using a less-exciting motivator to reduce such possible effects.

The direction of this motivation effect is in conflict with the literature which almost unanimously shows that motivation significantly improves performance (Causey & Bjorklund, 2014; Kliegel et al., 2010; Slusarczyk & Niedwienska, 2013; Somerville et al., 1983). This discrepancy may be attributed to the way in which motivation is manipulated. In these prior studies, motivation was manipulated intrinsically, meaning that both the PM action (e.g., asking for a sticker) and the PM outcome (e.g., receiving a sticker) were motivating. However, in the present study, motivation was manipulated extrinsically such that the PM action was mundane (i.e., placing the banana card in a box behind them) and only the PM outcome was exciting (i.e., using a coin to operate the mechanical piggy bank). The present findings may suggest that extrinsically and

intrinsically motivating tasks have differential effects on PM performance.

To the best of my knowledge, Guajardo and Best (2000) are the only other researchers to manipulate motivation extrinsically. Recall that in their task, children played a computer game in which they saw a series of pictures one by one and were informed that they would have to recall the images at the end of the task. Children were also instructed to press the spacebar when they saw a specified target picture (e.g., a duck) that was shown repeatedly. Motivation was manipulated such that half of the children immediately received a small reward every time they pressed the spacebar while the others did not.

Guajardo and Best (2000) did not find a significant main effect of motivation. There are several methodological differences between Guajardo and Best's (2000) study and the present study that may account for the differential findings. First, although the PM instructions in Guajardo and Best's (2000) study were more simplistic than that of the present study, their ongoing task was much more taxing on children's EF abilities. This may have left children with insufficient resources for the PM task and impeded the reward's ability to improve their PM performance beyond that of the low-motivation condition. Second, it is possible that a number of children in Guajardo and Best's (2000) study were unable to adequately remember the PM instructions; unlike the present study, the researchers did not ask a comprehension question at the end of the PM paradigm to screen out children with poor recollection of these instructions. Therefore, it is possible that such children may have accounted for a large proportion of those who were unsuccessful on the PM task, potentially masking a true effect of motivation. Finally, it is possible that the level of motivation achieved by the high-motivation task differed in

the two studies. Perhaps the children in Guajardo and Best's (2000) study were insufficiently motivated by the rewards (goldfish crackers, goldfish pretzels, pennies or fruit chews), hindering the high-motivation condition from bolstering their PM performance. While the anecdotal evidence from the present study suggests that the piggy bank was very exciting, it appears to have been so exciting that it distracted younger children and worsened their PM performance. A future study could examine the effects of differentially motivating motivators.

The interaction effect between age and motivation is also not consistent with the majority of previous research. Only one (out of five) previous studies found a significant interaction (Kliegel et al., 2010). Kliegel and colleagues (2010) found that 3-year-olds performed better in the high-motivation condition while 5-year-olds performed comparably across the motivation conditions. However, the remaining four studies did not find an interaction such that motivation bolstered children's PM performance regardless of age (Causey & Bjorklund, 2014; Guajardo & Best, 2000; Slusarczyk & Niedzwinska, 2013; Somerville et al., 1983). This may indicate that, compared to the present study and Kliegel et al.'s (2010) study, those four PM tasks were more difficult or more taxing on children's EF skills and lead even the older children (4- to 6-year-olds) to benefit from the more motivating conditions. This claim is supported by the fact that the 5-year-olds in the present study performed at ceiling on the PM task, clearly indicating that the task was easier than those utilized in prior studies in which greater variability was found among the older children.

This study aimed to manipulate motivation extrinsically not only because merely one study has but also because of an argument made by Causey and Bjorklund (2014).

Specifically, these researchers postulated that manipulating motivation intrinsically may inaccurately represent a true PM scenario which should be characterized by *spontaneous* remembering. The researchers argued that intrinsically motivating tasks may lead children to become consumed by their excitement to perform the PM action, potentially leading them to mentally rehearse the PM action throughout the ongoing task. However, the present study seems to indicate that extrinsically motivating tasks can also lead children to become consumed by their excitement but instead with respect to receiving or performing the PM outcome. This suggests that my PM outcome (in the high-motivation condition) may have been too motivating, thereby consuming children's thoughts throughout the ongoing task and ultimately leaving them unable spontaneously recall the PM action.

The third hypothesis, which stated that the early-placement goal maintenance condition would result in a better total PM performance score than the late-placement goal maintenance condition, was not supported. Instead, children's total PM score did not differ based on the placement of the target cards, suggesting that receiving a greater number of target cards early in the ongoing task did not improve children's performance overall. Prior to examining the fourth, fifth and sixth hypotheses, the seventh hypothesis, which concerned children's performance on the first and second comparison pairs, will be discussed.

Recall that by the first comparison pair (positions 10 and 13; see Figure 1 on page 53), which is the first pair of target cards that is common across conditions, children in the early-placement condition had already received one pair of target cards (positions 2 and 5) while children in the late-placement condition had not. By the second comparison pair

(positions 32 and 40), all children had received two prior pairs regardless of condition. Interestingly, across the whole sample, children performed better on the second comparison pair than on the first, suggesting that children's performance improved with repeated exposure to the target cards. This effect is qualified by a significant interaction between comparison pair and goal maintenance (discussed below).

The seventh hypothesis, which predicted that children in the early-placement condition would demonstrate better PM performance on the first comparison pair (positions 10 and 13) than children in the late-placement condition, was supported. The first comparison pair was designed to examine how the proportion/number of target cards effects children's PM performance. However, although children in the early-placement condition performed better on the first comparison pair than children in the late-placement condition, the effect of having seen a greater proportion of target cards (2/13 vs. 0/13) and simply having had previous exposure to more target cards (2 vs. 0) cannot be parsed apart. Examining the target card in the 10th position indicates that children in the early-placement condition who had seen two previous target cards performed more favourably than children in the late-placement condition who had not seen any previous target cards (80% vs. 59%). Though not part of the original analyses, a follow-up *t*-test demonstrated that performance on this target card was only marginally significantly different by goal maintenance condition⁹. This indicates that prior exposure to target cards (though not necessarily position) somewhat impacts children's PM performance and therefore should be controlled when examining the effect of proportion/number.

⁹ $t(83.3) = 2.16, p = 0.03$; a Bonferroni corrected alpha of 0.025 was used (0.05 was divided by two to also account for both this *t*-test and the one on the following page).

Thus, to better understand the effect of proportion/number, performance on the target card in the 13th position should be examined. By this target card, all children had already seen at least one target card and the proportion/number of previously seen target cards varied by goal maintenance condition. By this card, children in the early-placement condition had seen a greater proportion/number of target cards (3/12) than children in the late-placement condition (1/12). Children in the early-placement condition were more successful at sorting the 13th card than children in the late-placement condition (82% vs. 66%), suggesting that the proportion/number of previously seen target cards does effect PM performance. However, though not part of the original analyses, a follow-up *t*-test demonstrated that performance on this target card was not significantly different by goal maintenance condition¹⁰.

Taken together, the results of the two-tests suggest that proportion/number and exposure significantly impact children's PM performance in conjunction but not individually. The proportion/number of target cards varies substantially in the literature (see Table 1 on page 41). However, no previous studies have examined the effect of these variables on children's PM performance. While the proportion of target to non-target cards and the number of target cards are conflated in the present study, a future study could examine these two variables independently. A more detailed description of how this could be done is presented in the forthcoming future directions section.

The eighth hypothesis, which predicted that children in the early-placement condition would demonstrate better PM performance on the second comparison pair (positions 32

¹⁰ $t(83.2) = 1.72, p = 0.09$; a Bonferroni corrected alpha of 0.025 was used (see footnote on previous page).

and 40) than children in the late-placement condition, was not supported. This comparison pair was designed to evaluate the effect of initial target card placement on later PM performance. Recall that by this comparison pair, all children had received an equal proportion/number of prior target cards (4). However, children in the early-placement condition had received target cards earlier in the ongoing task while children in the late-placement condition had received prior target cards more recently. This hypothesis was based on the expectation that early exposure to target cards would solidify children's memory of the PM task instructions and enable them to be more successful on later target cards than children without this early exposure. However, children performed similarly on the second comparison pair regardless of card placement, demonstrating that earlier exposure to target cards did not improve children's later performance on the PM task.

Alternatively, this finding may suggest that the time-lapse before the presentation of the first target card in the late-placement condition (10th position) was not long enough to produce the effect predicted in the eighth hypothesis. It is possible that extending this gap by presenting the first target card in the 20th position for the late-placement condition, for example, would have led children in this condition to perform less favourably on the second comparison pair as compared to children in the early-placement condition. This would provide support for the notion that early exposure, relative to much later initial exposure, better solidifies children's memory of the PM instructions and produces long-term benefits to children's PM performance. Future work could investigate this issue by adopting several conditions in which the length of time before the presentation of the first card varies. However, increasing the elapsed time may also cause more children to

forget the PM instructions completely (i.e., fail the post-PM task memory question) and be eliminated from the analyses. The current study suggests that this could happen; of the fourteen children who were removed for failing the post-PM memory question in the current study, 10 were in the late-placement condition. If these children forgot the task instructions as a result of the time delay, then excluding them may have biased the effect of goal maintenance on PM performance.

Previous studies examining the effect of target card placement on PM performance only compared target cues that were placed in the middle with those placed at the very end of the ongoing task (Kvavilashvili et al., 2001; Wang et al., 2008; Ford et al., 2012). In these studies, only one target cue was included in the ongoing task. The placement of this target cue was manipulated within subjects such that children participated in the ongoing task twice, once when the target cue was in the middle of the task and once when the target cue was at the very end of the task. These studies consistently demonstrated that children perform better when the target is at the end of the ongoing task and the researchers postulate that this effect may be attributable to the reduced demands on IC since children knew they were on the final stimuli and the target card must be coming since it had not yet appeared.

Children in these prior studies only received the first target cue in the 5th, 7th or 10th positions (depending on the total number of cards in the set). The present study, in which children in the early-placement condition received their first card in the 2nd position, may suggest that receiving the first target card even earlier (and thereby more recently after the task instructions) may lead children to be equally or more successful than when the target card is placed in the final position (as evidenced by overall success rates). The

present study demonstrates that children's performance on the first target card is dependent on its placement in the ongoing task; children in the early-placement condition performed more favourably on the first target card (2nd position; 82%) than children in the late-placement condition (10th position; 59%). Moreover, receiving the initial target card early in the ongoing task led children to perform with equal success on the first and last target cards (82% vs. 82%). However, receiving the initial target card later in the ongoing task appears to have lowered children's performance on that card, resulting in worse performance on the first target card relative to the last target card (59% vs. 80%). Thus, the present study suggests that receiving the first target card early in the ongoing task can equate children's performance with that of the last target card when, according to Kvavilashvili et al. (2001), Wang et al. (2008) and Ford et al. (2012), the IC demands are reduced. Nonetheless, the present study cannot be directly compared to the prior studies since performance on the last target card was also influenced by the previous target cards, a variable that did not exist in the prior studies. As a result, a future study is required to truly understand whether presenting the first target card earlier in the ongoing task can equate children's performance on these trials.

Taken together, children's performance on the first and second comparison pairs demonstrated that receiving the first target card very early on in the ongoing task (2nd position) resulted in higher PM performance on that card relative to receiving the first card later (10th position). This may be attributable to children more readily recalling the PM instructions (which were presented more recently) or being less engaged in the ongoing task. However, receiving the first target card that early did not improve children's overall performance on the PM task. Rather, by the end of the task, it is the

mere presence of previous target cards and not their placement or recency to the current trial that effects children's performance. Specifically, children in the early-placement condition likely performed better on the first comparison pair because they had had previous exposure while children in the late-placement condition had not. However, by the second comparison pair, children in both conditions had seen the same number of previous target cards and therefore achieved the same level of performance.

I will now turn to the hypotheses pertaining to the interactions between age and goal maintenance and motivation and goal maintenance. The fifth hypothesis, which predicted no age by goal maintenance interaction, was supported; 4-year-olds performed better on the PM task than 3-year-olds regardless of goal maintenance condition. However, this hypothesis was not supported in the way that was predicted. This hypothesis was nested in third hypothesis which predicted a main effect of goal maintenance such that children would perform more favourably in the early-placement condition than the late-placement condition. Thus, it was expected that children would perform better in the early-placement condition regardless of age, assuming that both age groups would benefit from the reduced WM demands of the early-placement condition since neither has reached their full developmental capability on this skill. However, given that no main effect of goal maintenance emerged, finding no age by goal maintenance interaction does not support the fifth hypothesis in the way that was expected.

The sixth hypothesis, which predicted a motivation by goal maintenance interaction, was not supported; (younger) children performed more favourably in the low-motivation condition than the high-motivation condition and this was not impacted by goal

maintenance condition. This hypothesis predicted that the low-motivation condition and late-placement conditions in conjunction would result in the lowest PM performance (compared to the other three conditions) since this combination of factors would place a greater strain on children's EF. Again, this hypothesis was nested in the second and third hypotheses which predicted main effects of motivation and goal maintenance. Given that the main effect of motivation was not in the predicted direction and no main effect of goal maintenance was found, the sixth hypothesis is no longer meaningful in the context of this study's findings.

A significant four-way interaction between comparison pair, age, motivation and goal maintenance was also found. However, four-way interactions are very complex and thus difficult to interpret, so I am not able to offer an explanation of this finding.

Relation Between PM and Executive Functioning

The ninth hypothesis predicted that children's PM performance would be positively correlated with IC and WM. Consistent with prior research, children's PM performance was positively correlated with IC (Dimensional Change Card Sort and Black / White Stroop) and WM (Auditory Backward Digit Span; Causey & Bjorklundm 2014; Ford et al., 2012; Mahy et al., 2014; Mahy & Moses, 2011). The tenth hypothesis further predicted that IC and WM factor scores (derived from a principal components analyses) would predict children's PM performance across motivation and goal maintenance conditions, even after controlling for age and language ability. However, since one of the IC measures (Simon Says) was eliminated due to a poor performance on the screener trials (see pages 70 - 71 for details), the relevant principal component analyses were no longer possible. As a result, an exploratory factor analysis was instead conducted and an

overarching EF factor emerged (based on all of the five remaining EF measures).

Finding a single EF factor is consistent with other work examining EF development in preschoolers (e.g., Fuhs & Day, 2011; Wiebe, Espy, & Charak, 2008; Wiebe, Sheffield, Nelson, Clark, Cheavlier, & Espy, 2011; see Lee et al., 2013, for a review).

The analyses demonstrated that EF independently predicted PM, above and beyond the contributions made by age and general language ability, thereby indicating that children with more advanced EF abilities were more successful on the PM task. This finding is consistent with previous studies demonstrating the relation between PM and IC (Ford et al., 2012; Mahy et al., 2014), WM (Ford et al., 2012; Mahy & Moses, 2011) and overall EF (Causey & Bjorklund). Moreover, this study converges with Causey and Bjorklund's (2014) finding that children's PM performance was predicted by their composite EF score in both the low- and high-motivation conditions. Similarly, the present study supports Ford et al.'s (2012) finding that children's IC and WM abilities predict their PM performance regardless of target card placement.

The present study is also merited for addressing some methodological concerns found in the literature. First, the informativeness of Mahy and Moses' (2011), Ford et al.'s (2012) and Mahy et al.'s (2014) findings are weakened by their use of only one measure of either WM or IC. The exploratory factor analysis used in the present study is merited because it removes much of the variance that is accounted for by other extraneous skills, thereby creating a more valid measure of executive function. Therefore, this method is also preferred to that of Causey and Bjorklund (2014) who simply created an average EF score from children's standardized scores on seven measures.

Second, some of the prior studies did not control for age or language ability in their

regression analyses (Causey & Bjorklund, 2014; Mahy & Moses, 2011). The present study's regression analyses demonstrated that age independently predicted PM performance while language ability did not. Nonetheless, the present study controlled for both variables and still found EF to be a significant predictor of PM performance. Finally, the inclusion of the Simon Says task may have biased Mahy et al.'s (2014) sample. As per the researcher's task protocol, children only complete this task if they are successful on one of the three practice trials. Thus, children who complete the task and are therefore included in the analyses may have more advanced IC abilities than children who are not successful on the practice trials, resulting in a more advanced final sample for subsequent analyses. The present study excluded this task from analyses because it reduced the sample size substantially and, in retrospect, would have resulted in a more biased sample had it been retained. Thirty-five percent of children in the present study failed these practice trials and slightly different patterns of correlations between EF measures and PM performance emerged when only this subset of children were included in the analyses (See Appendix X).

The eleventh hypothesis speculated that EF abilities would be a weaker predictor of PM performance among children in the high-motivation condition than in the low-motivation condition. This hypothesis was grounded in the notion that highly motivating tasks would be easier by reducing the EF requirements. Again, this hypothesis was not supported; EF was an equal predictor of PM performance across all motivation conditions. This is surprising since, although contrary to the original hypothesis, the abovementioned results suggest that children's EF would be a stronger predictor in the high-motivation condition; 3-year-olds performed more poorly in this condition and it is

speculated that the more complex instructions in the high-motivation condition and the distraction of the piggy bank would have placed a greater strain on children's EF. However, this effect may have been clouded by the 4-year-olds who performed comparably across motivation conditions.

The eleventh hypothesis also speculated that EF abilities would be a weaker predictor of PM performance in the early-placement condition than in the late-placement condition. This hypothesis was based on the speculation that the late-placement condition would make it more difficult to retrieve the PM rule from memory (due to elapsed time). Moreover, I expected that children with stronger EF abilities would be more successful at shifting their attention from the ongoing task to the PM task since they have greater WM resources (to recognize the target card and then retrieve the memory) and greater IC resources (to stop the ongoing task to follow through on the PM requirement). However, this hypothesis was not supported; EF was an equal predictor of PM performance across goal maintenance conditions. This hypothesis was nested in the predicted main effect of goal maintenance which postulated that children would demonstrate more advanced PM performance in the early-placement condition than the late-placement condition. However, since no main effect of goal maintenance was found, it is not surprising that individual differences in children's EF abilities did not impact their performance in these conditions.

The regression analysis also revealed that EF abilities were a stronger predictor of 3-year-olds' performance than 4-year-olds' performance. This suggests that the PM task was more difficult for the 3-year-olds because they had less developed EF skills. A mediation analysis revealed that EF fully mediated the relation between age and PM

performance, indicating that age-related differences in EF abilities fully explain the relation between age and PM performance. In other words, age alone does not account for differences in PM performance. Rather, age-related differences in EF contribute to the development of PM such that children with more advanced EF skills perform better on the PM task regardless of their chronological age. This finding is consistent with that of Mahy and Moses (2011) who demonstrated that IC fully mediated the relation between age and PM. However, the present study extends Mahy and Moses' (2011) finding by employing a more reliable measures of EF (the prior researchers only used one measure of IC) by creating a single factor from five tasks.

Limitations and Future Directions

Although the present study provides valuable insight into the predictors of children's PM performance and factors that do (or do not) make a difference, there are a number of limitations that need to be acknowledged. First, since this study was initially designed for 4- and 5-year-old children, some of the IC and WM tasks were too difficult for the 3-year-olds. As a result, several of these younger children performed at floor on these tasks. This limitation is difficult to overcome, however, since most measures of EF do not produce variability in both 3- and 4-year-olds. Thus, in retrospect, it would have been better to only collect data on a larger sample of 4-year-old children who do not perform at floor and also display more variability on these tasks. However, this limitation is qualified by the fact that many of the 3-year-olds did demonstrate some success on the EF measures as well as the PM task.

Second, as was mentioned, the results indicate that the piggy bank was more of a distraction than an enhancement to the younger children's performance. Given that the

only other study that utilized an extrinsically motivating PM task did not find an effect of motivation, further research is needed to understand how to best manipulate motivation extrinsically and how this manipulation affects children's PM performance. Future work could examine the effect of differentially motivating motivators. It may be that the increasing motivation of the PM task benefits PM performance but only up to a certain point, after which it decreases performance by acting as a distractor. One challenge for such a study would be to find an objective measures of how motivating different motivators actually are in order to test for this possibility.

Third, with respect to examining the effect of goal maintenance, the methodology of the present study did not allow me to differentiate between the effect of the proportion of target to non-target cards and the number of previously seen target cards (these two variables were conflated in the present study). Differentiating between these two constructs was not a goal of the current study; this study aimed to compare the effects of placement and proportion and could not independently manipulate the number of previously seen target cards as well. Thus, future studies should examine these variables independently to gain an understanding of their unique effects on children's PM performance. To examine how proportion impacts children's PM performance, a study could examine four different conditions (between subjects), for example, in which the proportion systematically varies but the number of exposures remains constant. The first target card could be shown in the 2nd, 7th, 12th or 17th positions such that all children have not seen any previous target cards and the proportion of target cards to non-target cards varies from 0/1 to 0/16. The second card could be shown in the 7th, 12th, 17th or 22nd positions such that all children have seen one previous target card and the proportion

varies from 1/6 to 1/21. This pattern could be repeated to include the desired number of target cards.

To examine how the number of previously seen cards impacts children's PM performance, a study could compare preschoolers' performance across four conditions (between subject), for example, in which the number systematically varies but the proportion remains constant. For example, children's performance could be compared on trials where the proportions are 1/3 and 2/6 or 2/5 and 4/10. Thus, children would have seen a different number of target cards (1 vs. 2 or 2 vs. 4) but equal proportions of target to non-target cards (1:3 or 2:5) before the test card of interest (the comparison trial).

It is worth noting that these two potential studies would also be confounded by the elapsed time before children receive their first target card. However, it is not clear that elapsed time can be held constant while varying proportion/number of cards. Prior studies have indicated that the elapsed time does influence children's PM performance; Sommerville et al. (1983) found that 2- to 4-year-olds performed more favourably after a short delay (1 to 5 minutes) than a long delay (several hours or over night). Mahy and Moses (2011) examined this short delay more thoroughly and found that 4- to 6-year-olds performed more favourably after a 5-minute delay than a 1-minute delay. Future studies could examine whether lengthening the elapsed time before presenting the first target card prevents children in the late-placement condition from ultimately achieving the same overall level of performance (by the end of the task) as children in the early-placement condition.

Fourth, the methodology of the present study also limited the ability to parse apart whether children's PM performance was attributable to simply having had prior exposure

to target cards or due to the proportion of previously seen target cards to non-target cards. The first card in comparison pair one was evaluated to examine the effect of prior exposure but children in the early-placement condition had already received two prior target cards by that point in the task. A future study could compare children's performance when they have had no prior exposure and only one prior exposure. This would minimize the difference in proportion and provide a more accurate depiction of the effect of simply having been exposed to target cards.

Fifth, the present study could not examine the differential effects of IC and WM since one measure of IC was dropped from analyses, thereby not allowing for a principal components analysis on that construct. While it is informative to conclude that EF abilities contribute to children's PM performance, more specific applications could have been formulated if the results had implicated particular skills. In retrospect, the test trials in the Simon Says task should have been completed with all children (contrary to that measure's instructions) regardless of their performance on the practice trials. This would have been consistent with the way in which other IC and WM measures are administered.

Finally, a number of the children were unable to identify a few of the cards in the ongoing task (i.e., yogurt, scarf, popsicle, desk, skipping rope). As a result, the researchers had to tell children the names of some of the items in order to be confident that children's errors on the ongoing task were not related to identification errors. This was successful, however, as performance on the ongoing task was 96% (overall). Since the ongoing task was designed to be easy for children, in retrospect, I should have piloted these cards on a small number of children prior to beginning the full study.

Applications

Despite its limitations, this study has several real-world applications. This study indicates that offering young children rewards for successful PM performance should be considered carefully since some rewards will only serve to distract children instead of help them. This has implications in both home and school settings as parents and teachers should employ motivators that do not ‘overwhelm’ young children’s attention. The results also suggest that older children (4-year-olds) are more robust to very exciting motivators but do not necessarily benefit from them.

This study also demonstrates that providing children with a PM cue relatively soon after the task instructions (e.g., 2nd position) improves their performance on that cue while providing children with repeated opportunities to practice the PM task can improve their performance on PM cues that are presented after a longer delay. Thus, parents and teachers should give children the PM task instructions shortly before they expect them to complete the task (e.g., reminding children as they enter the washroom to wash their hands after they have finished using the toilet) and provide children with repeated opportunities to practice those tasks.

Finally, this research converges with prior studies demonstrating the strong relation between EF and PM performance. Thus, parents and teachers should be particularly sensitive to children’s developing EF abilities when expecting them to perform PM actions. This is especially true among younger children (3-year-olds) who have less developed PM abilities and therefore experience more difficulty on these tasks. Parents and teachers should be mindful of the complexity of the PM task instructions in order to ensure that children are able to successfully encode the PM task instructions as well as maintain them in mind during their current activity. Moreover, parents and teachers

should be aware that simply being able to recall the PM rule is not a clear indicator of whether or not a child can perform the PM action; rather, more complex processes are required for children to inhibit their current task and maintain the task instructions.

These applications might be particularly useful among children with impaired EF abilities, such as children with Autism Spectrum Disorder or Attention Deficit Disorder (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004).

Conclusion

The current study has expanded on our current understanding of preschool-aged children's PM ability. First, this study demonstrated, in contradiction to previous work, that 3-year-old children successfully sorted *fewer* target cards in a high-motivation condition relative to a low-motivation condition. This may indicate that young children's excitement to play with the piggy bank served as a distraction, that the more complex instructions of the high-motivation condition were too extensive for children to encode or maintain in memory during the ongoing task, or that both occurred. Future research is needed to pinpoint which of these factors contributed to children's poorer performance in this condition. This study also demonstrated that 4-year-olds performed comparably across motivation conditions, supporting the notion that methodological limitations may have led prior studies to underestimate the PM abilities of this older age group.

Second, the present study revealed that children who received a greater proportion/number of target cards early in the ongoing task performed better on the early target trials than children who received a greater proportion/number of target cards later in the ongoing task. However, by the end of the ongoing task, the performance of children in the late-placement condition was equivalent to that of children in the early-

placement condition, suggesting that early exposure to target cards does not have a long-term benefit to children's PM performance. Moreover, this finding also suggests that repeated exposure to the PM cues can also boost children's performance. Future research is required to develop a more thorough understanding of how proportion, number (of previous seen target cards) and placement impact children's PM performance.

Finally, extending on previous research, this study demonstrated that EF significantly predicted children's PM performance and fully mediated the relation between age and PM performance while employing a more reliable measure of EF and controlling for language ability. Thus, this study makes very clear the important role of EF skills to children's PM performance.

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Appendix A: Ethics Approval (Carleton University)

Clearance Certificate
✕

Carleton University Research Ethics Board (CUREB)

Certificate of Ethics Clearance

Principal Investigator

Department

Study Number

Alicia Bartlett

Psychology

16-051

Co-Investigators and other researchers:

Researcher	Study Role	Position
Sarah Gardiner	Other Research Personnel	Masters Candidate
Katherine Andrews	Other Research Personnel	Graduate Student
Audrey Brown	Other Research Personnel	Masters Candidate
Deepthi Kamawar	Faculty Supervisor	Faculty

Study Title: **Event-Based Prospective Memory and Executive Functioning: The Effects of Motivation and Goal Maintenance Support**

Approval Date: 02/26/2016

Expiry Date: 08/31/2016

Approval Type: Final

Submitted Date	Study Component	Approval Date

Validity Term:

Comments:

Certification

The protocol describing the above-named project has been reviewed by Carleton University Research Ethics Board and the research procedures were found to be acceptable on ethical grounds for research involving human participants.

Chair, Carleton University Research Ethics Board (CUREB)

This Certificate of Clearance is valid for the above term provided there is no change in the research procedures.

Close

Print

Appendix B: Ethics Approval (School Board)

Ottawa-Carleton Research and Evaluation Advisory Committee (OCREAC)

May 16, 2016

Alicia Barlett
32 Zokol Crescent
Kanata, Ontario
K2K 2K4

Re: **Event Based Prospective Memory and Executive Functioning: The Effects of Motivation and Goal Maintenance Support**

Dear Ms Barlett,

The Ottawa-Carleton Research and Evaluation Advisory Committee (OCREAC) has reviewed the revisions you have made to your research application and is granting you **approval** to conduct research in the Ottawa-Carleton District School Board and the Ottawa Catholic School Board. However, the final approval to participate in the study must come from the school principal.

The committee requests that at all times in which your research team is in our schools, their police clearance and a copy of this letter of approval be shown to the school staff.

In order to facilitate access to the schools, please contact me for the Ottawa-Carleton District School Board and Dr. Lauren Figueredo for the Ottawa Catholic School Board (lauren.figueredo@ocsb.ca or 613-224-4455 ext. 2341).

Should you have questions regarding this letter, please contact me directly. On behalf of the Ottawa-Carleton Research and Evaluation Advisory Committee, I thank you for approaching the Ottawa-Carleton area school boards as venues for your study and we wish you success in your research study.

Sincerely,

Tsala
Botsalano T. Mosimakoko, Ph.D. (Chair, OCREAC)
Research Officer, Quality Assurance
Ottawa-Carleton District School Board
613-596-8211 ext. 8571
tsala.mosimakoko@ocdsb.ca

On behalf of the Ottawa-Carleton Research and Evaluation Advisory Committee

Ottawa Catholic School Board
570 Hunt Club Road West • Nepean • Ontario • K2G 3R4

Ottawa-Carleton District School Board
133 Greenbank Road • Nepean • Ontario • K2H 6L3

Appendix C: Program Coordinator Informed Consent Form (Daycare)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear Program Coordinator,

As part of a current project on children's cognitive development, we are talking to children to learn about their developing ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (approval number #16-051; valid until 31/08/2016). In this letter, we will describe the project and request your permission for your centre's participation.

Should you wish to participate in the current project, we will provide you with individual informed consent letters to distribute to the parent(s) or guardian(s) of the four- and five-year-old children in your centre. Once consent letters have been returned to you from parents, we will arrange a convenient time for you to have our researchers at your centre to conduct the study. The researchers all have current police record checks, and copies of these documents will be provided to you before we commence any interviews with the children at your centre. The researchers will also be sensitive to the children at all times.

We are interested in children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children will be shown a series of cards, one by one. Children will be asked to say what is on each card (images of common items, including food and vehicles). Then, they will have to put the cards in boxes depending on whether the picture is of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They will also be asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box.

We are interested in examining whether children will do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We also want to find out if children have a better chance at remembering to look for the special cards when they get more special cards early in the game. We will also play games that measure related skills, such as memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child twice, for approximately 20-25 minutes each time. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the session and will still receive their stickers.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Alicia Bartlett, M.A. Candidate, and she can be reached by email at aliciabartlett@cmail.carleton.ca. This study is funded by the the Federal Government (Social Sciences and Humanities Research Council, Natural Sciences and Engineering Research Council of Canada) and the primary researcher's graduate funding from Carleton University.

This study has been approved by Carleton University's Research Ethics Board-B (ethics protocol number: #16-051) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

Your consent is required for your centre's participation in this project. Kindly sign the attached consent form indicating whether we may provide you with individual consent forms for parents or guardians of children within this age range in your centre. If you would like a summary of the research results once the study is completed, please contact Alicia Bartlett. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.

Sincerely,

A black rectangular box redacting the signature of Deepthi Kamawar.

Deepthi Kamawar, PhD

A black rectangular box redacting the signature of Alicia Bartlett.

Alicia Bartlett, M.A. Candidate

Carleton University Study – Preschoolers’ Development of Prospective Memory

The information collected for this project is confidential and protected under the Provincial Freedom of Information and Protection of Privacy Act.

I have read the attached description of the study of *Preschoolers’ Development of Prospective Memory* and I understand the conditions of my child care centre’s participation.

I understand that the study will require two 20- to 25-minute testing sessions, with children of appropriate ages, whose parents/guardians have given written consent for their children’s participation in the research project.

Name of Child Care Centre: _____

Address: _____

Signature: _____

Date: _____

Name & Title: *(please print)*: _____

Appendix D: Principal Informed Consent Form (School)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear School Principal,

As part of a current project on children's cognitive development, we are talking to children to learn about their developing ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (approval number #16-051; valid until 31/08/2016) and the Ottawa-Carleton Research and Evaluation Advisory Committee. In this letter, we will describe the project and request your permission for your school's participation.

Should you wish to participate in the current project, we will provide you with individual informed consent letters to distribute to the parent(s) or guardian(s) of the four- and five-year-old children in your school. Once consent letters have been returned to you from parents, we will arrange a convenient time for you to have our researchers at your school to conduct the study. The researchers all have current police record checks, and copies of these documents will be provided to you before we commence any interviews with the children at your school. The researchers will also be sensitive to the children at all times.

We are interested in children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children will be shown a series of cards, one by one. Children will be asked to say what is on each card (images of common items, including food and vehicles). Then, they will have to put the cards in boxes depending on whether the picture is of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They will also be asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box.

We are interested in examining whether children will do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We also want to find out if children have a better chance at remembering to look for the special cards when they get more special cards early in the game. We will also play games that measure related skills, such as memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the school teacher, so

that all children get some, even if their parents have not consented to their participation.

We will meet with each child individually, for two sessions lasting approximately 20-25 minutes each. These sessions will take place approximately one week apart. These sessions can take place wherever works best for you and your teachers – either in a quiet corner of the classroom, in the hallway just outside of the classroom, or in a lunch room or library. The sessions can also take place whenever works best for you and your teachers – either during classroom time or spare time – while ensuring that a teacher will be present at all times. We want to minimize inference with the children’s daily routine.

Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don’t, they will not be pressured into participating. Children can stop playing at any time during the session without giving a reason and will still receive their stickers. Children who choose not to participate, or who’s parents did not provide written consent, will continue with their usual daily routine. No information will be collected from the files or records of individual students. The study results will not appear in any school records.

The information collected in this study is confidential and will be coded such that a child’s name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children’s names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child’s responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Alicia Bartlett, M.A. Candidate, and she can be reached by email at aliciabartlett@email.carleton.ca. This study is funded by the the Federal Government (Social Sciences and Humanities Research Council, Natural Sciences and Engineering Research Council of Canada) and the primary researcher’s graduate funding from Carleton University.

This study has been approved by Carleton University’s Research Ethics Board-B (ethics

protocol number: #16-051) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. This study has also been approved by the Ottawa-Carleton Research and Evaluation Advisory Committee (ethics protocol number: #16-XXX).

If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

Your consent is required for your school's participation in this project. Kindly sign the attached consent form indicating whether we may provide you with individual consent forms for parents or guardians of children within this age range in your school. The form need not be returned should you decline to participate. If you would like a summary of the research results once the study is completed, please contact Alicia Bartlett. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD

Alicia Bartlett, M.A. Candidate

Carleton University Study – Preschoolers’ Development of Prospective Memory

The information collected for this project is confidential and protected under the Municipal Freedom of Information and Protection of Privacy Act, 1989.

I have read the attached description of the study of *Preschoolers’ Development of Prospective Memory* and I understand the conditions of my school’s participation.

I understand that the study will require two 20-25 minute testing sessions, with children of appropriate ages, whose parents/guardians have given written consent for their children’s participation in the research project.

Name of School: _____

Address: _____

Signature: _____

Date: _____

Name & Title: *(please print)*: _____

Appendix E: Parent Informed Consent Form (Daycare)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their developing ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (approval number #16-051; valid until 31/08/2016). In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

We are interested in children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children will be shown a series of cards, one by one. Children will be asked to say what is on each card (images of common items, including food and vehicles). Then, they will have to put the cards in boxes depending on whether the picture is of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They will also be asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box. We are interested in examining whether children will do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We also want to find out if children have a better chance at remembering to look for the special cards when they get more special cards early in the game. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child twice, for approximately 20- to 25-minutes each time. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. The researchers all have current police record checks, and copies of these documents will be provided to the child care centre coordinator before we commence any interviews with your child. The researchers will also be sensitive to the children at all times. Children can stop playing at any time during the session and will still receive their stickers.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

Should you wish to participate in future research and consent to be contacted about the children who you have provided information about within the next five years, any contact information provided along with the names and birth dates of your child and other children in the family, will be kept in a password protected database and will only be available to researchers in our lab. We request the children's birthdates so that we know which families to contact as our studies involve different age groups. Once your children are older than twelve years, their information will be removed from our database. Future participation is completely voluntary and you can ask to be removed from our database at any time.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Alicia Bartlett, M.A. Candidate and she can be reached by email at aliciabartlett@cmail.carleton.ca. This study is funded by the the Federal Government (Social Sciences and Humanities Research Council, Natural Sciences and Engineering Research Council of Canada) and the primary researcher's graduate funding from Carleton University.

This study has been approved by Carleton University's Research Ethics Board-B (ethics protocol number: #16-051) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

Your consent is required for your child's participation in this project. Kindly sign the attached consent form indicating whether your child may participate in this research and return it to your child's daycare. If you would like a summary of the research results once the study is completed, please contact Alicia Bartlett. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD

Alicia Bartlett, M.A. Candidate

Carleton University Study – Preschoolers’ Development of Prospective Memory

The information collected for this project is confidential and protected under the Provincial Freedom of Information and Protection of Privacy Act.

I have read and understood the request for my child to participate in the study of *Preschoolers’ Development of Prospective Memory*. I have discussed it with my child and ...

☐ I consent to my child’s participation in the current study
[please fill out the next page]

☐ I do not consent to my child’s participation in the current study

Child’s Name (please print): _____

Parent’s/Guardian’s Name (please print): _____

Signature: _____

Date: _____

Participant Information

If you have consented to your child participating on the previous page, please provide us with the following information about your child. If you have not provided consent, please do not fill out this page.

Please note: your child's name and birth date will be kept separate from their data and consent form, and only researchers directly involved in this project will have access to this information.

Child's Date of Birth: year _____ month _____ day _____

Please indicate the language(s) spoken at home and then please circle the one(s) that your child is fluent in: _____

Participation in Future Research at the Children's Representational Development Lab

In our lab we conduct many other studies that children find quite enjoyable (usually in the form of games and stories). We provide free parking and a small 'thank-you' gift to the children (a book).

May we contact you in the future to see if you are interested in having any of your children participate in other projects? All participation would be completely voluntary and you would be under no obligation to participate if we contact you. We will not share your personal information with anyone and we will remove children from our database once they are 12 years old.

____ Yes If yes, please provide phone number or email:

____ No

Other Children in the family:

Child's Name: _____

Date of Birth: year _____ month _____ day _____

Child's Name: _____

Date of Birth: year _____ month _____ day _____

Child's Name: _____

Date of Birth: year _____ month _____ day _____

Appendix F: Parent Informed Consent Form (School)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their developing ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (approval number #16-051; valid until 31/08/2016) and the Ottawa-Carleton Research and Evaluation Advisory Committee. In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

We are interested in children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children will be shown a series of cards, one by one. Children will be asked to say what is on each card (images of common items, including food and vehicles). Then, they will have to put the cards in boxes depending on whether the picture is of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They will also be asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box.

We are interested in examining whether children will do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We also want to find out if children have a better chance at remembering to look for the special cards when they get more special cards early in the game. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the school teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child individually, for two sessions lasting approximately 20-25 minutes each. These sessions will take place approximately one week apart. These sessions will take place wherever works best for your child's teacher – either in a quiet

corner of the classroom, in the hallway just outside of the classroom, or in a lunch room or library. The sessions will also take place whenever works best for your child's teacher – either during classroom time or spare time – while ensuring that a teacher will be present at all times. We want to minimize inference with your child's daily routine.

Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. The researchers all have current police record checks, and copies of these documents will be provided to the school principal before we commence any interviews with your child. The researchers will also be sensitive to the children at all times. Children can stop playing at any time during the session without giving a reason and will still receive their stickers. Children who choose not to participate, or who's parents did not provide written consent, will continue with their usual daily routine. No information will be collected from the files or records of individual students. The study results will not appear in any school records.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Alicia Bartlett, M.A. Candidate, and she can be reached by email at aliciabartlett@cmail.carleton.ca. This study is funded by the the Federal Government (Social Sciences and Humanities Research Council, Natural Sciences and Engineering Research Council of Canada) and the primary researcher's graduate funding from Carleton University.

This study has been approved by Carleton University's Research Ethics Board-B (ethics protocol number: #16-051) and has been deemed minimal risk. Some participants may

find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. This study has also been approved by the Ottawa-Carleton Research and Evaluation Advisory Committee (ethics protocol number: #16-XXX).

If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

Your consent is required for your child's participation in this project. Kindly sign the attached consent form indicating whether your child may participate in this research and return it to your child's daycare. The form need not be returned should you decline to participate. If you would like a summary of the research results once the study is completed, please contact Alicia Bartlett. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD

Alicia Bartlett, M.A. Candidate

Carleton University Study – Preschoolers’ Development of Prospective Memory

The information collected for this project is confidential and protected under the Municipal Freedom of Information and Protection of Privacy Act, 1989.

I have read and understood the request for my child to participate in the study of *Preschoolers’ Development of Prospective Memory*. I have discussed it with my child and ...

☐ I give permission for him/her to participate. **[please fill out the next page]**

This form is to be completed and returned to the school **ONLY** if I consent to my child participating in this research.

Name of Student: *(please print)*: _____

Date: _____

Name of Parent/Guardian: *(please print)*: _____

Signature of Parent/Guardian: _____

Participant Information

If you have consented to your child participating on the previous page, please provide us with the following information about your child. If you have not provided consent, please do not fill out this page.

Please note: your child's name and birth date will be kept separate from their data and consent form, and only researchers directly involved in this project will have access to this information.

Child's Date of Birth: year _____ month _____ day _____

Please indicate the language(s) spoken at home and then please circle the one(s) that your child is fluent in: _____

Appendix G: Verbal Assent Script

Hi [child's name], my name is [researcher's name]! And guess what my job is? I make games so that I can learn about how boys and girls think and play. Today I brought some of my favourite picture games. Your parents said it was ok for you to play them with me. I'm ready to play it right over there (*point to location as made available by teacher*). Would you like to come over and play with me?

[] Yes. Great! (*Sit down at table*). Before we start, I want you to know that there are no wrong answers -- I just want to know what you think. You don't have to answer any questions that you don't want to and you can stop at any time, and that's totally okay.

[] No. That's okay. Can I ask you again another day if you want to play? []

If child says you can ask them again, make a note of this and ask them one more time, on a different day. If child says you can't ask them again, make a note of this and do not ask them again.

Appendix H: Debriefing Form (Daycare)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear Parent(s) or Guardian(s),

Recently we contacted you to invite your child to participate in our study on Preschoolers' Development of Prospective Memory. Thank you for agreeing to allow your child to participate – we had a lot of fun!

The purpose of our current research program was to gain a better understanding of children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children were shown a series of cards, one by one. Children were asked to say what is on each card (images of common items, including food and vehicles), and then put the cards in boxes depending on whether the picture was of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They were also asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box. We were interested in examining whether children do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We wanted to find out if children have a better chance at remembering to look for the special cards when they get more special cards early in the game. We also played games that measured related skills such as memory and vocabulary. Your child's answers to these questions will help us to understand how children begin to remember to perform action in the future independently.

We are very excited to start investigating the results of our study. For more information about our findings, or for a summary of the project once it is complete, please contact Alicia Bartlett by email at aliciabartlett@cmail.carleton.ca or 613-520-2600, ext. 2885.

If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca. The ethics protocol number for this study is #16-051.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly

involved in the project. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016.

Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study. We cannot provide any information about an individual child, only about the study as a whole. If you have any concerns about any aspect of your child's development, we suggest that you consult with your family doctor or pediatrician.

If you would like to participate in future projects in our lab at Carleton University, please contact us at the Children's Representational Development Lab by email at crdl@carleton.ca or by phone at 613-520-2600 ext. 2885.

Thank you,

Sincerely,

Deepthi Kamawar, PhD

Alicia Bartlett, M.A. Candidate

Appendix I: Debriefing Form (School)

**Children's Representational
Development Lab**
www.carleton.ca/crdl

Winter/Spring 2016

Dear Parent(s) or Guardian(s),

Recently we contacted you to invite your child to participate in our study on Preschoolers' Development of Prospective Memory. Thank you for agreeing to allow your child to participate – we had a lot of fun!

The purpose of our current research program was to gain a better understanding of children's growing ability to remember to complete some task in the future. To examine how this changes in early childhood, children were shown a series of cards, one by one. Children were asked to say what is on each card (images of common items, including food and vehicles), and then put the cards in boxes depending on whether the picture was of something that people eat (e.g., strawberries, bread) or don't eat (e.g., cars, trucks). They were also asked to keep an eye open for 'special' cards (ones with a particular fruit), and put those cards (and only those cards) into a special box.

We predicted that children would do a better job at remembering to keep an eye open for the special cards when that results in something fun (e.g., putting a coin into a mechanical piggy bank). We also predicted that children would have a better chance at remembering to look for the special cards when they get more special cards early in the game. We also played games that measured related skills such as memory and vocabulary, and expect these skills to contribute to children's growing ability to remember to complete these tasks.

Your child's answers to these questions will help us to understand how children begin to remember to perform action in the future independently. This research can be applied to circumstances in which preschool-aged children are asked to perform future actions in order to improve their recollection and execution of these actions. Determining the skills that underlie preschoolers' recollection and execution of future actions can also help pinpoint why some children perform more poorly than others.

We are very excited to start investigating the results of our study. For more information about our findings, or for a summary of the project once it is complete, please contact Alicia Bartlett by email at aliciabartlett@cmail.carleton.ca or 613-520-2600, ext. 2885.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Alicia Bartlett, M.A. Candidate, and she can be reached by email at aliciabartlett@email.carleton.ca. If you have any ethical concerns about this study, please contact: Dr. Shelley Brown, Chair, Carleton University Research Ethics Board-B (Shelley.Brown@carleton.ca or 613-520-2600 ext. 1505). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca. The ethics protocol number for this study is #16-051 (Carleton University Research Ethics Board-B).

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses. The information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. Thus, the results will not appear in any of your child's school records. The consent form will be kept separate from the data in a locked cabinet and will be destroyed after 2 years. The datafile and hard-copies of data, though they do not include identifying information, are stored on a password protected computer (the datafile) and in a locked room (the hard copies).

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2016.

Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study. We cannot provide any information about an individual child, only about the study as a whole. If you have any concerns about any aspect of your child's development, we suggest that you consult with your family doctor or pediatrician.

Thank you,

Sincerely,

Deepthi Kamawar, PhD

Alicia Bartlett, M.A. Candidate

Appendix J: Verbal Debriefing Script

That was our last game. Thank you for playing with me – that was fun. I wanted to learn more about how kids think and remember things. Do you have any questions about any of the games we played today?

Thanks again for your help and have a great day! *[let child to pick a sticker]*

Appendix K: Prospective Memory Paradigm (Order 1)

Ongoing task instructions - I'm going to show you some cards with some pictures on them. I will show you each card one at a time. Some cards have a picture of food on them and some cards have a picture of something that is not food. We're going to play a sorting game. First, I want you to say what is on each card out loud and then put the card where it goes. Things that people eat go in this box, and things that people do not eat go in this box.

Experimenter demo 1: So if I show you this card, Show [book], I want you to say "book" and then put it in this box. Things that people do not eat go in this box.

Experimenter demo 1: But, if I show you this card, Show [cucumber slices], I want you to say "cucumber" and then put it in this box. Things that people eat go in this box.

Practice Trial 1a

Let's practice a few! *Show [watermelon].*

What is this? *Pause.* And where does it go?

If hesitation: Things that people eat go in this box, and things that people don't eat go in this box. Which box does this card go in?

If correct: Good job, that's right!

If incorrect: Remember, things that people eat go in this box, and things that people do not eat go in this box. Let's try again. *Repeat once, if necessary.*

Practice Trial 2a

Let's try another one. *Show [soccer ball].*

What is this? *Pause.* And where does it go?

If hesitation: Things that people eat go in this box, and things that people don't eat go in this box. Which box does this card go in?

If correct: Good job, that's right!

If incorrect: Remember, things that people eat go in this box, and things that people do not eat go in this box. Let's try again. *Repeat once, if necessary.*

LOW MOTIVATION CONDITION ONLY

PM instructions – Oh, there is one more thing. I have a box just for bananas, see. *Bring out box.* So, if you find a card like this one that has any bananas on it, I want you to say "Bananas", but don't put it in one of these boxes, *point to two boxes on the table.* Instead, put it in the box, place example card in third box, move box behind them, it's behind you. Bananas go in that box, *point.*

HIGH MOTIVATION CONDITION ONLY

PM instructions – Oh, there is one more thing. I have a box just for bananas, see. *Bring out box.* So, if you find a card like this one that has any bananas on it, I want you to say "Bananas", but don't put it in one of these boxes, *point to two boxes on the table.* Instead, put it in the box, place example card in third box, move box behind them, it's behind you. Bananas go in that box, *point.* Then, *place piggy bank on the table and turn on,* you'll get

a coin to put here, *place coin on piggy bank*, to give to the monkey. Watch what happens when I give it a little push, *demonstrate and then move piggy bank behind them*. The piggy bank is behind you too.

ALL CHILDREN

Okay good, you know how to play this game. I have to get some things set up before you can play. You can draw something while I get things ready. Here is some paper and crayons. *Let the child draw for 3 minutes*.

Ok, now it's time to start the sorting game so let's put our paper and crayons away.

CONTINUED

TESTING (NO FEEDBACK): Late-Placement Goal Maintenance Condition.

Circle child's response. (F = Food item; NF = Non-food item; B = Banana)

Correct responses are underlined.

1	<u>F</u>	NF	B
2	F	NF	<u>B</u>
3	<u>F</u>	NF	B
4	F	<u>NF</u>	B
5	F	NF	<u>B</u>
6	<u>F</u>	NF	B
7	F	<u>NF</u>	B

8	F	<u>NF</u>	B
9	F	<u>NF</u>	B
10	F	NF	<u>B</u>
11	<u>F</u>	NF	B
12	F	<u>NF</u>	B
13	F	NF	<u>B</u>
14	<u>F</u>	NF	B

15	<u>F</u>	NF	B
16	F	<u>NF</u>	B
17	<u>F</u>	NF	B
18	F	<u>NF</u>	B
19	<u>F</u>	NF	B
20	<u>F</u>	NF	B
21	F	<u>NF</u>	B

22	<u>F</u>	NF	B
23	F	<u>NF</u>	B
24	F	<u>NF</u>	B
25	<u>F</u>	NF	B
26	F	<u>NF</u>	B
27	<u>F</u>	NF	B
28	F	<u>NF</u>	B

29	F	<u>NF</u>	B
30	F	<u>NF</u>	B
31	<u>F</u>	NF	B
32	F	NF	<u>B</u>
33	F	<u>NF</u>	B
34	<u>F</u>	NF	B
35	<u>F</u>	NF	B

36	F	<u>NF</u>	B
37	F	<u>NF</u>	B
38	<u>F</u>	NF	B
39	F	<u>NF</u>	B
40	F	NF	<u>B</u>

Ok, that is the end of this game. Oh, can you remind me what you were supposed to do when you saw a banana card?

Great, thanks for helping me sort my cards.

CONTINUED

TESTING (NO FEEDBACK): Early-Placement Goal Maintenance Condition.

Circle child's response. (F = Food item; NF = Non-food item; B = Banana)

Correct responses are underlined.

1	<u>F</u>	NF	B
2	<u>F</u>	NF	B
3	F	<u>NF</u>	B
4	<u>F</u>	NF	B
5	F	<u>NF</u>	B
6	F	<u>NF</u>	B
7	F	<u>NF</u>	B

8	<u>F</u>	NF	B
9	F	<u>NF</u>	B
10	F	NF	<u>B</u>
11	<u>F</u>	NF	B
12	<u>F</u>	NF	B
13	F	NF	<u>B</u>
14	F	<u>NF</u>	B

15	<u>F</u>	NF	B
16	F	<u>NF</u>	B
17	<u>F</u>	NF	B
18	F	NF	<u>B</u>
19	<u>F</u>	NF	B
20	F	<u>NF</u>	B
21	F	NF	<u>B</u>

22	<u>F</u>	NF	B
23	F	<u>NF</u>	B
24	F	<u>NF</u>	B
25	<u>F</u>	NF	B
26	F	<u>NF</u>	B
27	<u>F</u>	NF	B
28	F	<u>NF</u>	B

29	F	<u>NF</u>	B
30	F	<u>NF</u>	B
31	<u>F</u>	NF	B
32	F	NF	<u>B</u>
33	F	<u>NF</u>	B
34	<u>F</u>	NF	B
35	<u>F</u>	NF	B

36	F	<u>NF</u>	B
37	F	<u>NF</u>	B
38	<u>F</u>	NF	B
39	F	<u>NF</u>	B
40	F	NF	<u>B</u>

Ok, that is the end of this game. Oh, can you remind me what you were supposed to do when you saw a banana card?

Great, thanks for helping me sort my cards.

Appendix L: Prospective Memory Paradigm Stimuli

L1. Food Cards

L2. Non-Food Cards

L3. Prospective Memory Target Cards

L4. Example Cards Affixed to Boxes

Appendix M: Piggy Bank

Source: (<http://www.aliexpress.com/item/New-Cute-Stealing-Money-Monkey-Automatic-Stole-Coin-Monkey-Piggy-Bank-Money-Saving-Box-Gifts/32558816753.html?spm=2114.40010308.4.2.A0fauX>)

Appendix N: Auditory Backward Digit Span
Source: Carlson et al. (2002)

Say one digit per second.

This is my friend, Willy. Whenever I say numbers, Willy says them backwards. Listen: 5 – 8. (Willy says:) 8 – 5. Now I want you to do the same as Willy and say my numbers backwards.

PRACTICE TRIALS: *Provide feedback.*

Let’s try one. Ready? Listen carefully. Remember to say the numbers backwards. 2 – 4.
Score below. Repeat once, if necessary.

Let’s try another one. Remember to say the numbers backwards. 7 – 1.
Score below. Repeat once, if necessary.

<u>Digits Forward</u>		<u>Child’s Response</u>
i.	2 – 4 (“That’s right!” or correct the mistake)	_____ – _____ ; _____ – _____
ii.	7 – 1 (“That’s right!” or correct the mistake)	_____ – _____ ; _____ – _____
<u>TEST TRIALS:</u> <i>Stop when child makes an error on both strings of the <u>same</u> length (e.g., when both items 5 and 6 are incorrect). No feedback.</i>		
1.	6 – 3	_____ – _____
2.	4 – 9	_____ – _____
3.	2 – 9 – 5	_____ – _____ – _____
4.	8 – 1 – 6	_____ – _____ – _____
5.	8 – 5 – 2 – 6	_____ – _____ – _____ – _____
6.	4 – 9 – 3 – 7	_____ – _____ – _____ – _____
7.	8 – 1 – 3 – 7 – 9	_____ – _____ – _____ – _____ – _____
8.	4 – 2 – 5 – 8 – 1	_____ – _____ – _____ – _____ – _____
9.	9 – 3 – 5 – 1 – 8 – 4	_____ – _____ – _____ – _____ – _____ – _____
10.	6 – 5 – 8 – 4 – 2 – 7	_____ – _____ – _____ – _____ – _____ – _____

Score: _____ / 10

Appendix O: Visual Backward Word Span

Source: Modified from Carlson et al. (2002), as in Vendetti (2015)

Now I'm going to show you some cards with some pictures on them. I will show you the picture on each card, one at a time, and say what it is, aloud. Then, I'll put them on the table, with the picture side down so we can't see it any more. Once you've looked at all of the pictures, I want you to tell me the names of them, but in backwards order.

So if I show you a cake [*show cake and then place face down*] and a ball [*show ball and place face down beside cake*], I want you to tell me 'ball' [*pointing to back of ball*] and 'cake' [*pointing to back of cake*]. Let's try one.

PRACTICE TRIAL 1:

Show cat. Cat. What's this? Child's response (circle one): [cat] [other]

Place card face down in a new row (below cake). Accept any reasonable answer.

Show grapes. Grapes. And what's this? Child's response (circle one): [grapes] [other]

Place card face down in a new row (below ball). Accept any reasonable answer.

Tell me the names of those pictures in backwards order. *Point as they name.*

[grapes – cat] ____ (✓ or x)

If correct: Good job, that's right!

If incorrect: Remember to tell me the pictures in backwards order.

You saw 'cat' then 'grapes' so you need to tell me 'grapes, cat'.

PRACTICE TRIAL 2:

Let's try another one!

Show tree. Tree. What's this? Child's response: [tree] [other]

Place card face down in a new row (below cat). Accept any reasonable answer.

Show pig. Pig. And what's this? Child's response: [pig] [other]

Place card face down in a new row (below grapes). Accept any reasonable answer.

Tell me the names of those pictures in backwards order. *Point as they name.*

[pig – tree] ____ (✓ or x)

If correct: Good job, that's right!

If incorrect: Remember to tell me the pictures in backwards order.

You saw 'pig' then 'tree' so you need to tell me 'pig, tree'.

CONTINUED

Test Trials: *DO NOT point to the back of pictures during test trials. For each new trial, place the cards in a row beneath the last trial – placing cards from left to right. Name each card for child before placing the card. Stop when the child makes an error on both strings of the same length.*

1. Dog – Bus _____ (✓ or x)
2. Hand – Snail _____ (✓ or x)
3. Fox – Shoe – House _____ (✓ or x)
4. Spoon – Book – Fish _____ (✓ or x)
5. Bee – Sock – Kite – Leaf _____ (✓ or x)
6. Cup – Bird – Drum – Plant _____ (✓ or x)
7. Frog – Star – Barn – Chair – Corn _____ (✓ or x)
8. Horse – Bed – Hat – Car – Heart _____ (✓ or x)

Score: _____ / 8

Appendix P: Self-Ordered Pointing

Source: Hongwanishkul, Happaney, Lee, & Zelazo (2005)

Before opening the binder - Now you and I are going to play a different pictures game. We're going to look at some pictures together, and I want you point to each picture just one time. Okay?

Open practice trial 1.

PRACTICE TRIAL 1:

Okay, point to a picture on this page.

Child selects: [Dog] [Rabbit]

Good job!

Turn page.

Now point to a picture that you didn't point to before.

Child selects: [Dog] [Rabbit]

If correct – Good job!

If incorrect – Oh, good try, but you already pointed to this picture before. Remember, in this game you point to a picture that you didn't point to before. Can you do that now? Good job! Let's try another one.

Turn to practice trial 2.

PRACTICE TRIAL 2:

Okay, point to a picture on this page.

Child selects: [Car] [Backpack]

Good job!

[Turn page.]

Now point to a picture that you didn't point to before.

Child selects: [Car] [Backpack]

If correct – Good job!

If incorrect – Oh, good try, but you already pointed to this picture before. Remember, in this game you point to a picture that you didn't point to before. Can you do that now? Good job! Let's try another one.

Now we're going to look at a bunch of pictures. Each time I turn the page, I want you to point to a picture you didn't point to before.

[Turn to test trials].

CONTINUED

No feedback from here on.

Number each picture the child points to in the “first point” column or in the “second point” column if child already pointed to the picture before. Stop task after the child made two errors (second point) at the same level.

For first item in each set - point to a picture on this page.

For second item – now point to a picture that you didn’t point to before.

For third item and up – now point to another picture that you didn’t point to before.

	First point	Second point		First point	Second point
1. Airplane			6. Book		
Gift			Bike		
Cow			Glasses		
2. Turtle			House		
Apple			Bird		
Hand			7. TV		
3. Tiger			Horse		
Elephant			Butterfly		
Chair			Bus		
Cake			Banana		
4. Ball			Spoon		
Flower			8. Bee		
Shell			Hat		
Pencil			Train		
5. Sun			Crayons		
Balloon			Barn		
Cup			Fish		
Carrot					
Cat					

See more trials in additional page.

CONTINUED

	First point	Second point		First point	Second point
9. Lion			11. Phone		
Fire truck			Feather		
Ladder			Pillow		
Scissors			Button		
Bed			Lemon		
Leaf			Sailboat		
Wagon			Penguin		
10. Chicken			Tree		
Dragonfly			12. Pot		
Pinwheel			Grapes		
Tooth Brush			Hair Brush		
Key			Dinosaur		
Tambourine			Jug		
Tractor			Strawberry		
			Ring		
			Umbrella		

Score (*please circle*): 3 4 5 6 7 8

Appendix Q: Black / White Stroop
Source: Vendetti, Kamawar, Podjarny, & Astle (2015)

Now we're going to play a different game!

Show black. This is black, right? When you see this card, I don't want you to say 'black'. No, I want you to say 'white'.

Remove black; show white. This is white, right? When you see this card, I don't want you to say 'white'. No, I want you to say 'black'.

TRAINING TRIALS:

Show white. If hesitation – “What do you say for this one?”

[W] [B] (Good.)

Show black. If hesitation – “What do you say for this one?”

[W] (Good.) [B]

Number of
training trials

If wrong or no response on either trial – repeat rules and training to a maximum of three training trials – always continue with test trials.

TESTING (NO FEEDBACK):

Circle, or write in child's response if not black/white

1	W	B	_____	12	W	B	_____
2	W	B	_____	13	W	B	_____
3	W	B	_____	14	W	B	_____
4	W	B	_____	15	W	B	_____
5	W	B	_____	16	W	B	_____
6	W	B	_____	17	W	B	_____
7	W	B	_____	18	W	B	_____
8	W	B	_____	19	W	B	_____
9	W	B	_____	20	W	B	_____
10	W	B	_____	21	W	B	_____
11	W	B	_____				

No self-correct: Record first complete response. E.g.: If child says 'Black – no white' code as 'black.' If child says 'Bl--White' code as 'white'.

Appendix R: Modified Simon Says

Source: Modified from Carlson (2005)

We're going to play a silly game now. In this game, you need to follow my instructions but only when I say "Simon says". If I don't say Simon says, then don't do anything and stay still! Let's practice, if I say "Simon says touch your knees", you should touch your knees. But, if I *just* say "touch your knees", you shouldn't do it because I didn't say Simon says!

PRACTICE TRIALS: *Demonstrate actions while giving commands. Example: Touch your feet when you say, "Simon says touch your feet".*

If children fail, repeat them up to 3 times. They must pass to continue to test trials.

Scoring: C = commanded movement; P = partial movement; D = different movement; N = no movement

	Child Movement			
P1. Simon says touch your knees	C	P	D	N
P2. Touch your knees	C	P	D	N

TEST TRIALS: *Do not demonstrate actions while giving commands. No feedback.*

	Child Movement			
1. Simon says touch your feet	C	P	D	N
2. Simon says touch your shoulders	C	P	D	N
3. Touch your head	C	P	D	N
4. Simon says touch your nose	C	P	D	N
5. Touch your neck	C	P	D	N
6. Simon says touch you ears	C	P	D	N
7. Touch your eyes	C	P	D	N
8. Simon says touch your elbows	C	P	D	N
9. Touch your tummy	C	P	D	N
10. Touch your mouth	C	P	D	N

Score only the non-Simon Says trials.

0 = commanded movement, 1 = partial movement,
2 = different movement, 3 = no movement

Score: ____ / 15

Appendix S: Dimensional Change Card Sort

Source: Modified from Zelazo (2006) as in Prodjarny (2015)

Place target cards on box lids and then say:

Here is a blue boat and here is a red rabbit. This one is blue, and this one is red. We are going to play a game. This is the colour game. The colour game is different from the shape game. All the blue ones go in this box, and all the red ones go in that box. We don't put any blue ones in that box. No way. We put all the blue ones over here and only red ones go over there. This is the colour game.

Experimenter demo: Here is a blue one. This one goes here because it's blue.

Child demo: Here is a red one. Where does this one go?

Feedback - Very good or No, this one's red, so it goes over here.

Okay, now I'm going to show you some blue ones and red ones.

Show preswitch cards, one at a time:

If it's a blue one, then it goes here. If it's a red one, then it goes there.

Show the child the card. It's a (blue/red) one.

Give the child the card. "Where does this go?"

No Feedback.

Let's do another one. *Continue for all 8 preswitch cards*

ACCURACY (✓ or X) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Okay, now we're going to switch, so I'm going to put my switch cards in now. *Put switch cards in.* We are not going to play the colour game anymore. We are going to play the shape game. All the boats go in this box, and all the rabbits go in that box. We don't put any boats in that box. No way. We put all the boats over here and only rabbits go over there. This is the shape game.

Show 8 postswitch cards (blue rabbits and red boats) and for each:

If it's a boat, then it goes here. If it's a rabbit, it goes there.

Show the child the card. It's a (boat/rabbit).

Give the child the card. Where does this go?

No Feedback.

Okay, let's do another one. *Continue for all 8 postswitch cards.*

ACCURACY (✓ or X) ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Score:
/ 16

Appendix T: Peabody Picture Vocabulary Test – Third Edition

Basal Set Rule: 1 or no errors in a set. Ceiling Set Rule: 8 or more errors in a set.

START Ages 2-6 - 3 SET 1					START Age 5 SET 3					SET 4					START Ages 6-7 SET 5				
Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error
1.	cat	.....	(2)	E	25.	broken	.....	(2)	E	37.	lock	.....	(4)	E	49.	cheering	.....	(1)	E
2.	baby	.....	(3)	E	26.	picking	.....	(4)	E	38.	panda	.....	(1)	E	50.	cobweb	.....	(3)	E
3.	airplane	.....	(1)	E	27.	bottle	.....	(4)	E	39.	triangle	.....	(4)	E	51.	jogging	.....	(4)	E
4.	running	.....	(1)	E	28.	dressing	.....	(1)	E	40.	fruit	.....	(1)	E	52.	huge	.....	(3)	E
5.	money	.....	(3)	E	29.	coin	.....	(2)	E	41.	arguing	.....	(1)	E	53.	uniform	.....	(4)	E
6.	swinging	.....	(4)	E	30.	peeking	.....	(3)	E	42.	full	.....	(2)	E	54.	wrist	.....	(2)	E
7.	broom	.....	(2)	E	31.	camera	.....	(3)	E	43.	dentist	.....	(3)	E	55.	sharing	.....	(2)	E
8.	eating	.....	(4)	E	32.	goat	.....	(4)	E	44.	time	.....	(3)	E	56.	binoculars	.....	(2)	E
9.	mail	.....	(3)	E	33.	ambulance	.....	(1)	E	45.	caterpillar	.....	(3)	E	57.	statue	.....	(4)	E
10.	circle	.....	(4)	E	34.	pulling	.....	(1)	E	46.	computer	.....	(4)	E	58.	coming	.....	(3)	E
11.	ladder	.....	(2)	E	35.	desk	.....	(3)	E	47.	branch	.....	(2)	E	59.	jewelry	.....	(1)	E
12.	candle	.....	(1)	E	36.	yawning	.....	(2)	E	48.	chain	.....	(2)	E	60.	terrified	.....	(1)	E
No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>				

START Age 4 SET 2					SET 6					START Ages 8-9 SET 7					START Ages 10-11 SET 8				
Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error
13.	neck	.....	(3)	E	61.	liquid	.....	(4)	E	73.	ankle	.....	(1)	E	85.	shuttle	.....	(4)	E
14.	throwing	.....	(4)	E	62.	peacock	.....	(3)	E	74.	sanding	.....	(2)	E	86.	tropical	.....	(2)	E
15.	kangaroo	.....	(2)	E	63.	leaking	.....	(3)	E	75.	hyena	.....	(4)	E	87.	refueling	.....	(2)	E
16.	plant	.....	(1)	E	64.	brain	.....	(2)	E	76.	pair	.....	(3)	E	88.	angle	.....	(1)	E
17.	can	.....	(4)	E	65.	hive	.....	(1)	E	77.	antlers	.....	(4)	E	89.	river	.....	(3)	E
18.	shark	.....	(3)	E	66.	root	.....	(1)	E	78.	nutritious	.....	(2)	E	90.	deflated	.....	(1)	E
19.	pouring	.....	(2)	E	67.	floating	.....	(2)	E	79.	annoying	.....	(1)	E	91.	calculating	.....	(1)	E
20.	horn	.....	(1)	E	68.	tortoise	.....	(1)	E	80.	walrus	.....	(3)	E	92.	shore	.....	(3)	E
21.	shovel	.....	(4)	E	69.	printing	.....	(4)	E	81.	flaming	.....	(3)	E	93.	funnel	.....	(2)	E
22.	farmer	.....	(3)	E	70.	rough	.....	(4)	E	82.	jaw	.....	(4)	E	94.	predatory	.....	(3)	E
23.	gate	.....	(2)	E	71.	tugging	.....	(2)	E	83.	cliff	.....	(1)	E	95.	cruiser	.....	(4)	E
24.	swimming	.....	(1)	E	72.	tornado	.....	(3)	E	84.	directing	.....	(2)	E	96.	grain	.....	(4)	E
No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>				

3

Basal Set Rule: 1 or no errors in a set. Ceiling Set Rule: 8 or more errors in a set.

SET 9					START Ages 12-16 SET 10					SET 11				
Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error
97.	sorting	.....	(1)	E	109.	compass	.....	(3)	E	121.	trumpet	.....	(2)	E
98.	canine	.....	(2)	E	110.	harvesting	.....	(4)	E	122.	escorting	.....	(4)	E
99.	greeting	.....	(3)	E	111.	abundant	.....	(2)	E	123.	speedometer	.....	(3)	E
100.	triplets	.....	(4)	E	112.	astonished	.....	(3)	E	124.	salutation	.....	(4)	E
101.	applauding	.....	(3)	E	113.	gnawing	.....	(3)	E	125.	parallel	.....	(4)	E
102.	arctic	.....	(2)	E	114.	scholar	.....	(4)	E	126.	archaeologist	.....	(1)	E
103.	exiting	.....	(4)	E	115.	fictional	.....	(1)	E	127.	glider	.....	(3)	E
104.	pelican	.....	(1)	E	116.	beverage	.....	(1)	E	128.	construction	.....	(2)	E
105.	pyramid	.....	(3)	E	117.	grooming	.....	(2)	E	129.	pod	.....	(3)	E
106.	snarling	.....	(4)	E	118.	steeple	.....	(2)	E	130.	assembling	.....	(1)	E
107.	colliding	.....	(1)	E	119.	assisting	.....	(1)	E	131.	banister	.....	(2)	E
108.	hoof	.....	(2)	E	120.	reel	.....	(4)	E	132.	hovering	.....	(1)	E
No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>				

SET 12					START Ages 17-Adult SET 13					SET 14				
Item	Word	Key	Response	Error	Item	Word	Key	Response	Error	Item	Word	Key	Response	Error
133.	sedan	.....	(4)	E	145.	porcelain	.....	(2)	E	157.	siblings	.....	(1)	E
134.	duet	.....	(1)	E	146.	embracing	.....	(3)	E	158.	illumination	.....	(4)	E
135.	irregular	.....	(1)	E	147.	liberated	.....	(1)	E	159.	incisor	.....	(2)	E
136.	physician	.....	(4)	E	148.	peninsula	.....	(4)	E	160.	fowl	.....	(3)	E
137.	swine	.....	(3)	E	149.	goblet	.....	(4)	E	161.	enticing	.....	(3)	E
138.	wedge	.....	(3)	E	150.	orating	.....	(1)	E	162.	trowel	.....	(4)	E
139.	composing	.....	(2)	E	151.	aviation	.....	(2)	E	163.	angler	.....	(1)	E
140.	easel	.....	(4)	E	152.	descending	.....	(2)	E	164.	dwelling	.....	(1)	E
141.	lubricating	.....	(1)	E	153.	attire	.....	(4)	E	165.	nape	.....	(2)	E
142.	amphibian	.....	(3)	E	154.	gavel	.....	(3)	E	166.	enumerating	.....	(4)	E
143.	weary	.....	(2)	E	155.	currency	.....	(3)	E	167.	reflection	.....	(2)	E
144.	axle	.....	(2)	E	156.	agriculture	.....	(1)	E	168.	submerging	.....	(3)	E
No. of Errors <input type="text"/>					No. of Errors <input type="text"/>					No. of Errors <input type="text"/>				

ABBREVIATED INSTRUCTIONS AND SETS OF TEST STIMULUS WORDS

Study Part 2 of the manual before using the test and using the Training Items as Training Plates. Use Training Items A and with persons 8 and older.

IQ AND SCORING THE TEST When the appropriate Training Items, begin test.

When you begin a set of test items, always start and always start with the first item in the set with the Start Item, which is the first item designated for the test taker's age. Begin sets and in the box below.

Basal Set Rule is one (1) or no errors in a set. Try, reverse sequentially by sets until the Ceiling Set is obtained.

Ceiling Set Rule is eight (8) or more errors in a set.

RECORDING RESPONSES AND ERRORS

Errors for Each Item. Use numerals to record the number of errors in the Response column through the E in the last column as shown.

Errors Per Set. At the end of each item set, record the number of errors in the box provided.

Raw Score. Transfer the number of errors made by the examinee from the Basal Set through the highest Ceiling Set. This is the Raw Score.

CALCULATING the RAI

Record the number of the Ceiling Item, which is the last item in the Ceiling Set. Subtract from it the total number of errors made by the examinee from the Basal Set through the Ceiling Set. This is the Raw Score.

Ceiling Item
Total Errors
Raw Score

4

Appendix U: Comparison of Administering Self-Ordered Pointing in Session 1 or 2

Table U1.

Independent Sample T-tests Comparing Effect of Moving Self-Ordered Pointing Task

Variable	<i>t</i>	<i>df</i>	<i>p</i>
Self-Ordered Pointing	-1.24	90	0.22
Black/White Stroop	-0.27	87	0.79
Simon Says ¹	-0.67	56	0.50
Visual Backward Word Span	1.22	88	0.23
PPVT-III	-0.86	89	0.39

Note. 30 children received Self-Ordered Pointing in Session 1, and 63 received it in Session 2

¹ This task was removed from the analyses since only 58 children completed the task.

Appendix V: Preliminary Analyses

Table V1.

Comparing Groups on Prospective Memory, Ongoing Task, Working Memory, Inhibitory Control, Vocabulary, and Age

	High / Early	Mean (SD)		Low / Late	F	ANOVA	
		High / Late	Low / Early			df	p
Prospective Memory							
Total	4.25 (2.57)	3.67 (2.65)	5.40 (1.61)	5.00 (1.86)			
Comparison Pair 1	0.71 (0.46)	0.52 (0.49)	0.90 (0.29)	0.72 (0.45)			
Comparison Pair 2	0.69 (0.46)	0.67 (0.48)	0.94 (0.22)	0.91 (0.29)			
Ongoing Task	32.38 (3.82)	31.71 (4.68)	33.36 (0.95)	32.87 (3.52)	0.94	(3,89)	0.43
Working Memory							
Auditory Backward Digit Span	0.78 (1.17)	0.60 (1.19)	0.56 (1.08)	0.55 (1.22)	0.20	(3,86)	0.89
Self-Ordered Pointing	3.75 (3.25)	4.62 (3.03)	4.13 (3.17)	4.52 (2.98)	0.38	(3,88)	0.77
Visual Backwards Word Span	1.36 (1.22)	1.05 (1.10)	1.04 (1.14)	1.35 (1.19)	0.54	(3,86)	0.66
Inhibitory Control							
Dimensional Change Card Sort	5.63 (3.61)	4.40 (3.78)	5.80 (3.44)	5.00 (3.69)	0.68	(3,88)	0.57
Black/White Stroop	12.30 (6.98)	13.00 (7.93)	14.76 (6.72)	12.91 (7.19)	0.53	(3,88)	0.67
Simon Says ²	5.93 (6.11)	4.58 (5.28)	3.41 (5.40)	5.33 (5.60)	0.59	(3,54)	0.63
PPVT-III	60.54 (16.42)	56.90 (15.07)	59.58 (16.96)	61.35 (20.37)	0.26	(3,87)	0.85
Age	49.63 (5.59)	50.29 (5.26)	48.32 (5.20)	49.43 (5.56)	0.53	(3,89)	0.66

Note. Prospective Memory Total (0-6), Prospective Memory Comparison Pair 1 or 2 (0-2), Ongoing Task (0-34), Auditory Backward Digit Span (0-10), Self-Ordered Pointing (0-12), Visual Backward Word Span (0-8), Dimensional Change Card Sort (0-8), Black/White Stroop (0-21), Simon Says (0-15), PPVT-III (20-160). The sample sizes of the measures within each condition vary slightly. See the Participants section in the Results section for a more detailed breakdown.

² This task was removed from the analyses since only 58 children completed the task.

Table V2.

Comparing Groups on Gender

	High / Early	High / Late	Low / Early	Low / Late
Males	13	10	14	11
Females	11	11	11	12

-- Note. Gender did not differ by group, $\chi^2(3) = 0.52, p = 0.91$.

*Figure V1: Total PM Performance Score
(Score out of 6; n = 93)*

*Figure V2: Auditory Backward Digit Span
(Score out of 10; n=90)*

*Figure V3: Visual Backward Word Span
(Score out of 8; n=90)*

*Figure V4: Dimension Change Card Sort
(Score out of 8; n=92)*

Figure V5: Self-Ordered Pointing
(Score out of 12; $n=92$)

Figure V6: Simon Says³
(Score out of 15; $n=58$)

Figure V7: Black/White Stroop
(Score out of 21; $n=92$)

Figure V8: Peabody Picture Vocabulary Test
(Score out of 160; $n=91$)

³ This task was removed from the analyses since only 58 children completed the task.

Table V3.

Normality Statistics for Measures of Working Memory, Inhibitory Control, and Vocabulary

Measure	Skewness	Kurtosis
Total Prospective Memory	- 1.32	0.05
Working Memory		
Auditory Backward Digit Span ⁴	1.84 (1.25)	2.70 (- 0.10)
Self-Ordered Pointing	0.93	0.28
Visual Backward Word Span	0.72	- 0.30
Inhibitory Control		
Dimensional Change Card Sort	- 0.70	- 1.46
Black/White Stroop	- 0.68	- 1.04
Simon Says ⁵	0.64	- 1.23
Vocabulary Test	0.17	- 0.73

Note. Scores within +/- 2.0 indicate normality.

*Figure V9: Auditory Backward Digit Span
(Transformed; Score out of 8; n = 90)*

⁴ Square root transformation statistics presented in brackets

⁵ This task was removed from the analyses since only 58 children completed the task.

Appendix W: Exploratory Factor Analysis

Table W1.

Factor Loading for Executive Functioning Factor

	Factor Loading
Visual Backward Word Span	0.55
Self-Ordered Pointing	0.18
Auditory Backward Digit Span (<i>Transformed</i>)	0.67
Dimension Change Card Sort	0.61
Black / White Stroop	0.47

Note. Extraction Method: Principal Axis Factoring.

Appendix X: Correlation Analyses after Excluding Simon Says Task

Table X1.

*Correlations Among Measures of PM, Age, Working Memory, Inhibitory Control, and PPVT,
After Excluding the Simon Says Task*

	Measure	1	2	3	4	5	6	7	8
1	PM	---	0.29*	0.39**	0.10	0.19	0.23	0.31*	0.19
2	Age (in months)		---	0.63**	-0.12	0.22	0.15	0.22	0.39**
3	ABDS _T (WM)			---	-0.06	0.31*	0.31*	0.32*	0.49**
4	SOP (WM)				---	0.10	0.14	0.11	0.16
5	VBWS (WM)					---	0.35**	0.14	0.32*
6	DCCS (IC)						---	0.27*	0.33*
7	BW (IC)							---	-0.04
8	PPVT								---

Note. PM = Prospective Memory. ABDS_T = Auditory Backward Digit Span (Transformed). SOP = Self-Ordered Pointing. VBWS = Visual Backward Word Span. DCCS = Dimensional Change Card Sort. BW = Black / White Stroop. PPVT = Peabody Picture Vocabulary Test.

* $p < 0.05$; ** $p < .01$.