

INVESTIGATING THE ROLE OF EXECUTIVE PROCESSES IN YOUNG  
CHILDREN'S PROSPECTIVE MEMORY

by

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## DISSERTATION ABSTRACT

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Prospective memory (PM) is the ability to remember to carry out one's intentions. This is a critical ability for children to develop in order to function independently in their daily activities. This dissertation examines the role of executive functioning in preschoolers' PM in two studies that vary the executive demand at different stages of the PM task.

Study 1 investigated the role of task difficulty during the retention interval prior to the PM task. A difficult working memory task during the delay period resulted in worse PM performance in 4- and 5-year-olds compared to an easy working memory task. In addition, children's working memory, planning ability, and theory of mind correlated with PM but only in the difficult filler task condition.

Study 2 examined age differences between 4- and 5-year-olds in PM task performance when the task: (1) was embedded in an easy or difficult ongoing task, (2) had an instruction to focus on the intention versus an instruction to focus on the distractor activity during the retention interval, and (3) varied in the salience of prospective targets. Overall, 5-year-olds performed better on the PM task than 4-year-olds. Children also had superior PM when targets were salient compared to non-salient and marginally superior

PM when they received an instruction to monitor their intention compared to when they received an instruction to focus on the distractor activity. In addition, positive relations between executive functioning and PM were documented.

Taken together, these studies suggest that disrupting or encouraging monitoring has a direct impact on PM performance in certain conditions. The implications of these results for theories that suggest differing roles for controlled processes in PM are discussed.

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## CHAPTER I

### INTRODUCTION

Future orientation is thought to be a uniquely human characteristic. Our ability to think about, anticipate, and plan for the future sets us apart from our recent primate ancestors (Atance & O’Neill, 2001; Donald, 1991; Suddendorf & Corballis, 2007).

Future orientation is critical in daily life in situations ranging from academic performance to financial planning to social functioning.

One central aspect of future orientation is prospective memory (PM), defined as memory for activities to be performed in the future (Einstein & McDaniel, 1990). In order to lead a productive life independent from others, one must develop the ability to remember to carry out one’s intentions. PM is essential to daily functioning in areas such as academics (e.g., handing in an assignment on its due date), safety (e.g., remembering to put on a helmet before riding a bicycle), and interpersonal relationships (e.g., remembering to attend a friend’s birthday party). PM typically involves the ability to successfully carry out intentions in the face of ongoing distractions. Often individuals must remember to do something at a certain time or after a specific event has occurred while completing other tasks in which they are actively immersed.

This dissertation examines the role of executive functioning in young children’s PM by varying the level of executive demand at various stages of the PM task and by measuring individual differences in executive ability and related cognitive abilities and how they relate to individual differences in PM. In what follows, I will review conceptual distinctions surrounding PM, why and how it is studied in children, and then empirical literature documenting its development. I will then review how executive



function develops in childhood, how EF might play a role in specific processes in PM, theories that posit a role for EF in PM, and finally four lines of empirical evidence that suggest controlled processes such as monitoring play a special role in prospective remembering.

### Prospective Memory versus Retrospective Memory

PM can be differentiated from retrospective memory (RM) defined as memory for information or events from the past. There are at least five ways in which PM differs from RM; (1) PM tends to rely on self-initiated retrieval processes and monitoring whereas RM does not rely on active monitoring processes, (2) PM involves *spontaneous* remembering in response to a cue in the environment whereas RM often involves *explicitly cued* remembering (Einstein & McDaniel, 1996), (3) PM performance typically requires time-delimited action unlike RM (Guajardo & Best, 2000), (4) PM usually involves an ongoing activity which must be interrupted to perform a PM action whereas RM does not necessarily involve an ongoing task (Einstein & McDaniel, 1996; Kidder, et al., 1997), and (5) PM often involves a greater moral or social component because it is very often embedded within an interpersonal context (Brandimonte & Ferrante, 2009). Despite the several distinctions between PM and RM, it is also the case that RM processes are involved in PM. An individual carrying out a prospective action must remember *what* she was supposed to do, not just *when* she was supposed to do it, as it is useless to remember that you had to do something (prospective component intact) but fail to remember exactly what it was you were supposed to do (RM failure). It is the content of the prospective intention or the '*what*' of the action that relies on RM processes.

## Event-Based versus Time-Based Prospective Memory

An important conceptual distinction is between *time-based* and *event-based* PM. Time-based PM requires an action to be completed at a certain time or after a specific amount of time has passed (e.g., meet a friend at 3 o'clock or 2 hours from now), whereas event-based PM requires an action to be carried out after a certain event occurs (e.g., mail a letter when you see the mailbox). Clinical studies suggest that time-based PM is generally more difficult than event-based PM for individuals with mild cognitive impairment (Troyer & Murphy, 2007) and that ageing negatively affects time-based PM whereas event-based PM often remains intact (Bastin & Meulemans, 2002; Einstein, et al., 1995; Jäger & Kliegel, 2008; Park, et al., 1997). Within the child development literature, however, most research has focused on event-based PM because of the challenges that children have with telling time, calibrating their internal clock to an external one, and judging the amount of time that has passed (Block, Zakay, & Hancock, 1999; Friedman, 1978; 1989).

### Why Study Prospective Memory Development during Childhood?

There are many reasons to study the development of PM. First, it has been argued that a majority of adults' daily memory errors are prospective (e.g., forgetting to put out the garbage on pickup day) rather than retrospective (e.g., forgetting the name of a new colleague; Smith, Della Sala, Logie, & Maylor, 2000). According to a diary study, Terry (1988) found that 70% of memory errors made by university students are prospective. The majority of forgetting had to do with neglecting to perform an action due to absentmindedness in comparison to forgetting facts, names, or other information known in the past. Naturalistic studies such as these have not been conducted with children but

laboratory studies with children indicate high rates of forgetting in both experimental and quasi-naturalistic PM tasks (e.g., Guajardo & Best, 2000; Somerville, et al., 1983). PM errors have a significant impact on daily functioning on adults and children alike and is therefore deserving of study developmentally in order to find ways in which to minimize PM errors that negatively affect quality of life.

Second, the development of PM during early childhood is of interest because this is a period of rapid cognitive development when children shift from relying on their parents to remind them to perform activities to carrying out many of their intentions independently. Parents of infants and toddlers play an important scaffolding role in their children's PM. At this stage, the ability to independently carry out a future intention reliably seems largely beyond these children's abilities (see Kliegel & Jäger, 2007). Fortunately for most children, parents or teachers often give helpful reminders that aid children's ability to remember to do things. By the time children reach school age, however, they are expected to be able to remember to carry out many of their self-formed intentions as well as future tasks assigned to them by others, many of which may impact their academic success. For example, remembering to bring a permission slip for a field trip home for a parent to sign or remembering to bring an assignment back to school on its due date are common PM tasks that occur within academic settings. If a child fails to complete tasks relevant to such assignments, their academic performance will likely suffer. Therefore, the preschool years mark an important transition where children need to become increasingly independent in their prospective remembering and accordingly this period is characterized by improvements in PM task performance (Kliegel & Jäger, 2007; Kvavilashvili, et al., 2001; Mahy & Moses, 2011).

Third, beyond the academic realm failures in PM may have serious negative consequences such as putting oneself in danger, (e.g., forgetting to turn off the oven after baking cookies) or compromising social relationships (e.g., forgetting to meet a friend). In fact, it has been suggested that PM failures especially impact interpersonal relationships because they are often attributed to the unreliability of the *individual* rather than the unreliability of the individual's memory (Brandimonte & Ferrante, 2009). This is in sharp contrast to errors in retrospective memory that are not typically seen as personal shortcomings but simply attributed to poor memory for past events or facts.

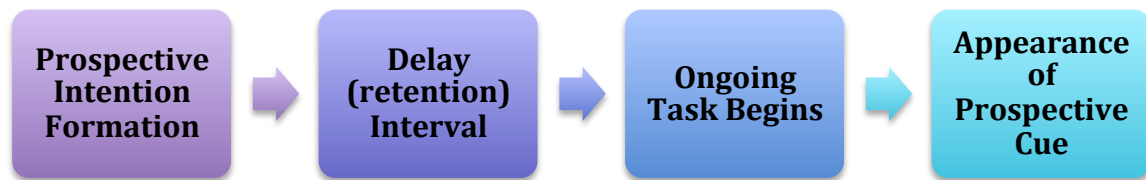
Finally, in order to understand the factors that influence PM in adults, it is important to understand what factors influence children's PM and how this ability develops during childhood. Poor prospective remembering often compromises independence and autonomy across the lifespan particularly in childhood and old age (Guajardo & Best, 2000; Meacham & Colombo, 1980; Rendell & Craik, 2000) so it is important to investigate both ends of the developmental trajectory where it is improving or declining. In addition, longitudinal studies show an inverted U-shape developmental trajectory in PM performance across the lifespan (Kliegel, Mackinlay, & Jäger, 2008; Zimmermann & Meier, 2006). It is possible that there may be common cognitive mechanisms that account for the development and decline in PM at the beginning and the end of the lifespan.

#### How Is Prospective Memory Studied?

A typical PM assessment has two main components: a PM task and an ongoing task (OT; Einstein & McDaniel, 1990). The PM task involves remembering to perform an action when a particular target cue appears. Prospective targets are embedded in an

OT that provides a distraction from the prospective intention. For example, experiments with children often involve an OT consisting of a simple card-naming task (Kvavilashvili et al., 2001; Mahy & Moses, 2011; Wang et al., 2008). When a specific card appears the prospective action must be carried out. After instructions are given for the OT and prospective task, there is typically a retention interval or delay period in which the PM stimulus does not appear and the OT has not yet begun. This retention interval is necessary in order to provide time for some forgetting to occur. Often, this period is filled with a task unrelated to the OT or prospective action. Once this delay period ends the OT begins and periodically the prospective targets appear (see Figure 1 for a schematic of the standard PM paradigm).

**Figure 1.** A Typical Prospective Memory Paradigm



#### Prospective Memory Development during Childhood

Developmental gains in PM during early childhood are now well established (Kliegel & Jäger, 2007; Kvavilashvili, Ebdon, & Messer, 2001; Mahy & Moses, 2011; Wang, Kliegel, Liu, & Yang, 2008). Whereas toddlers are fairly unreliable in their prospective remembering (Kliegel & Jäger, 2007; Somerville, Wellman, & Cultice, 1983), school-age children show more reliable PM (Ceci & Bronfenbrenner, 1985) with much

improvement occurring during the preschool years (Guajardo & Best, 2000; Kvavilashvili, et al, 2001; Mahy & Moses, 2011). Children under the age of four years often experience PM failures due to RM errors in forgetting *what* one was supposed to do leading to failure to carry out the prospective action (see Kliegel & Jäger, 2007; Mahy & Moses, 2011). Throughout the preschool years, however, there is a clear improvement in children's ability to remember *what* they were supposed to do and in remembering to actually do it (Ford, et al., 2012; Kvavilashvili. et al., 2001; Mahy & Moses, 2011).

Factors shown to influence children's PM include: (a) motivation (Guajardo & Best, 2000; Somerville, et al., 1983), (b) the length of the retention interval or delay (Mahy & Moses, 2011; Somerville, et al., 1983), (c) whether the prospective cue interrupts the OT or appears after it (Ford, et al., 2012; Kvavilashvili, et al., 2001; Wang, et al., 2008), (d) the nature of the OT (Wang, et al., 2008), and (e) the nature of the PM cue and the presence of reminders (Guajardo & Best, 2000; Kliegel & Jäger, 2007; Meacham & Colombo, 1988). Very little research, however, has investigated the mechanisms that underlie the impact that these factors have on PM and how they interact with children's development. Further, many studies suggesting cognitive mechanisms that may be involved in children's PM performance offer post-hoc speculations that do not explicitly assess the targeted mechanism.

One domain-general cognitive ability, executive functioning (EF), has been suggested as a potential mechanism involved in the development of children' PM (Atance & Jackson, 2009; Kvavilashvili, Messer, & Ebdon, 2001; Mackinlay, et al., 2009; Mahy & Moses, 2011; Rendell, Vella, Kliegel, & Terrett, 2009; Wang, Kliegel, Liu, & Yang, 2008; Ward, Shum, McKinlay, Baker-Tweney, & Wallace, 2005; West, 1996). Various

components of EF including working memory, inhibitory control, set shifting, planning, and monitoring have been proposed as important for successful PM (Kliegel, Mackinlay, & Jäger, 2008; Marsh & Hicks, 1998; West & Craik, 2001). Further, studies have established a positive relation between EF and PM in a wide range of children from preschoolers to adolescents (Kerns, 2000; Mackinlay, Kliegel, & Mäntylä, 2009; Mahy & Moses, 2011; Mäntylä, Carelli, & Forman, 2007; Ward, et al., 2005, Yang, Chan, & Shum, 2011). Many studies have found that 6- to 12-year-olds' PM is related to their working memory, set shifting, inhibition, and planning abilities (Kerns, 2000; Mackinlay, et al, 2009; Yang, Chan, & Shum, 2011). In earlier work, I found positive relations among PM and working memory in children aged four to six (Mahy & Moses, 2011), suggesting executive abilities may be among the mechanisms driving age-related changes in PM.

#### The Development of Executive Functions in Early Childhood

EF covers a range of cognitive abilities that play a role in the conscious control of thought and action (Zelazo, Carlson, & Kesek, 2008). Abilities that fall under the umbrella of EF include: working memory, inhibitory control, set shifting, planning, monitoring, and problem solving. Carlson (2005) showed that children improve in their ability to pass EF tasks between the ages of 2 and 6-years-old, with particularly rapid development occurring between 2- and 5-years-old. Zelazo et al. (1997) suggested a problem-solving framework to organize diverse aspects of EF that included four components of a task: problem representation, planning, execution, and evaluation. Between two and five years of age, children become dramatically better in all four aspects of EF tasks outlined by the problem-solving framework. The rapid development

of EF in this period is thought to correspond to rapid brain development during these years, in particular development of prefrontal brain regions (Bunge, et al., 2002; Zelazo & Bunge, 2006).

#### How Might Executive Functions Be Involved in Prospective Memory?

How might EF be specifically involved in successful PM? In a typical PM task, an OT (e.g., card sorting or simple judgment task) must be interrupted in order to carry out the PM action (e.g., pressing a button or placing a card in a box when a specific cue is presented). Two types of monitoring play an important role in remembering to carry out one's intentions while completing the OT. The first type is internal, cognitive monitoring of one's own intentions. In order to remember the prospective intention, it must be maintained in active memory or easily retrieved from it so that when the cue appears the appropriate prospective action is activated. Further, the intention may need to be refreshed in order to maintain it in mind under some circumstances. This internal monitoring may occur during the delay prior to the OT or during the OT itself and may either occur intentionally or more automatically. The second type is monitoring of the external environment for the appearance of the PM cue. In order for the PM action to be carried out, an individual must first detect the PM cue in the environment. This type of monitoring is necessary during the OT when the target cue could appear but would not be necessary during the initial delay when the cue does not appear. Many basic EFs including working memory, inhibition, and set shifting are involved in internal monitoring of one's mind as well as monitoring of the external environment.

First, working memory may be involved in maintaining the content of the prospective action in mind long enough for it to guide action. In order for cognitive



monitoring to occur, the intention must be accessible in mind. Hicks, Marsh, and Cook (2005) suggested that intentions can fade in and out of the focus of working memory over time as in Cowan's model of working memory (Cowan, 1995; 2005). Individuals who are able to maintain the intention in their focus of attention for larger amounts of time or those who simply have a larger working memory capacity will likely benefit in their PM performance. Zelazo et al. (2007) describe two phases of goal execution: first, keeping a plan in mind long enough for it to guide thought and action and second, execution of the plan. It is clear that in this first phase, working memory plays a critical role in maintaining an intention in mind so the intention can be carried out at a later time, which is the second phase of execution. Working memory may be especially important in monitoring one's intentions during both the delay interval and the OT in the face of other cognitively demanding tasks. Working memory may also play an important role in monitoring for the external cue in the environment, as children who keep the external cue active in working memory likely will more easily recognize its significance when it appears.

Second, inhibition may play an important role in monitoring the external environment for the prospective cue. Inhibitory control may aid in suppressing performance of the OT (the pre-potent response) when the target cue appears in order to activate the novel response necessary for the PM task. Many elements of the PM task may alter the amount of inhibition needed to complete the prospective intention. For example, the salience of the PM cue may impact the level of inhibitory control necessary: cues low in salience may require higher levels of inhibition of the OT in order to be detected. Other PM tasks may more explicitly manipulate the need for inhibition by

placing the prospective target at the end of the OT rather than interrupting the OT resulting in the need for less inhibition to complete the prospective task. Further, inhibition may play a role in internal cognitive monitoring as individuals with better inhibition may be better able to inhibit other distractors in order to refresh their intentions. Work with adults suggests that individuals with better inhibitory control may be better at selecting relevant information to maintain in working memory (Awh & Vogel, 2008; Vogel, McCollough, & Machizawa, 2005), so it is possible that children with better inhibition are more able to maintain their prospective intentions in working memory rather than irrelevant information.

Third, set shifting may play a role in PM in that the child must shift back and forth between the OT and the PM task in order to perform both tasks well. The PM paradigm is essentially a dual task procedure in which two tasks need to be performed with flexible switching between them being necessary for successful performance. Better set shifting should aid in monitoring for the cue in the external environment, as it would allow for more efficient switching once the cue appears and for a smoother transition back to the OT after the PM task is carried out. Set shifting may also be necessary for monitoring one's intentions as presumably one monitors one's intentions somewhat sporadically rather than constantly thinking about the intention (as would be the case in a vigilance task; see Brandimonte & Passolunghi, 1994). Therefore, children with better shifting ability may be better able to switch from cognitive processes supporting the task during the delay interval or the OT to refreshing the prospective intention in mind.

## Theories of the Role of Controlled Processes in Prospective Memory

Two influential models that implicate EF in PM to varying degrees are the preparatory attentional and memory processes (PAM) model and the multiprocess model. In the PAM model, controlled executive processes that are working prior to the presentation of cues to the prospective action are argued to be necessary components of successful event-based PM (Smith, 2003; Smith & Bayen, 2004). These so called *preparatory attentional processes* carry out effortful monitoring of the environment for the appearance of the prospective cue. According to the PAM model, without the operation of these processes PM would not be possible.

In contrast, in the multiprocess model it is argued that PM does not necessarily require effortful strategic processes but that characteristics of the target cue, OT, and individual personality traits determine whether such processes are needed (Guynn, McDaniel, & Einstein, 2001; McDaniel, Robinson-Riegler, & Einstein, 1998). For example, McDaniel and Einstein (2000) have suggested that strategic, effortful processes are more likely to occur under experimental conditions where there is: higher perceived PM task importance, a weaker association between triggering cue and the action, or a more engaging or difficult ongoing task. Further, they also suggested that individuals with certain personality profiles such as high conscientiousness or high compulsiveness would be better in PM tasks that would benefit from controlled processes such as strategic monitoring.

Although these two theories give differing weight to executive and automatic processes they are similar in recognizing the role of controlled processes at least under certain conditions. If such capacity-consuming processes are potentially important in PM

as both theories suggest, individual differences in EF may play a role in PM especially during early childhood when the abilities needed to consciously control thoughts and actions are still developing (Zelazo, et al., 2008). Further, the role of controlled processes such as EF should be more important in tasks that are more difficult.

### The Role of Executive Processes in Prospective Remembering

The focus of this dissertation is the role of executive processes in preschoolers' prospective remembering. The preschool period represents an ideal age to examine changes in EF, PM, and the role of EF in PM for two reasons. First, both EF and PM show rapid development in the early years of childhood (Kliegel & Jäger, 2007). Second, EF and PM are important abilities to establish during the preschool years so that children are ready for formal schooling by age six or so.

In both the PAM and multiprocess model, monitoring has been suggested to be a key executive function involved in detecting the target and carrying out one's intentions (e.g., Smith, 2003; Smith & Bayen, 2004). Evidence from four different sources suggests that monitoring may play an important role in the development of PM: (1) time-based PM studies, (2) retention interval studies, (3) task interruption studies, and (4) task difficulty studies.

#### *Time-Based Prospective Memory Studies*

In contrast to event-based PM in which an action must be carried out after a certain event has occurred, time-based PM involves an action that needs to be carried out at a particular time or after a certain period of time has passed (i.e., giving a message to a colleague at 3 pm or in 45 minutes). Time-based PM tasks are generally thought to have greater self-initiated processing demands than event-based tasks due to their additional

time monitoring requirement (Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; Craik, 1986). To be successful on a time-based PM task, an individual must monitor time by checking a clock (an external strategy) and/or relying on his/her own internal sense of time (a self-initiated, internal monitoring process) while simultaneously carrying out the OT. Children generally perform worse on time-based than event-based PM tasks (Mackinlay, Kliegel, & Mäntylä, 2009; Yang, Chan, & Shum, 2011). Aberle and Kliegel (2010) examined time-based PM in kindergarteners and found that PM performance was related to working memory ability lending support to the idea that greater working memory ability may support the monitoring necessary for successful time-based PM performance.

#### *Retention Interval Studies*

Past research in our lab has suggested that differences in the ability to monitor one's own intentions (internal monitoring) may be related to successful PM and that there may be age-related changes in this ability (Mahy & Moses, 2011). We manipulated the length of the retention interval in a PM task in children 4 to 6 years old and found that 4-year-olds' PM was worse after a longer delay compared to 5-year-olds. Five-year-olds' PM actually improved significantly from a short retention interval to a long interval, whereas 4-year-olds' performance tended to get worse after a long delay. Our interpretation of this pattern was that 5-year-olds may be able to take advantage of a longer retention interval in order to refresh and consolidate their intentions (see Hicks, Marsh, & Russell, 2000, for a similar finding and interpretation with adults), whereas they do not have as much opportunity to do this at a short delay. In contrast, 4-year-olds

may not have a well-developed ability to monitor their intentions and therefore their performance on a PM task is not helped by a longer retention interval.

### *Task Interruption Studies*

PM tasks can include task interruption or not depending on when the prospective target appears. If the PM target appears at the end of the ongoing task, then no task interruption occurs. However, if the PM target appears in the midst of the ongoing task as most do, then it is necessary to interrupt the OT to complete the prospective task. Kvavilashvili et al. (2001) found that 4-, 5-, and 7-year-old children had poorer PM when the PM cue interrupted the OT compared to when it appeared after the OT was completed. With 3- to 5-year-olds, Wang et al. (2008) also found that children performed worse on the PM task when they had to interrupt the OT and the effect of age disappeared when children did not have to interrupt the OT to carry out the prospective intention. The authors argued that differences in inhibitory control were driving the age effect in the task interruption condition. Task interruption studies may require higher levels of inhibitory control in order to break away from the OT to carry out the PM task. Additionally, performing the OT may interfere with children's ability to monitor the external environment for the PM target compared to performing the OT and the PM task sequentially where monitoring can occur unhindered by other potentially strong cognitive demands.

### *Task Difficulty Studies*

Just as PM tasks are easier to perform successfully when it is not necessary to interrupt the OT, it is also easier when the OT poses minor versus major cognitive demands. By manipulating the difficulty of the PM task and the OT, researchers have

intentionally or unintentionally manipulated the amount of monitoring necessary to detect the PM target. There are two ways in which task difficulty has been manipulated within PM paradigms in studies with children: (1) by varying the difficulty of the OT and (2) by varying the distinctiveness of the PM cue. Further evidence for the role of controlled processes in PM comes from studies that show that EF and PM are often correlated in cognitively difficult PM conditions but not in easy conditions.

Researchers have manipulated the OT in ways that may affect the need for monitoring by asking children to memorize cards during the OT (Wang, et al., 2008), and by decreasing the duration of the presentation of OT stimuli and PM cues (Ward, et al., 2005). These manipulations focused on depleting the cognitive resources available for the PM task by increasing the demands of the OT. Both manipulations resulted in either worse PM performance or slower PM latencies in children, presumably because of increased monitoring demands.

Other research has focused on manipulating aspects of the PM task rather than the OT by increasing the distinctiveness of PM cues. McGann, Defeyter, Ellis, and Reid (2005) increased the perceptual distinctiveness of the PM cue via making the target items larger than the distractor items in the OT and found that this resulted in superior PM performance in 4-, 5-, and 7-year-olds. Further, increasing target distinctiveness also improved PM in the younger children and eliminated the age effect on PM.

Studies examining the impact of task difficulty on PM that have also measured individual differences in EF have found that children's EF was related to PM only for high difficulty conditions. Ward et al (2005) found that 7- to 10-year-old children's working memory and focused attention/inhibition were both significant predictors of their

PM performance on the high cognitive-demand version (600 ms stimuli presentation) but not on the low demand version (850 ms stimuli presentation) of the PM task. Shum et al (2008) found that 8- to 9-year-old children and 12- to 13-year-old children's EF (working memory, inhibition, and cognitive flexibility) significantly added to the prediction of PM in the Interruption condition (difficult) than the Non-interruption condition (easier). To further support these findings, executive functioning accounts for a larger amount of variance in adult's PM performance when the OT is difficult (Martin, et al., 2003). Taken together, these studies suggest that in older children and adults there is a relation between EF and PM under cognitively demanding conditions potentially because EF ability can aid PM performance under such conditions.

It is worth noting that studies with adults and children have sometimes revealed PM and OT tradeoffs, where better PM accuracy comes at the expense of slower OT performance or slower PM performance (e.g., Wang, et al., 2008), or where better OT performance comes at the expense of PM accuracy (Marsh, Hicks, & Cook, 2005). These effects sometimes depend on whether PM is emphasized as important (e.g., Kliegel, Martin, McDaniel, & Einstein, 2001; Kliegel, Martin, & Moor, 2003) and in which task more effort is invested (Marsh, Hicks, & Cook, 2005). Therefore, another way to detect the effect of OT difficulty is not only by examining its effect on PM performance but on OT accuracy and speed as well.

### Goals of the Current Studies

Each of the above lines of evidence suggests the importance of controlled processes and monitoring in children's PM, but no research has systematically examined



the factors that may impact monitoring during various stages of the PM task. The aims of the dissertation are: (1) to investigate age-related changes the effects of task manipulations that may aid or hamper children's ability to monitor their intentions and the appearance of PM targets and (2) to examine relations between individual differences in EF and individual differences in PM.

In order to examine the role of internal monitoring in children's PM, Study 1 assessed whether manipulating task difficulty during the retention interval would have an effect on later PM. Recall that Mahy and Moses (2011) found that a longer retention interval helped 5-year-olds' prospective remembering compared to a shorter interval, while the longer delay did not help 4-year-olds' PM. I hypothesized that 5-year-olds were taking advantage of longer delay intervals to monitor their intentions whereas 4-year-olds were not. By manipulating task difficulty during the retention interval, we further tested the hypothesis that children are taking advantage of longer delays to refresh their intentions. If monitoring during the retention interval is critical to PM, then children who engage in a difficult task during the retention interval should show worse PM compared to children who complete an easy task. A difficult task should disrupt monitoring more than an easy task. In addition, if monitoring is affected, EF should relate more strongly to PM in the difficult condition compared to the easy condition because children with better EF may be better able to cope with disruptions to monitoring in difficult conditions which would benefit PM performance. I tested this hypothesis by assessing children's EF independently of their PM performance and then examining the relation between individual differences in EF and PM in the easy versus the difficult condition.

Study 2 further examined the role of internal monitoring but also included manipulations designed to impact external monitoring of the environment in PM. Three manipulations focused on manipulating internal and external monitoring. First, OT difficulty was manipulated such that the easy OT required less inhibition than the difficult OT. This manipulation should interfere with both internal and external monitoring as a difficult OT should reduce opportunities to refresh the PM intention and should also reduce the likelihood of detecting the PM cue. Second, to further examine the monitoring hypothesis that arose from previous work (Mahy & Moses, 2011), I manipulated whether children were explicitly instructed to think about PM intention during the retention interval or to think about the distractor task (drawing pictures). This manipulation specifically focused on encouraging children to monitor their intentions during the delay and therefore was a direct manipulation of internal monitoring given that children follow this instruction. Finally, this study also manipulated cue salience in order to assess whether external monitoring demands impact young children's PM. Further, Study 2 continued to investigate relations between EF and PM in conditions that varied in their executive demand.

The two studies address an area of research that has not been thoroughly investigated in young children. By manipulating factors that may impact monitoring ability in different stages of a PM task, these studies provide a systematic assessment of the importance of executive processes to the various requirements of the PM task.

## CHAPTER II

### STUDY 1

#### Introduction

The primary goal of this study was to investigate the role of internal, cognitive monitoring in PM. The findings of Mahy and Moses (2011) suggested that there might be age differences in children's ability to monitor their intentions during a delay period that have an impact on later PM. Specifically, they found a developmental difference in the effect of a long retention interval on children's PM: 5-year-olds' PM improved after a long delay (5 minutes) compared to a short delay (1 minute), while 4-year-olds tended to show worse PM after a longer delay compared to a shorter one. These results suggested that 5-year-olds but not 4-year-olds were perhaps able to take advantage of a longer delay to monitor and refresh their intentions. The findings and interpretation are similar to those of Hicks et al. (2000) who found that adults performed better on a PM task after a long delay with several intervening activities than shorter delays or delays that were filled with fewer activities.

Study 1 was designed to follow up on the monitoring hypothesis by filling the delay period either with an easy task that would potentially allow children to monitor their intentions or a difficult task that would require more executive resources and would potentially limit monitoring of intentions. The rationale was that if children were in fact taking advantage of a longer retention interval to monitor their intentions, then having to complete a cognitively demanding task during this delay would result in worse PM via decreasing opportunities to monitor or refresh intentions. Conversely, children's monitoring and their PM should be relatively less affected by an easy filler task. The

Self-Ordered Pointing Task was selected as the filler task as it has been used with young children (Hongwanishkul, et al., 2005) and has two possible versions: one with high working memory demands and one with lower working memory demands.

In addition, given that EFs play a role in cognitive monitoring, children with better EF should do better on PM tasks. Although EF and PM are related abilities in older children and adolescents (Kerns, 2000; Ward, Shum, McKinlay, Baker-Tweney, & Wallace, 2005) as well as adults (Martin, Kliegel, & McDaniel, 2003), evidence of these relations in preschool children is fairly limited (Ford, et al., 2012; Mahy & Moses, 2011). The current study sought to further examine this relation by including a widely used measure of working memory (Backward Digit Span) and a planning task (Truck Loading).

Understanding one's own mind and mental states may also be related to cognitive monitoring. Theory of mind (ToM), the ability to ascribe mental states to oneself and others (Wellman and Liu, 2004) may be related to monitoring as children with a better understanding of the mind may more generally be more inclined to reflect on mental states and processes. A recent study with preschoolers found that performance on false belief tasks predicted PM above and beyond age, working memory, and inhibitory control (Ford, et al., 2012). Therefore, we included a measure of advanced ToM in the current study in order to investigate the relation between PM and children's ability to appreciate their own previous mental states as well as the mental states of others (the Restricted View Task; Taylor, Cartwright, & Bowden, 1991). In particular, one might expect that children who have a more sophisticated understanding of mental states may also be better at monitoring their intentions. In addition, a parent-report measure of children's social understanding was collected in order to gain another perspective on children's ToM. The

Children's Social Understanding Scale (CSUS; Tahiroglu, et al., 2009) asked parents about various aspects of their children's awareness of the mind and mental states.

Finally, other future oriented abilities may also play a role in monitoring one's intentions. The ability to make choices for and think about the future may be related to monitoring as both play a role in preparing for and anticipating future events. Atance and Jackson (2009) found positive relations between preschooler's PM and future thinking using a mental time travel task in which children were asked to imagine going somewhere in the future, choose one of three items that they would take them, and then justify their choice (e.g., bringing a water bottle to the desert because they might get thirsty). In the current study, I also used the mental time travel task as a measure of future thinking in order to investigate its relation with PM.

Relations among these individual differences measures were examined separately for children who received the easy and difficult filler task conditions as children with higher EF, ToM, and future thinking may be able to capitalize on these abilities to do better on the PM task after the difficult filler task. Previous studies have found that children's EF was related to PM in high cognitive demand cognitions compared to low cognitive demand conditions (Shum, et al., 2008; Ward, et al., 2005) suggesting that children with better EF cope well with difficult tasks to the benefit of their PM. All four measures were selected because they had been used successfully with 4- and 5-year-olds previously (Atance & Jackson, 2009; Carlson, 2005; Carlson & Moses, 2001; Taylor, et al., 1991).

### *Hypotheses*

I hypothesized that:

- (1). Four-year-olds would perform worse on the PM task than 5-year-olds.
- (2). Children would perform worse on the PM task after a difficult filler task than after an easy one. It was also possible that age and filler task difficulty might interact such that:
  - (a) five-year-olds would be negatively affected by the difficult filler task but 4-year-olds would be unaffected because of differing abilities to monitor one's intentions, or
  - (b) four-year-olds' PM would be particularly harmed by the difficult condition as they would not be able to monitor their intentions in this conditions whereas 5-year-olds may be able to monitor their intentions regardless of the filler task difficulty level.
- (3). Children's performance on the EF tasks (Backward Digit Span and Truck Loading), Restricted View Task, and Mental Time Travel would be more strongly related to PM performance in the difficult filler task condition than in the easy filler task condition.

## Method

### *Participants*

Sixty-eight 4- and 5-year-old children participated. Four participants were not included in the final analysis because two children failed the control question in the PM task, one child had participated in a previous study using a similar PM task, and one child misunderstood the rules of the PM task. The final sample consisted of 32 4-year-olds ( $M = 4.30$ ,  $SD = .28$ ) and 32 5-year-olds ( $M = 5.46$ ,  $SD = .33$ ) with equal numbers of girls and boys in each age group. Children were assigned to one of two conditions within their age group: an easy filler task condition or difficult filler task condition. Assignment was random with the constraints that an equal number of 4- and 5-year-olds and girls and boys were in each condition. There were no significant differences in age between the two conditions within age groups ( $ps > .10$ ). Children were mostly Caucasian and from

middle-class backgrounds reflecting the population from which the sample was taken. Participants were recruited from a University database compiled from birth announcements from local newspapers.

### *Measures*

#### *Prospective Memory Task*

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

Once children were familiar with the task and indicated they understood the rules, a picture game was introduced that filled the retention interval. The delay between the introduction of the PM task rules and the card sorting was approximately three minutes (the length of five trials of the filler task). The filler task consisted of five trials of 6-item arrays of the self-ordered pointing task (SOPT; Hongwanishkul, et al., 2005). In this task children were asked to point to one of six pictures of objects on a page. The page was then turned and they were shown the same items and asked to point to an item they had

not pointed to previously. The procedure continued until children had viewed the array six times, thus giving them the opportunity to point to each of the six items once. The remaining trials included new 6-item arrays.

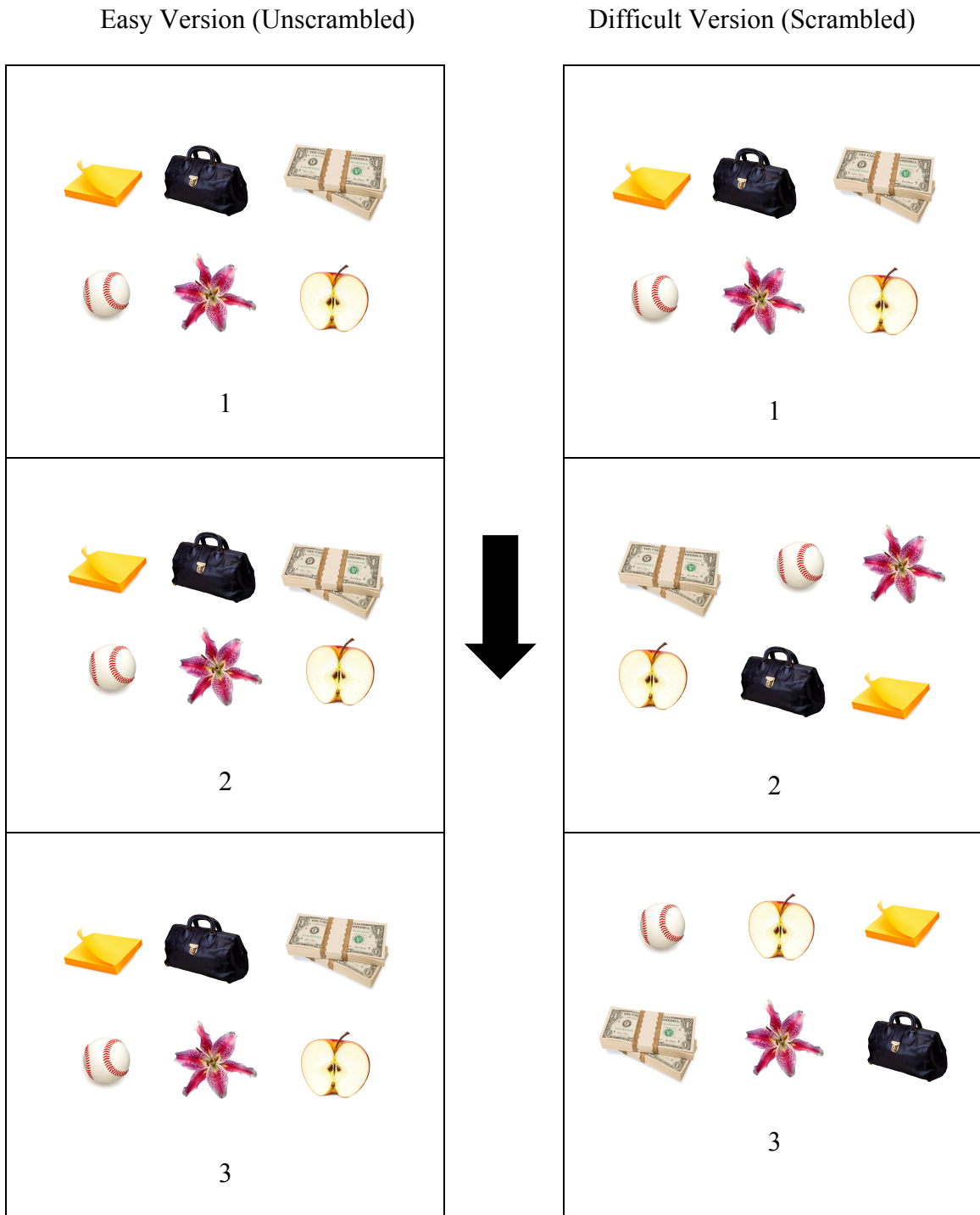
Children completed either an easy or a difficult version of this task. In the easy version, children were presented with six items that appeared in the same location on each trial so that both location and object identity could be used as memory cues. In contrast, in the difficult version the pictures were scrambled before each trial so that children could only use object identity as a memory cue (Figure 2).

After the filler task was completed, children were told that the card game would begin and were then asked to name the items in the first stack of cards. Subsequently, children alternated between drawing a picture for one minute and naming a stack of cards until they had named all four stacks of cards. Each stack contained twelve cards: Of these, one was a target card (an animal). Target cards were placed in a fixed position in each stack, the 7<sup>th</sup> card in the first stack, the 4<sup>th</sup> in the second stack, the 11<sup>th</sup> card in the third stack, and the 5<sup>th</sup> in the fourth stack.

When children completed naming the four stacks of cards they were asked, “what were you supposed to do when you saw a picture of an animal?” This control question ensured that participants remembered the initial rule and thus that forgetting didn’t arise from a retrospective memory failure for the task instructions. Only two 4-year-old children were excluded from the final analysis for failing this control question and both were from the easy filler task condition suggesting that the PM task was age-appropriate for the vast majority of children. Children were given a PM score out of four based on the number of target cards they correctly placed in the box.



**Figure 2.** First Three Trials of the Easy and Difficult Versions of the Self-Ordered Pointing Task



### *Retrospective Memory*

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

### *Backward Digit Span*

To measure working memory, children completed the digits forward and digits backward subscales from the WISC-III (Wechsler, 1991). The Backward Digit Span task was used as the measure of working memory but the forward digit span was also administered as a warm-up and in order to familiarize children with the task. In the digits backward subscale, they were asked to repeat a series of numbers in backward order after the experimenter read them aloud. They began with two numbers and after completing two trials successfully an additional number was added. The task ended when children failed two consecutive trials. Backward Digit Span was calculated by summing the number of backward digit strings children were able to repeat accurately.

### *Truck Loading*

This planning task followed the procedure used by Carlson, Moses, and Claxton (2004). Children were asked to pretend they were mail carriers that needed to deliver party invitations to a neighborhood. Children were shown a one-way street that was lined

with cardboard houses. Their attention was drawn to the fact that the color of the invitations corresponded to the color of the houses. Children were asked to place the invitations into the truck and then deliver them while following four rules: (1) they could only drive the truck in one direction on the one-way street, (2) the invitations needed to be delivered as fast as possible so they should drive down the block only once, (3) the invitations must be delivered to the appropriate color-matched house, and (4) invitations could only be delivered from the top of the pile in the back of the truck. These four rules were explained to children and the experimenter demonstrated a trial with two houses. Then, they were asked to practice delivering invitations to the two houses. Once children performed this practice trial correctly, the houses were replaced with two different color houses and the test trials began. Children were asked to deliver the invitations to houses on the block twice (two trials), and if they successfully delivered the invitation on at least one of the trials then an additional house was added. There were four levels of trials ranging from two houses to five houses. If children failed two trials on the same level consecutively the game was ended. Children were scored on their highest level of achievement from zero (could not deliver invitations to two houses correctly) to four (delivered invitations to five houses correctly).

#### *Restricted View Task*

In this advanced ToM task (adapted from Taylor, et al., 1991), children first were introduced to a game in which they had to guess the contents of several pictures. Each picture was mounted on card stock, and a sheet of blue card stock was taped to one edge to serve as a removable cover. A small rectangular opening was cut in each cover. The extent to which the picture could be seen when the cover was in place varied to create

three types of stimuli: (1) identifiable—sufficient content showed through the opening to allow identification of the picture; (2) empty—no part of the object could be seen, that is, the view showed empty white paper and (3) non-descript/ambiguous—only a small non-descript part could be seen. There were two identifiable stimuli (dog/girl), two empty stimuli (turtle/bunny), and one non-descript stimulus (reindeer).

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

### *Mental Time Travel*

This task was adapted from Atance and Jackson (2009). Children were asked to imagine going to a pictured place (e.g., a mountain). They were then shown three objects that they could bring to the place (e.g., a bowl, grass, or lunch) and asked to choose one. There was a correct choice for each location (in this case, lunch) as well as two incorrect options: a distracter item that was semantically related but not useful to bring to the location (grass) and an irrelevant item that was not semantically related to the location (a bowl). Regardless of their choice, children were asked to justify choosing the selected item. Children's choices were scored on whether they selected the correct item and their justifications were scored on whether they were future oriented. Children were given four trials and received one point for each correct item choice and one point for each reasonable, future-oriented explanation up to eight points on this task. Inter-rater coding reliability of children's justifications was high (Cronbach's Alpha = .96).

### *Children's Social Understanding Scale*

While children were participating in the experimental session, parents were asked to fill out a 42-item scale that assessed children's social understanding (CSUS; Tahiroglu, et al., under review; Tahiroglu, et al., 2009; see Appendix A for CSUS items). The scale consists of six subscales measuring parent's estimation of their child's understanding of belief, desire, knowledge, emotion, intention, and perception. Examples of items include: "when given an undesirable gift, pretends to like it so as not to hurt the other person's feelings", "understands that telling lies can mislead other people", and "talks about the difference between the way things look and how they really are". Parents rated their children's behavior on a four point Likert scale. This scale took approximately fifteen

minutes for parents to complete. CSUS total score was calculated by averaging all 42 completed items for a total score out of a possible four.

### *Procedure*

Children were individually interviewed by an experimenter in a laboratory at the University of Oregon. All tasks were administered in a fixed order as is convention in individual differences research: Prospective Memory Task, Retrospective Memory Task, Digit Span Tasks, Truck Loading, Restricted View Task, and Mental Time Travel. While children were participating in the study, their parents were asked to provide basic demographic information and to fill out the Children's Social Understanding Scale. At the end of the experimental session, children were given a small toy and a gift certificate to a local toy store and were thanked for their participation. All procedures were approved by the University of Oregon's Office for Protection of Human Subjects.

## Results

### *Filler Task Manipulation Check*

Table 1 shows means and standard deviations for SOPT errors in each condition. In order to investigate whether the difficulty manipulation worked, children's performance on the easy and difficult versions of the SOPT was measured. A 2 (Age) X 2 (Filler task difficulty) ANOVA revealed that children made fewer errors on the SOPT in the easy condition ( $M = 1.63$ ,  $SD = 1.82$ ) compared with the difficult condition ( $M = 2.88$ ,  $SD = 2.17$ ),  $F(1, 60) = 6.28$ ,  $p < .05$ , confirming that this difficulty manipulation was successful. There was no statistically significant effect of age on the number of errors on the SOPT, although 5-year-olds ( $M = 1.97$ ,  $SD = 1.93$ ) tended to make fewer errors than

4-year-olds ( $M = 2.53$ ,  $SD = 2.23$ ),  $F(1, 60) = 1.27$ ,  $p = .27$ . There was no interaction between filler task difficulty and age group on SOPT performance.

**Table 1.** Means and Standard Deviations for Self-Ordered Pointing Task Performance by Age Group and Filler Task Difficulty Condition

	Filler Task Difficulty	Age Group	
		4-year-olds	5-year-olds
SOPT Errors	Easy	2.19 (2.14)	1.06 (1.29)
	Difficult	2.88 (2.33)	2.88 (2.06)

*Note*—SOPT = Self-Ordered Pointing Task.

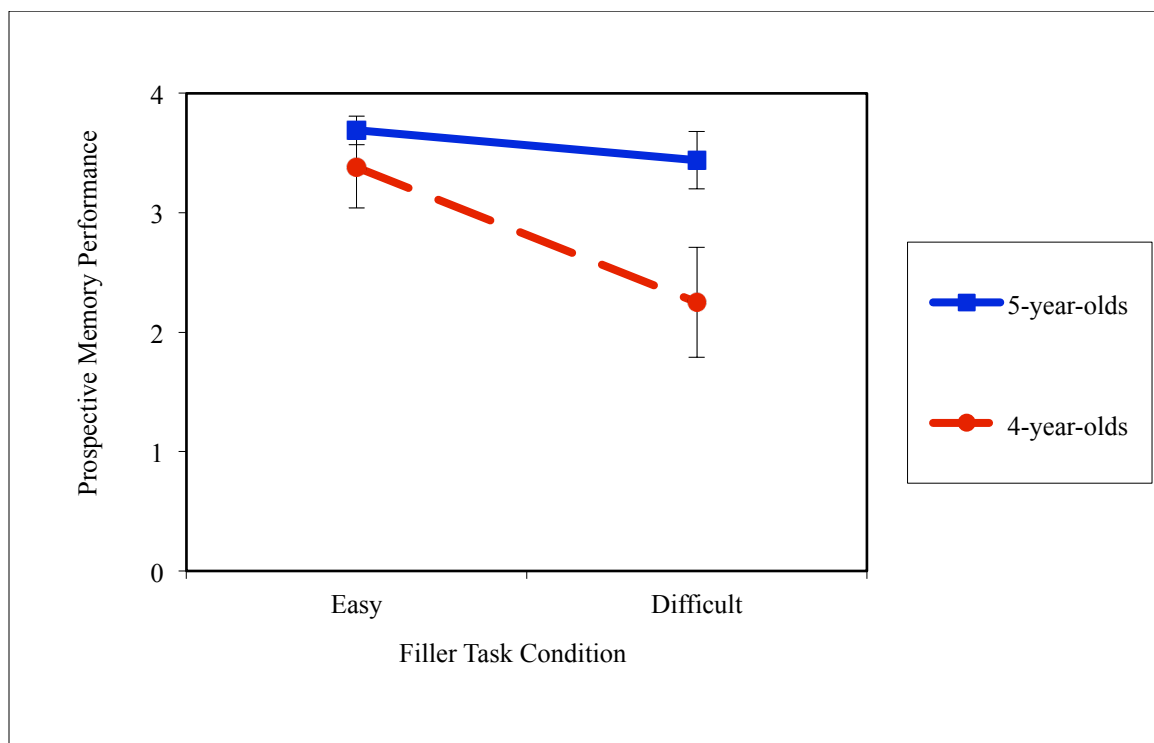
### *Prospective Memory Task*

Figure 3 shows PM performance according to age and condition. A 2 (Age) X 2 (Filler task difficulty) ANOVA on PM revealed main effects of age and filler task difficulty.<sup>1</sup> Five-year-olds performed significantly better on the PM task than 4-year-olds,  $F(1, 60) = 5.62$ ,  $p < .05$ ,  $\eta^2 = .09$ . In addition, children performed better on the PM task after an easy filler task than after a difficult one,  $F(1, 60) = 4.72$ ,  $p < .05$ ,  $\eta^2 = .07$ . There was no significant interaction between age and filler task difficulty ( $p > .17$ ). However, simple effects revealed that 5-year-olds performed significantly better on the PM task than 4-year-olds when the retention interval was filled with a difficult task,  $F(1, 60) = 7.04$ ,  $p < .05$ , but did not differ when the retention interval contained an easy task

<sup>1</sup> Although gender was not predicted to affect PM, boys scored significantly higher than girls on the PM task,  $F(1, 56) = 5.25$ ,  $p < .05$ . The main effect of gender was qualified by a significant interaction between gender and age such that 4-year-old girls performed much worse than 5-year-old girls, whereas boys PM perform did not differ by age group,  $F(1, 56) = 5.25$ ,  $p < .05$ . Importantly, including gender in the analysis did not have any impact on the significance of the effects of age or filler task difficulty.

( $p > .48$ ). Four-year-olds performed marginally worse on PM after a difficult task filled the delay compared to when an easy task filled the delay,  $F(1, 30) = 3.85, p = .06$ , whereas 5-year-olds' PM did not differ between the easy and difficult task. Five-year-old children's performance neared ceiling on this task so this may have affected our ability to detect interactions between age and filler difficulty.

**Figure 3.** Prospective Memory Performance by Difficulty Condition and Age Group



The length of the retention interval was coded to rule out the possibility that the effect of difficulty was due to children taking longer to complete the filler task rather than due to the actual difficulty of the task. Inter-rater reliability on the length of the filler task was high (Cronbach's Alpha = .97) for 25% of the data (16 participants coded) indicating sufficient coding reliability. Children took significantly longer to complete the self-



ordered pointing task in the difficult condition ( $M = 3.24$ ,  $SD = .55$ ) compared to the easy condition ( $M = 2.94$ ,  $SD = .42$ ),  $t(62) = 2.48$ ,  $p < .05$ . Importantly, however, when the length of time to complete the filler task was added as a covariate the main effect of difficulty persisted,  $F(1, 59) = 5.28$ ,  $p < .05$ , and length of the delay task did not emerge as a significant covariate.

In order to further investigate PM performance over the course of the task, I examined trends in performance. Children's PM performance did not change significantly over the PM task; there were no significant linear, quadratic, or cubic trends in PM performance over time,  $F_s(1, 63) > .06$ ,  $p_s > .30$ . Children's performance on the four PM items was highly reliable (Cronbach's Alpha = .88).

#### *Retrospective Memory Task*

Table 2 shows means and standard deviations for RM performance in each condition. A 2 (Age) X 2 (Filler task difficulty) ANOVA revealed that there were no significant effects of age or filler task difficulty on retrospective memory performance. Children overall did very well on this task, scoring near ceiling ( $M = 19.84$ ,  $SD = 2.98$ ) and significantly above chance levels in each age and condition,  $t_s(15) > 8.77$ ,  $p_s < .001$ . Performance on this task was not related to PM score, Backward Digit Span, Truck Loading, or the Restricted View Task, but was marginally related to scores on Mental Time Travel and was related to the CSUS.

#### *Individual Differences*

Means and standard deviations for individual difference measures by age group are shown in Table 3. Five-year-olds performed significantly or near significantly better than 4-year-olds on the Backward Digit Span task, Truck Loading, Restricted View Task,

and Mental Time Travel,  $t_s(60) > 1.98, p_s < .06$ . CSUS scores did not differ between 4- and 5-year-olds ( $p > .45$ ). Truck Loading and Backward Digit Span performance were highly correlated, likely reflecting the important role of working memory in the planning task.

**Table 2.** Means and Standard Deviations for Retrospective Memory Performance by Age Group and Filler Task Difficulty Condition

	Filler Task Difficulty	Age Group	
		4-year-olds	5-year-olds
Retrospective Memory Performance	Easy	20.31 (2.02)	19.19 (3.73)
	Difficult	19.67 (3.56)	20.19 (2.46)

*Note*—N per cell = 16.

**Table 3.** Means and Standard Deviations of Performance on All Measures by Age Group

Task	4-year-olds	5-year-olds
Backward Digit Span	.81 (1.09)	2.29 (1.27)
Truck Loading	2.28 (1.22)	3.37 (1.13)
Restricted View Task	1.39 (.40)	1.69 (.34)
Mental Time Travel	4.88 (2.51)	6.00 (2.02)
Children's Social Understanding Scale	3.28 (.30)	3.32 (.32)

*Note*—Range of possible scores: Backward Digit Span (0-16), Truck Loading (0-4), Restricted View Task (0-2), Mental Time Travel (0-8), Children's Social Understanding Scale (1-4). Standard deviations are in parentheses.

In the easy filler task condition, children's PM performance was not significantly correlated with Backward Digit Span, Truck Loading, Restricted View Task, Mental

Time Travel or CSUS score. In contrast, Backward Digit Span, Truck Loading, and Restricted View task were positively associated with PM performance in the difficult filler task condition. These relations remained significant after controlling for chronological age (Table 4).

**Table 4.** Raw and Age-controlled Correlations among Measures in Study 1 in Easy and Difficult Filler Conditions

	1.	2.	3.	4.	5.	6.	7.	8.
1. Age	-	.32 <sup>†</sup>	.13	.44*	.53**	.44*	.34	.10
2. PM	.25	-	.31 (.28)	.50** (.45*)	.50** (.44*)	.48** (.50**)	.17 (.11)	.11 (1.3)
3. RM	-.14	-.25 (-.22)	-	.31 <sup>†</sup> (.27)	.00 (-.07)	-.19 (-.26)	.40* (.40*)	.52** (.54**)
4. BDS	.68**	.12 (-.04)	.00 (.02)	-	.64** (.54**)	.38** (.22)	.17 (.02)	.17 (.14)
5. TL	.52**	.26 (.17)	.24 (.40*)	.46* (.11)	-	.50** (.36 <sup>†</sup> )	.09 (-.12)	.07 (.02)
6. RVT	.31 <sup>†</sup>	.23 (.22)	.21 (.16)	.45* (.19)	.31 <sup>†</sup> (.10)	-	.02 (-.20)	.02 (-.07)
7. MTT	.29	-.21 (-.32 <sup>†</sup> )	.07 (-.01)	.46** (.19)	.23 (-.04)	.36* (.08)	-	.45* (.43*)
8. CSUS	.10	-.29 (-.33 <sup>†</sup> )	.05 (-.04)	.30 (.16)	.03 (-.13)	.52** (.40*)	.47** (.30)	-

*Note* – PM = Prospective Memory, RM = Retrospective Memory, BDS = Backward Digit Span, TL = Truck Loading, RVT = Restricted View Task, MTT = Mental Time Travel, CSUS = Children’s Social Understanding Scale. Below the diagonal is performance for children in the easy filler task condition and above is performance for children in the difficult filler condition. <sup>†</sup>.  $p < .10$ , \* .  $p < .05$ , \*\* .  $p < .01$ . Degrees of freedom range from 31 to 32. Partial correlations controlling for age in months are in parentheses.

Overall, Parent-reported social understanding was positively related to performance on the Retrospective Memory Task, Restricted View Task, and Mental Time Travel,  $r_s (63) > .27, ps < .05$ , and marginally related to Backward Digit Span,  $r (63) = .23, p = .07$ . After controlling for age, the relation between CSUS score and Restricted View Task as well as CSUS score and Backward Digit Span became non-significant but the relation between CSUS and Mental Time Travel remained robust. There was no relation between the CSUS and PM performance.

## Discussion

This study examined the effect of age and filler task difficulty on young children's PM performance. It also assessed individual differences in working memory, planning, ToM, and future thinking, as they relate to PM performance in different conditions.

### *Summary of Experimental Findings*

Five-year-olds performed better than 4-year-olds on the PM task. This task had sufficient sensitivity to detect age related changes in this narrow age range as past studies have also shown (Kvavilashvili, et al., 2001; Mahy & Moses, 2011). However, 5-year-olds' PM performance was close to ceiling levels in both the easy and difficult filler condition suggesting that the task may have been too easy for them. In contrast, the PM task elicited greater variability in 4-year-olds who showed lower levels of performance particularly in the difficult filler task condition.

The goal of the filler task difficulty manipulation was to disrupt internal, cognitive monitoring by a difficult compared to an easy filler task and to examine the impact this had on PM. The filler task difficulty manipulation was successful as children made more errors on the difficult version of the SOPT than the easy version of the SOPT. As hypothesized, after a difficult filler task, children's PM was worse than after completing an easy filler task. These findings suggest that cognitive monitoring during the delay interval may have been disrupted by the difficult filler task but not by the easy filler task. The findings are consistent with previous work in our lab (Mahy & Moses, 2011) as well as work in the adult literature that suggests that individuals take advantage

of longer delay intervals to refresh their intentions in their mind resulting in superior PM (Hicks, et al., 2000).

No interaction emerged between age and filler task difficulty, although simple effects suggested that 4-year-olds' PM was worse than 5-year-olds' PM after a difficult filler task. Given that performance on the PM task was approaching ceiling, it is likely that the task was too easy for 5-year-olds (insufficient to disrupt cognitive monitoring) and therefore difficult to detect any condition differences at that age.

#### *Role of Individual Differences in Prospective Memory*

The correlational analyses suggest that executive processes and ToM may play a more important role in PM when there is a higher cognitive demand in the retention interval. Children with better working memory, planning abilities, and understanding of the mind remembered to carry out an intention when the retention interval was filled with a difficult task but not when it was filled with an easy task. Children with superior working memory and planning may have been better able to overcome the disruption to monitor their intentions during the delay period in the difficult filler condition (Hicks, et al., 2000). Cowan's model (Cowan, 1995; 2005) suggests that children with better working memory ability are better able to hold information in the focus of their working memory which may have allowed children with superior working memory to maintain the intention in the focus of attention over the delay period. These results are similar to studies that have shown that children's EF is related to PM in high cognitive demand conditions but not in lower cognitive demand conditions (Shum, et al., 2008; Ward, et al., 2005).

The finding that PM is related to understanding of the mind is supported by work that shows that PM and false belief task are related in preschoolers (Ford, et al., 2012). Notably, in Study 1 this relation was only significant after a difficult filler task suggesting that children with better ToM are better able to cope with a difficult task during the delay to the benefit of their later PM, possibly because of the role ToM plays in cognitive monitoring.

In contrast to previous work that has shown a positive relation between future thinking and PM (Atance & Jackson, 2009), in the current study future thinking as measured by mental time travel was unrelated to PM. This discrepancy of findings may be due to differences in the scoring scheme of the mental time travel task. The scoring for children's future-oriented explanations used in the current study was more lenient than that used by Atance and Jackson (2009) whose coding scheme may have penalized children who had poorer expressive verbal ability. Alternately, it is possible that the relation between PM and future thinking is tenuous as the relation did not hold up after age was controlled in Atance and Jackson's (2009) study.

*Alternative Account: Executive Exhaustion*

An alternative to the monitoring explanation of our findings is that the difficult filler task simply exhausted executive resources during the delay and that this exhaustion then lingered during the PM task, resulting in worse PM. Baumeister has shown that executive resources are finite in that when they are exhausted, performance on later tasks suffers (Baumeister, 2002). Because task difficulty was manipulated only during the retention interval, it is difficult to tease the monitoring and lingering executive exhaustion explanations apart. That said, while filler task difficulty had an impact on children's PM,

it is worth noting that the manipulation did not affect later performance on Retrospective Memory, Backward Digit Span, Truck Loading, Restricted View Task, or Mental Time Travel, as might have been expected with an executive exhaustion interpretation. Further, PM performance did not decline over the course of the PM task after the difficult filler task as one might expect if executive exhaustion was occurring. Nonetheless, in Study 2, I address this limitation by manipulating difficulty concurrently, during the OT, rather than during the initial retention interval.

### *Limitations*

There were several limitations of the current study that Study 2 was designed to address or ameliorate. In particular, the OT and PM tasks appeared to be too easy for many children and the RM task was not sensitive enough as a measure of processing difficulty of the OT. Therefore, several procedural modifications were made to the PM and RM tasks in order to make them more difficult and to yield more variability in performance. A number of modifications were made in order to improve these two tasks. In order to examine the executive exhaustion interpretation of the data, I manipulated OT difficulty in order to examine the impact of concurrent executive difficulty on PM. This concurrent manipulation of difficulty was designed to control for this alternate interpretation that Study 1 was susceptible to as the manipulation of task difficulty prior to the PM task and therefore could have exhausted executive resources by the time of PM task began. In addition, Study 2 included manipulations designed to further test the monitoring hypothesis. Study 1 measured only two aspects of EF: working memory and planning. In order to measure the three core facets of EF (Miyake, et al., 2000), Study 2

included a greater variety of EF measures tapping: working memory, inhibition, and set shifting.



## CHAPTER III

### STUDY 2

#### Introduction

Study 2 attempted to address the limitations of Study 1 and also further explore some of the intriguing findings that emerged from it. By increasing the difficulty of the PM task, OT, and RM task, as well as including a broader assessment of EF (Miyake, et al., 2000), I hoped to be able to better explore the effects of several experimental manipulations of monitoring on PM as well as further examining individual difference variables that might be related to PM performance.

Study 2 sought to examine the role of executive processes in PM via three manipulations—a manipulation of OT difficulty, an explicit instruction to monitor one’s intentions during the retention interval, and a manipulation of target salience. Specifically, the difficulty manipulation was extended to the OT, in contrast to Study 1 where it had been manipulated in the filler interval. In order to further test the monitoring hypothesis arising from past studies (Mahy & Moses, 2011) and Study 1, children were also given an instruction either to think about what they had to do in the card game (i.e., monitoring their prospective intention) or to think about what they were drawing (i.e., focus on the distracting activity that filled the retention interval). Finally, to examine the role of external monitoring in PM, target salience was manipulated by including some targets with a bright red border and some without a border like the distractor cards in the OT.

As the results of Study 1 could have been due to lingering executive exhaustion rather than direct disruption of cognitive monitoring, Study 2 circumvented this alternate

interpretation by manipulating concurrent difficulty of the OT rather than prior difficulty of the retention interval. This avoids the issue of executive exhaustion as the manipulation will be concurrent with the PM task so executive resources would be less likely to be exhausted at the start of the PM task. In the newly adapted PM task, children were asked to identify whether an object depicted on a card was a large or small item and then to place it in its appropriate box. In the easy condition, the boxes corresponded to the category of the item (e.g., small items go into the box with a picture of a small item on it, and large items go into the box with a large item on it), whereas in the difficult condition children were asked to sort the items into the opposite boxes (e.g., big items into the small box, and small items into the big box). This manipulation of OT difficulty was designed to affect executive processing by varying working memory and inhibitory load (remembering the rules that conflict with examples on each box and inhibiting the pre-potent response to place the item in its matching box). By varying the amount of attention children would need to pay to the distractor cards in the OT, I aimed to correspondingly affect the executive resources available for monitoring in the PM task. The current study extended the manipulation of difficulty to the OT in order to examine the impact of increasing executive difficulty throughout the OT rather than just when the PM intention is being formed or consolidated during the retention interval.

Second, children were instructed by the experimenter to either think about what they were drawing a picture of or to think about what they would have to do in the PM task during the retention interval. This manipulation was designed to examine the impact of children's own cognitive monitoring on their PM performance and the instruction was meant to either explicitly encourage children to monitor their intentions during the

retention interval or to distract them from doing so by asking them to focus on what they were drawing during the retention interval. If children's PM is benefited by refreshing their intentions, then thinking about their intentions during the delay period should improve their PM performance relative to when they are instructed to think about the distracter task during the delay.

Third, the monitoring hypothesis was further tested by varying the salience of the PM targets compared to the items in the ongoing task. For salient targets, a bright red border surrounded the target picture, whereas the non-salient targets had no border and were similar in that respect to the distracter items in the OT. Whereas the OT difficulty was designed to disrupt internal and external monitoring and the explicit monitoring manipulation was designed to enhance internal monitoring, the manipulation of PM target salience was designed to vary the amount of external monitoring needed to detect the PM cues. Past manipulations of target salience have revealed that for older adults decreasing target salience by using a non-focal cue (where one must notice a cue that is not in the focus of processing during the OT) resulted in poorer PM performance (Rendell, et al., 2007), and in school-aged children enhancing the salience of PM targets by increasing their size relative to OT items resulted in better PM in school-aged children (McGann, et al., 2005). Therefore, target salience was predicted to have a substantial impact on children's PM because they may struggle with cognitively demanding PM tasks that do not have salient or easily detected PM targets.

Study 2 also further examined the relation between PM and retrospective memory. Study 1 found no evidence of a positive relation between PM and RM, in accordance with previous findings with children this age (Kvavilashvili, et al., 2001), and it did not

find a developmental change in the relations between PM and RM between 4 and 5 years of age. However, the power to detect such developmental differences could have been due to the fact that children did very well on the RM task, scoring near ceiling. Study 2 modified the RM task from Study 1 to make it more difficult in order to better examine whether there are age differences in the PM and RM relation. Specifically, lure items were added that were semantically similar to items children had seen in the OT but varied on dimensions such as color or shape.

Working memory, inhibition, and set shifting were measured in order to examine the relation between three core facets of EF and PM (Miyake, et al., 2000). Whereas Study 1 specifically examined working memory and planning, this study attempted to examine links to inhibition and set shifting, as they have been found to relate to PM ability in older children (e.g., Kerns, 2000; Ward, et al., 2005). In addition, children's receptive vocabulary was measured as a control variable when examining the relations between PM and EF, as past studies have shown at least a marginal relation between receptive vocabulary and PM performance (Ford, et al., 2012).

Finally, parents reported on their children's social understanding, EF ability, and temperament. These reports provided more information about children's abilities by: (1) adding a second perspective on children's functioning beyond what was measured behaviorally in the laboratory and (2) potentially providing a more naturalistic estimation of children's abilities as observed in their daily life. As PM is an essential cognitive ability that requires self-regulation and may have an impact on children's social functioning, I was interested in examining how parent estimations of their children's social understanding, self-regulation, and temperament in daily life related to PM.

## *Hypotheses*

I hypothesized that:

- (1). Children would show better PM in the easy OT condition compared to the difficult OT condition.
- (2). Children would show better PM performance when instructed to think about what they are supposed to do in the game during the delay interval than when instructed to think about what they are drawing.
- (3). Children would show better PM performance for salient targets (brightly colored borders) than for the non-salient targets.
- (4). OT difficulty, presence of a monitoring instruction, and target salience may interact such that children forget to carry out their intentions especially often during a difficult ongoing task, when they were asked to spend the retention interval focused on a distracter task, and for non-salient targets.
- (5). Performance on the PM task should be positively related to working memory, inhibition, and set shifting, while controlling for age and verbal ability, particularly for conditions in which monitoring is more challenging (difficult OT, distracter task emphasis, and low salience targets).
- (6). The parent measures of children's social understanding, behavioral regulation, and EF should positively relate to PM, and also to the behavioral measures of EF.

## Method

### *Participants*

One hundred and twenty 4- and 5-year-old children (53 girls) participated in the study. Eight participants were not included in the final analysis because six failed the

control question in the PM task, one child failed to reach criterion on the training for the card sorting component of the PM task, and one child had participated in a similar experiment before and indicated that she remembered the PM task. The final sample included 56 4-year-olds ( $M = 52.98$ ,  $SD = 3.56$ ; 28 girls) and 56 5-year-olds ( $M = 66.14$ ,  $SD = 3.88$ ; 23 girls). Children were mostly Caucasian and from middle-class backgrounds reflecting the population from which the sample was taken. Participants were recruited from a University database compiled from birth announcements from local newspapers.

### *Measures*

#### *Prospective Memory Task*

In the PM task, children were asked to help a family who had just moved into a new house. It was explained that the family needed help sorting their things into categories of small or large items and children were asked to name whether an item was small or large and then to sort it into the appropriate box. Household items were depicted on cards that were approximately 3 X 3 inches (See Appendix B for full list of items). Large items were larger than small items both in the real world and in pictorial size. The large items took up most of the space on the cards whereas the small items took up a small square in the middle of the card (approximately 1 by 1 inch; see Figure 4). Children practiced naming and then sorting five cards depicting the household items to ensure they understood the rules. Only children who were able to sort at least four out of five cards correctly were included in the analyses. As noted earlier, only one child did not meet this criterion for card sorting.

In addition to the card sorting task, children were told that the family was also looking for their pet animals. They were asked to help the family by ringing a bell on a table approximately three feet behind them if they saw an animal picture card. After children were asked if they understood the rules, they drew pictures for a three minute delay period to allow for some forgetting. After this filler interval, children began the card sorting. Participants sorted a total of 96 cards that were divided into three stacks of 32 which each contained two target cards. Target cards depicted a guinea pig, a dog, a goldfish, a cat, a parrot, and a rabbit. The target cards appeared as the 12<sup>th</sup> and 30<sup>th</sup> cards in the first stack, 14<sup>th</sup> and 21<sup>st</sup> in the second stack, and 7<sup>th</sup> and 23<sup>rd</sup> in the third stack. In between sets of cards, children drew pictures for one minute. The PM score was the number of times children rang the bell when they encountered one of the six animal cards.

**Figure 4.** Example of Ongoing Task Stimuli



OT performance was measured by assessing children's accuracy in sorting the cards into the appropriate category and the number of incorrect reaches that children

made in sorting the cards. Children were given two points for sorting the card correctly, one point for initially reaching to the incorrect box and then correcting themselves to place it into the correct box, and zero for placing the card in the incorrect box. Children's OT score was out of a possible 192 points.

Three factors were experimentally manipulated within this PM task: (1) ongoing task difficulty, (2) presence of a monitoring instruction, and (3) target salience.

The manipulation of ongoing task difficulty was between subjects such that half of the children received a difficult sorting task and half received an easy card sorting task. Children were asked to sort cards into boxes that had an exemplar of the category on the front. In the easy condition, children had to sort cards into the corresponding box (e.g., large cards into the box with a large item on it, small cards into the box with the small item on it). In the difficult condition, children sorted the cards by opposites (e.g., large cards into the box with a small item on it, small cards into the box with the large item on it). The difficult condition was designed to have higher demands on working memory as children could not simply rely on the exemplars on the box to aid their sorting but needed to remember the rule to sort by opposites and also inhibitory control as children needed to overcome the pre-potent response to place the card in the box with the matching exemplar on it.

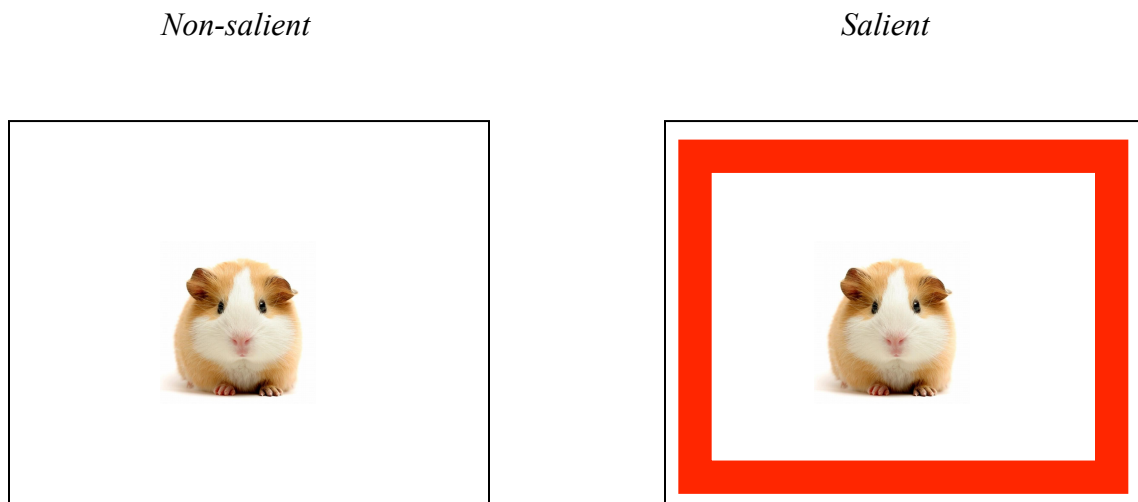
Monitoring instructions during the delay interval were also manipulated between subjects such that children were either told to 'think about what you are drawing a picture of' or to 'think about what you have to do in the game' during the delay. This simple instruction was designed to shift children's attention either to focus on a distracting



activity (drawing) and away from monitoring their intentions or to shift their attention to monitoring their future intentions and away from drawing.

The manipulation of target salience was within subjects such that each child received three PM target cards with a salient, red border and three targets that were non-salient without a colored border (see Figure 5). The targets with a colorful border were thus more distinct from the ongoing task items than the non-salient targets. Children were randomly assigned to which of the three targets would appear as salient and which three targets would be non-salient from 20 possible counterbalanced orders (see Appendix C). Half of the counterbalanced orders included a salient target appearing first and half had a non-salient card appear first.

**Figure 5.** Example of Salient and Non-salient PM Target Stimuli



As a control, at the end of the PM task, all children were asked “what were you supposed to do in this game when you saw a picture of an animal?” Only children who answered this question correctly were included in the final analysis in order to rule out

PM errors due to retrospective memory failures. A second question of “how many animals did you see?” was asked to examine whether children who failed to perform the PM action were simply failing to detect the animal targets or whether they had detected the targets but forgotten to perform the PM action at the appropriate moment.

#### *Retrospective Memory Task*

After the PM task, children completed a recognition memory measure in which 24 cards depicting household items were presented. Children were asked to make judgments of whether they saw the item in the PM task or not. Half of the cards pictured items that they saw in the PM task (old) and the other half pictured novel items (new; see Appendix D for a complete list of items). In Study 1, children neared ceiling on this task so the task was changed to make it more challenging. In this study, half of the novel items were from the same basic category as an item presented in the PM but were not identical. For example, if children originally sorted a card with a blue couch on it, a novel “lure” item might be a purple couch whereas a completely novel item might be a red shovel. Children were warned that they should only say “yes” to an item if it was the *exact same* as one they had seen previously. Children were assigned an RM score based on the number of items out of 24 they correctly categorized as old or new. Further, they were given scores out of 12 for how accurate they were in recognizing the old items, a score out of 6 for how accurate they were in recognizing the completely novel items, and a score out of 6 for how accurate they were in classifying the novel, lure items as new.

#### *Backward Digit Span*

As a measure of working memory, children were given the Backward Digit Span. The procedure was the same as in Study 1.

### *Simon Says*

This task was used as a measure of conflict inhibitory control (Carlson, 2005). In this task the experimenter asked children to follow her instructions. The experimenter and child stood facing each other, and the experimenter asked children to do some “silly” things, such as “touch your feet.” Then she explained that they should perform an action only if she prefaced the command with “Simon says.” They were told to remain perfectly still otherwise. Children were given two practice trials where they were asked to show the experimenter what they would do if she said, “Simon says clap your hands” and “clap your hands”. If children performed either of the practice trials incorrectly, the experimenter told them what the correct response should be. The experimenter issued commands in quick succession without demonstrating the actions. Ten trials were administered (five with and five without “Simon says”). Performance on non-Simon-says trials was taken as an index of inhibitory control (0 = commanded movement, 1 = partial movement, 2 = different movement, 3 = no movement; scored individually for each non-Simon-says trial; range 0-15; Carlson, & Meltzoff, 2008). Inter-rater coding reliability on non-Simon-says trials was high (Cronbach’s Alpha = .96).

### *Card Sort*

The Dimensional Change Card Sort was used as a measure of set shifting (Frye, Zelazo, & Palfai, 1995). Children were shown two boxes with target cards (e.g., a blue rabbit and a red boat) on the front of them. The experimenter presented a series of cards (red and blue rabbits and boats) and instructed children to place all the rabbits in the box with the red rabbit and to place all the boats in the box with the blue boat in the “shape game.” Children were given two practice trials in which they received feedback on their

performance. Children then completed five test trials. After children had sorted five cards in the shape game, the experimenter announced that they were not going to play the shape game and would now play the “color game.” Children were told that in the color game all the red items should go in the box with the red boat on it and all the blue items should go in the box with the blue rabbit on it. There were five post-switch trials and three of these trials were incompatible with the first rule (i.e., sorting by the old rule would now lead to an incorrect response). Before each of the 10 trials, the rule and the relevant dimension were identified by the experimenter (e.g., “Remember, red cards go here and blue cards go here. Here’s a red boat”) in order to avoid errors due to working memory failures, and then the card was given to the child to sort. The total number of correct incompatible post-switch trials was recorded (0-3).

#### *Episodic Memory Recall*

This measure of episodic memory was adapted from Naito (2003). Children were asked to name 12 line drawings of items pictured on large index cards as the experimenter placed them on the table in front of them. After they named all 12 items, children were told to study all the pictures because they would be asked to remember the items in a few minutes. Whether children used a rehearsal strategy during this study period (e.g., naming the items) was recorded. After approximately 20 seconds, the index cards were collected and put away. Children then were asked to complete a complex drawing maze for one minute. They were then asked to freely recall as many items as they could from the pictures on the index cards that they were previously shown. Children were given a score out of 12 of how many pictures they correctly recalled.

### *PPVT-III*

Children completed the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997) as a measure of verbal intelligence. Children were asked to point to the picture that corresponded to the word that the experimenter read aloud. For each word, children were presented with four line drawings from which to choose. Children were given two practice trials in which they were given feedback and told that it was okay to guess if they didn't know what the word meant. Then, children were given the first set of words depending on their chronological age. The test was administered until participants failed eight out of 12 items in a given set. Raw scores on this measure were used in the analysis rather than age-corrected scores.

### *Parent Measures*

#### *Children's Social Understanding Scale*

The CSUS was administered to parents as it was in Study 1.

#### *Behavior Rating Inventory of Executive Function-Preschool*

Parents completed the BRIEF-P, a 63-item questionnaire that asks parents to estimate children's problems with working memory, inhibition, shifting, emotional control, and planning/organizing within the last 6 months (Gioia, Espy, & Isquith, 2003). Examples items are: "overreacts to small problems", "has trouble with activities or tasks that have more than one step", and "is disturbed by changes in the environment" (see Appendix E for complete list of items). Parents were asked to rate how often a given behavior had been problematic in the past six months from three options: never, sometimes, or often. Higher scores indicate greater difficulty with a given behavior.

This scale took approximately 10 minutes for parents to complete. Possible scores ranged from 63 to 189.

#### *Children's Behavior Questionnaire*

Parents completed the short form of the Children's Behavior Questionnaire, a 94-item questionnaire that asks parents to estimate various facets of their child's temperament and self-regulation (Rothbart, et al., 2001; Putnam & Rothbart, 2006). Subscales include Negative Affectivity, Extraversion/Surgency, and Effortful Control. Example items are: "often rushes into new situations", "dislikes rough and rowdy games", and "tends to say the first thing that comes to mind, without stopping to think about it" (see Appendix F for a complete list of items). Parents rated children's behavior on a 7-point Likert scale. This scale took approximately 20 minutes for parents to complete. Possible scores for the three subscales ranged from one to seven.

#### *Procedure*

Children were individually interviewed by an experimenter in a laboratory at the University of Oregon and all tasks were administered in a fixed order as is convention in individual differences research: PM task, RM task, Backward Digit Span, Simon Says, Card sort, Episodic Recall, and the PPVT-III. Parents were asked to provide demographic information as well as complete the three questionnaires on their children's behavior while their child participated in the study. At the end of the experimental session, children were given a small toy and ten dollars cash and were thanked for their participation. All procedures were approved by the University of Oregon's Office for Protection of Human Subjects.

## Results

Means and standard deviations for all behavioral tasks by age group are shown in Table 5.

**Table 5.** Means and Standard Deviations for all Behavioral Measures Broken Down by Age

Task	4-year-olds	5-year-olds
Prospective Memory	1.70 (2.15)	2.80 (2.29)
Retrospective Memory	18.50 (3.21)	19.46 (2.52)
Backward Digit Span	1.50 (1.28)	2.54 (1.24)
Simon Says	5.64 (5.40)	10.23 (4.75)
Card Sort	1.89 (1.33)	2.50 (.93)
Episodic Recall	4.11 (1.71)	4.82 (1.85)
Peabody Picture Vocabulary Test	76.63 (14.61)	91.27 (15.61)

*Note* — Prospective Memory (0-6), Retrospective Memory (0-24), Backward Digit Span (0-16), Simon Says (0-15), Card Sort (0-3), Episodic Recall (0-12), Peabody Picture Vocabulary Test (40-160). *N*s = 53-56.

### *Ongoing Task Difficulty Manipulation Check*

In order to assess whether the manipulation of OT difficulty was successful, a 2 (Age) X 2 (OT difficulty) X 2 (Monitoring Instruction) mixed ANOVA was conducted to investigate the effects of age and experimental conditions on ongoing task accuracy (card sorting). Ongoing task accuracy was significantly affected by age and OT difficulty. Five-year-olds did better on the OT ( $M = 180.19$ ,  $SD = 9.37$ ) than 4-year-olds ( $M = 170.09$ ,  $SD = 31.02$ ),  $F(1, 99) = 5.04$ ,  $p < .05$ . Children in the difficult condition performed worse on card sorting ( $M = 168.95$ ,  $SD = 30.81$ ) than those in the easy

condition ( $M = 181.60$ ,  $SD = 7.36$ ),  $F(1, 99) = 8.16$ ,  $p < .01$ . Therefore, the manipulation of task difficulty in the OT was successful.

To examine if the difficult OT imposed a higher inhibitory demand than the easy OT, I examined linear trends in card sorting performance in the easy and difficult OT conditions. A 2 (OT difficulty) X 96 (OT score for each card) mixed ANOVA was conducted to investigate any differences across time in card sorting performance. Results revealed no significant trends across OT performance ( $p > .15$ ) and no interaction between card sorting and OT difficulty condition ( $p > .75$ ) suggesting the inhibitory demand was fairly minimal in the difficult OT condition or at least was not greater than in the easy OT condition.

#### *Prospective Memory Task*

Table 6 shows means of PM performance by age, OT difficulty, monitoring instruction, and target salience. A 2 (Age) X 2 (OT difficulty) X 2 (Monitoring instruction) X 2 (Target salience) mixed ANOVA on PM performance with repeated measures on the last factor revealed a significant main effect of age. Five-year-olds ( $M = 2.80$ ,  $SD = 2.29$ ) performed better than 4-year-olds ( $M = 1.70$ ,  $SD = 2.15$ ) on the PM task,  $F(1, 104) = 6.91$ ,  $p < .01$ ,  $\eta^2 = .06$ . There was no significant effect of ongoing task difficulty on PM ( $p > .30$ ). However, performance was at least in the predicted direction with better PM in the easy OT condition ( $M = 2.46$ ,  $SD = 2.45$ ) than the difficult OT condition ( $M = 2.04$ ,  $SD = 2.10$ ). A marginally significant effect of monitoring instruction emerged,  $F(1, 104) = 3.48$ ,  $p = .07$ ,  $\eta^2 = .03$ , such that children who received an instruction to monitor their intentions during the delay tended to perform better on the PM task ( $M = 2.64$ ,  $SD = 2.40$ ) than children who had received an instruction to attend to



the distractor activity ( $M = 1.86$ ,  $SD = 2.10$ ). Finally, children remembered to carry out the PM task more often for salient targets ( $M = 1.29$ ,  $SD = 1.33$ ) compared to non-salient targets ( $M = .96$ ,  $SD = 1.15$ ),  $F(1, 104) = 13.60$ ,  $p < .001$ ,  $\eta^2 = .12$ .<sup>2</sup>

**Table 6.** Performance on PM Task by Condition and Age Group in Study 2

		Monitoring Instruction			No Monitoring Instruction		
		Easy OT	Difficult OT	Combined	Easy OT	Difficult OT	Combined
4 year olds	Salient	1.36 (1.39)	1.21 (1.42)	1.29 (1.38)	.64 (1.28)	.93 (1.27)	.79 (1.26)
	Non-Salient	.93 (1.00)	.57 (.94)	.75 (.97)	.64 (1.15)	.50 (.86)	.57 (1.00)
	Combined	2.29 (2.27)	1.79 (2.16)	2.04 (2.19)	1.29 (2.40)	1.43 (1.83)	1.36 (2.09)
5 year olds	Salient	1.86 (1.35)	1.43 (1.22)	1.64 (1.28)	1.50 (1.35)	1.43 (1.28)	1.46 (1.29)
	Non-Salient	1.79 (1.37)	1.43 (1.34)	1.61 (1.34)	1.14 (1.17)	.64 (.84)	.89 (1.03)
	Combined	3.64 (2.56)	2.86 (2.45)	3.25 (2.49)	2.64 (2.21)	2.07 (1.86)	2.36 (2.02)

*Note*—Scores are out of 3 except for combined scores which are out of 6. Standard deviations are in parentheses.

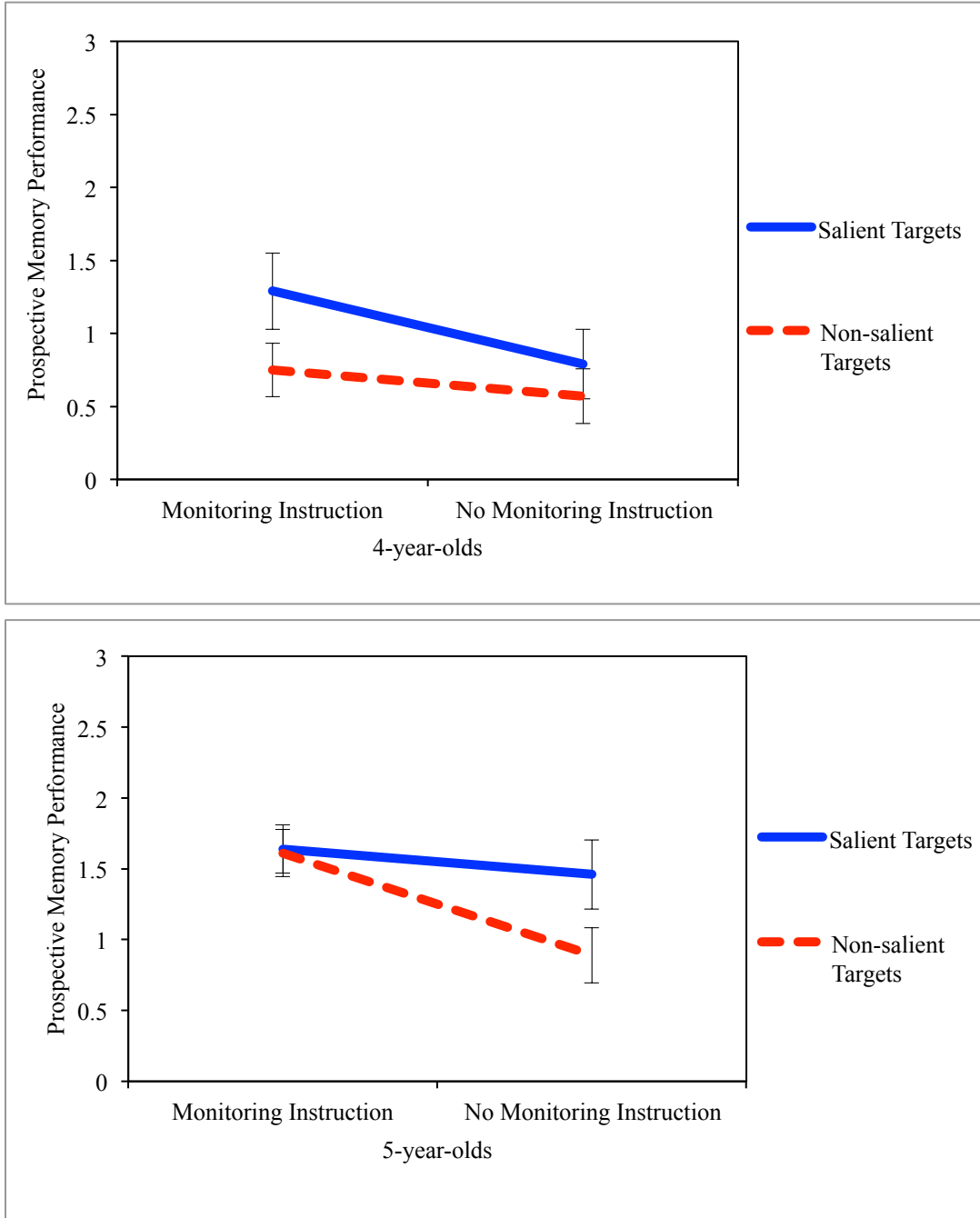
There were no significant two-way interactions among age, OT difficulty, monitoring instruction, and target salience. However, one three-way interaction emerged between age, monitoring instruction, and target salience,  $F(1, 104) = 5.42$ ,  $p < .05$ ,  $\eta^2$

<sup>2</sup> Although gender was not predicted to affect PM given the results of Study 1 I examined its effect on PM. There was a trend level effect of gender on PM with girls ( $M = 2.58$ ,  $SD = 2.35$ ) outperforming boys ( $M = 1.98$ ,  $SD = 2.21$ ),  $F(1, 96) = 3.06$ ,  $p = .08$ . Gender also showed a trend level interaction with OT difficulty such that boys were unaffected by OT difficulty, whereas girls PM performance was better in the easy OT condition compared to the difficult OT condition,  $F(1, 96) = 3.12$ ,  $p = .08$ . Importantly, gender did not have any impact on the other main effects or interactions reported.

= .05 (see Figure 6). Simple two-way interactions revealed that for 5-year-olds there was a marginally significant interaction between salience and monitoring instruction,  $F(1, 52) = 3.83, p = .06$ , but not for 4-year-olds. Five-year-olds' PM was especially poor for non-salient targets when there was no monitoring instruction compared to all other conditions,  $F(1, 52) = 7.58, p < .01$ . Additionally, for children who received the monitoring instruction there was a significant interaction between age and salience,  $F(1, 54) = 4.30, p < .05$ , but this interaction did not emerge for children who received no monitoring instruction. In the monitoring condition, five-year-olds' PM performance was unaffected by target salience,  $F(1, 54) = .01, ns$ , whereas 4-year-olds' PM was helped by salient targets compared to non-salient targets,  $F(1, 54) = 4.08, p < .05$ .

In order to examine the overall impact of EF on PM performance, a composite was formed by combining scores on the Backward Digit Span, Simon Says, and Card Sort task. These three EF measures were highly inter-correlated,  $r_s(108) > .43, p_s < .001$ , suggesting that a composite score was appropriate. This EF composite and verbal ability were then entered as covariates into a 2 (Age) X 2 (OT Difficulty) X 2 (Monitoring Instruction) X 2 (Target Salience) ANOVA. The EF composite was a highly significant covariate,  $F(1, 102) = 10.68, p < .01$ , and verbal ability was a marginally significant covariate,  $F(1, 102) = 3.15, p = .08$ . The ANCOVA revealed that after controlling for general EF ability and verbal ability, age ( $p > .99$ ), monitoring instruction ( $p > .15$ ), and target salience ( $p > .60$ ) no longer had an impact on PM suggesting that these effects were largely driven by EF and verbal ability. However, the three-way interaction between age, monitoring instruction, and salience remained significant ( $p < .05$ ).

**Figure 6.** Interaction between Age, Monitoring Instruction, and Target Salience



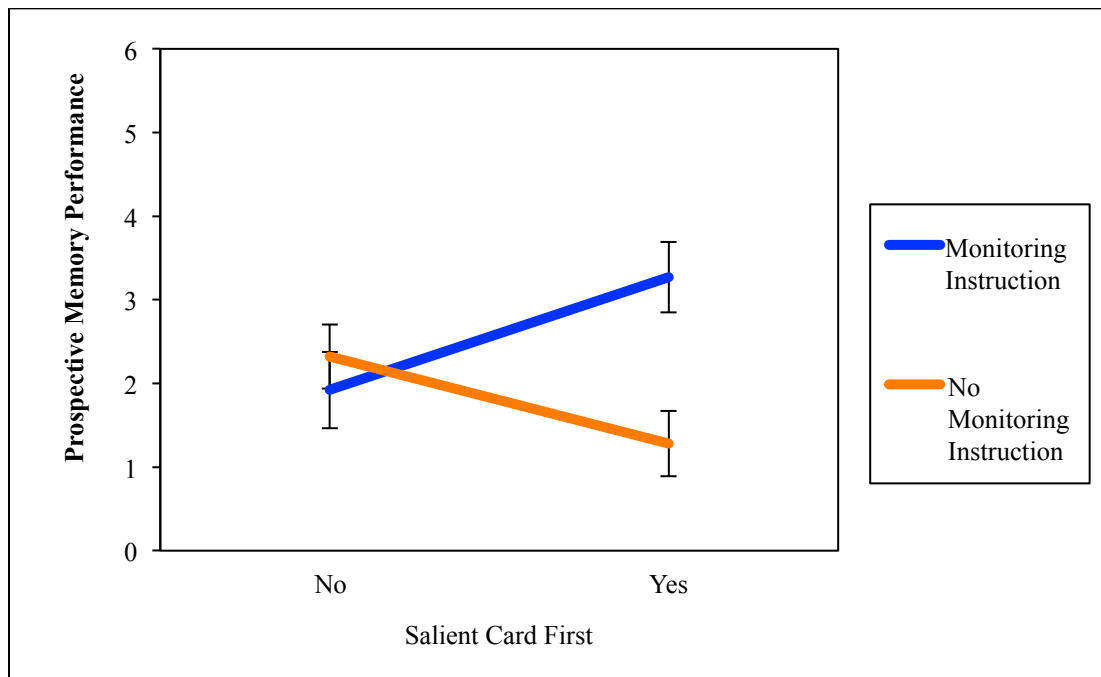
Given that the main effect of target salience was strong in the original ANOVA, was manipulated within-subjects, and that PM performance may have been more influenced by the salience of the *first* target event, children who received a salient target

first ( $N = 55$ ) were compared to those who received a non-salient target in the first position ( $N = 57$ ). This allowed for examination of the impact of the first target salience on subsequent PM. A 2 (Age) X 2 (OT difficulty) X 2 (Monitoring Instruction) X 2 (First Target Salience Level) ANOVA on PM performance was conducted and the only significant main effect to emerge was age,  $F(1, 96) = 3.82, p = .05$ , demonstrating again that 5-year-old children had better PM than 4-year-olds. One interaction emerged as significant between monitoring instruction and first target salience level,  $F(1, 96) = 5.99, p < .05$  (Figure 7). When children were instructed to monitor their intentions during the delay, children's PM performance benefited when the first target card was salient ( $M = 3.27, SD = 2.32$ ) compared to when it was non-salient ( $M = 1.92, SD = 2.33$ ),  $F(1, 96) = 5.71, p < .05$ . In contrast, when children were not instructed to monitor their intentions during the delay interval, there was no effect of first target card salience. Relatedly, a salient target appearing first was helpful to PM in the monitoring condition compared to the no monitoring condition,  $F(1, 96) = 11.48, p < .01$ , whereas having a non-salient target first did not differentially influence PM between the two monitoring conditions,  $F(1, 96) = .43, ns$ .

Over the course of the task, children's PM improved linearly,  $F(1, 111) = 4.99, p < .05$ . There was no quadratic trend in PM performance, but cubic, order 4, and order 5 trends were present,  $F_s(1, 111) > 13.50, p_s < .001$ , suggesting that there was variation in performance on PM targets. Specifically, children performed the PM less often for the guinea pig and goldfish targets (the less prototypical animals) compared to the other animal targets,  $F_s(1, 111) > 4.63, p_s < .05$ . However, despite the variation children's

PM performance on the six PM targets, reliability for the items was high (Cronbach's Alpha = .89).

**Figure 7.** Interaction between Monitoring Instruction and First Target Card Salience



#### *Prospective Memory Control Questions*

All children included in the present analysis were able to report the rule of having to ring the bell when they saw a picture of an animal, even those children who failed to ring the bell at all. In addition, the experimenter asked all children how many animals they saw while they were sorting cards in order to gain insight into whether children were detecting the appearance of target items. In general, children who had better PM reported seeing more animals,  $r(107) = .47, p < .001$ . When how many animals children reported seeing was examined by experimental condition, it was revealed that children who received the monitoring instruction reported seeing more animals ( $M = 3.43, SD = 3.48$ )

than those who did not receive a monitoring instruction ( $M = 2.31$ ,  $SD = 1.81$ ),  $F(1, 99) = 4.82$ ,  $p < .05$ . Further, 5-year-olds tended to report seeing more animal targets ( $M = 3.38$ ,  $SD = 3.33$ ) than 4-year-olds ( $M = 2.37$ ,  $SD = 2.10$ ),  $F(1, 99) = 3.70$ ,  $p = .06$ .

### *Retrospective Memory*

Children performed significantly better than chance on the retrospective memory measure ( $M = 18.98$ ,  $SD = 2.91$ ;  $t(111) = 25.37$ ,  $p < .001$ ). Overall, children were less accurate in recognizing the lure items ( $M = 4.18$ ,  $SD = 1.47$ ) as new compared to the completely novel items ( $M = 5.42$ ,  $SD = 1.18$ ),  $t(111) = 9.97$ ,  $p < .001$ . There was no difference in memory for old items compared to the new items (both novel and lure items).

Overall, RM was related to performance on the PM task (Table 7). However, a 2 (Age) X 2 (OT difficulty) X 2 (Monitoring instruction) ANOVA on RM revealed only a marginal effect of age with 5-year-olds ( $M = 19.46$ ,  $SD = 2.52$ ) outperforming 4-year-olds ( $M = 18.50$ ,  $SD = 3.21$ ),  $F(1, 104) = 3.16$ ,  $p = .08$ . No other main effects or interactions reached statistical significance. When retrospective memory for the old, new, and new lure items were examined separately, it was found that 5-year-olds were significantly better than 4-year-olds in categorizing the new and new lure items,  $t_s(110) > 2.09$ ,  $p_s < .05$ , but not in categorizing items as old. There were no experimental condition effects on retrospective memory performance for these three item types examined separately.

No evidence for tradeoffs between performance on the PM task and the OT were found. In fact, children who performed well on the PM task tended to perform well on the RM,  $r(112) = .33$ ,  $p < .001$ , and OT card sorting accuracy,  $r(107) = .22$ ,  $p < .05$ .

When verbal ability was controlled, PM remained significantly positively correlated with RM and OT card sorting accuracy,  $r_s(104) > .20, p_s < .05$ . PM and RM were significantly positively related in 4-year olds,  $r(56) = .37, p < .01$ , and related at the level of a trend in 5-year-olds,  $r(56) = .22, p = .10$ .

**Table 7.** Correlations among Behavioral Measures in Study 2

	1.	2.	3.	4.	5.	6.	7.
1. Age							
2. PM	.28**						
3. RM	.24**	.33** (.23*)					
4. BDS	.44**	.28** (.10)	.37** (.24*)				
5. SS	.50**	.40** (.27**)	.18 (.06)	.61** (.47**)			
6. CS	.28**	.32** (.19*)	.29** (.18 <sup>†</sup> )	.44** (.29**)	.43** (.31**)		
7. ER	.20*	.13 (.04)	.13 (.09)	.15 (.05)	.28** (.18 <sup>†</sup> )	.16 (.07)	
8. PPVT	.49**	.38**	.30**	.46**	.44**	.40**	.21*

*Note* – PM = Prospective Memory, RM = Retrospective Memory, BDS = Backward Digit Span, SS = Simon Says, CS = Card Sort, ER = Episodic Recall, PPVT = Peabody Picture Vocabulary Test. Partial correlations controlling for age in months and PPVT are in parentheses.

<sup>†</sup>.  $p < .10$ , \* .  $p < .05$ , \*\* .  $p < .01$ , degrees of freedom range from 49 to 64.

### *Relations among Behavioral Measures*

Table 7 shows correlations among behavioral measures and partial correlations controlling for age in months and PPVT scores. The three behavioral measures of executive function, Backward Digit Span, Simon Says, and Card Sort, were highly inter-correlated. Performance on the PM task was positively related to RM but not to Episodic Recall. PM performance was significantly related to all three measures of EF and to PPVT scores. PM and Episodic Recall performance were unrelated to whether children spontaneously rehearsed the items during the study period of the Episodic Recall Task.

A linear regression was used to predict PM performance from age, PPVT scores, and the three EF tasks. The score on the Simon Says task emerged as the only significant predictor of PM performance beyond PPVT score,  $t(106) = 2.35, p < .05$ , and accounted for approximately 5% of the variance in PM scores,  $F \text{ Change}(1, 103) = 6.98, p < .05$ . PPVT score was also a marginally significant predictor in the model,  $t(106) = 1.79, p = .08$ . Overall, age, PPVT, and EF scores accounted for 21% of the variance in PM.

#### *Correlations with Executive Function by Prospective Memory Condition*

Correlations among the PM, Backward Digit Span, Simon Says, and Card Sort tasks were examined separately in the OT difficulty and monitoring conditions as well as for salient and non-salient target items to investigate the role of EF in various conditions of our experimental manipulations. Age and verbal ability were controlled for all of the reported correlations.

Better PM performance in the easy OT condition was only related to superior Simon Says performance,  $r(49) = .34, p < .05$ . Against prediction, in the difficult OT condition, better PM was unrelated to any of the three EF tasks.

PM performance was related to Simon Says in the monitoring instruction condition,  $r(49) = .29, p < .05$ . Similarly, PM was related to Simon Says performance in the no monitoring instruction condition at the level of a trend,  $r(49) = .23, p = .09$ .

All children received half salient and half non-salient target items. Therefore, EF correlations with PM were compared for salient and non-salient targets. For salient targets, PM performance was only related to Simon Says performance,  $r(104) = .23, p < .05$ . For non-salient targets, PM performance was related to both Simon Says and Card Sort performance,  $r_s(104) > .21, p_s < .05$ .



Because there were four conditions that each contained two types of targets (salient and non-salient) in our fully crossed design for OT difficulty and monitoring instruction, comparisons between the most difficult condition (difficult OT, no monitoring instruction, non-salient targets) and the easiest condition (easy OT, monitoring instruction, salient targets) were possible. Table 8 shows the correlations between PM and the EF composite score (BDS, Simon Says, and Card Sort) and partial correlations after controlling for age and verbal ability in parentheses. Counter to prediction, when correlations among PM and the EF tasks were examined in the most difficult condition, there were no significant relations among PM and the EF composite. In contrast, there were strong positive relations among PM and EF composite in the easiest condition. In fact, EF was related to PM in all conditions except the difficult conditions where children had no monitoring instructions and had to sort by opposite categories in the OT. After controlling for age and verbal ability, however, correlations between PM and EF only remained in the easy OT, monitoring instruction condition, with salient targets (the easiest condition) and marginally in the difficult OT, monitoring instruction, with salient targets (a relatively easy condition). Therefore, it seems that relations between PM and EF were most robust in the easier experimental conditions.

**Table 8.** Executive Function Composite and Prospective Memory Relation by Condition

	Monitoring instruction		No Monitoring instruction	
	Salient	Non-Salient	Salient	Non-Salient
Easy OT	.52** (.20)	.56** (.15)	.53** (.40*)	.45* (.32)
Difficult OT	.44* (.37 <sup>†</sup> )	.39* (.27)	.01 (-.01)	.27 (.28)

<sup>†</sup>.  $p < .10$ , \*.  $p < .05$ , \*\*.  $p < .01$ ,  $N = 28$ .

### *Parent Reports and Children's Behavioral Performance*

Overall scores on the CSUS were correlated with Backward Digit Span, Simon Says, and PPVT,  $r_s(108) > .22, p_s < .05$ , but not with PM performance ( $p > .30$ ).

Table 9 shows correlations among subscales of the BRIEF-P and the three behavioral measures of EF, as well as other behavioral measures. The subscales from the BRIEF-P were significantly correlated with behavioral measures of EF. Notably, the Working Memory scale of the BRIEF-P was correlated with performance on Backward Digit Span indicating that parent-reported fewer problems with working memory was related to children's superior working memory performance in the lab. Better behavioral performance on Simon Says related to lower reports of problematic behaviors on the Inhibit subscale of the BRIEF-P. The BRIEF-P Shift score was not correlated with the Card Sort, the behavioral measure of set shifting. All three behavioral measures of EF were correlated with the BRIEF-P Global Executive Composite.

PM was not related to the subscales or the Global Executive Composite of the BRIEF-P. However, four items on the BRIEF-P seemed to tap into PM in particular. Table 10 shows the four items from the BRIEF-P that might plausibly relate to PM in a more specific way. These were used to create a PM composite (Cronbach's Alpha = .61). Scores on the BRIEF-P PM scale correlated with behavioral PM performance,  $r(109) = -.21, p < .05$ . Parents who reported their children had more problems with behaviors associated with PM ability in daily life had children who performed worse on the PM task, suggesting that parent's estimation of their children's naturalistic PM ability in daily life is related to their behavioral PM performance on a laboratory PM task. At the item

level, parent responses to the first and last item were more related to children's PM performance than the middle two items.

**Table 9.** Correlations among Parent-Reported Behavioral Rating Inventory of Executive Function Scales and Behavioral Measures

Tasks	BRIEF scales								
	WM	Inh.	Shift	EC	Plan	ISC	Flex.	EMC	GEC
Prospective Memory	-.19	-.09	-.12	-.03	-.01	.08	-.07	-.11	-.09
Retrospective Memory	-.12	.01	-.10	-.19	.01	-.04	-.11	-.05	-.05
Backward Digit Span	-.29**	-.12	-.33**	-.13	-.24*	-.13	-.25*	-.30**	-.28**
Simon Says	-.28**	-.24*	-.26*	-.07	-.21*	-.19 <sup>†</sup>	-.16 <sup>†</sup>	-.27**	-.28**
Card Sort	-.20*	-.19	-.18	-.18	-.13	-.11	-.18 <sup>†</sup>	-.18 <sup>†</sup>	-.22*
Episodic Recall	-.14	-.09	.02	.18 <sup>†</sup>	-.03	.03	.13	-.10	-.03
PPVT	-.18 <sup>†</sup>	-.07	-.08	-.09	-.10	-.10	-.09	-.16 <sup>†</sup>	-.15

*Note:* PPVT= Peabody Picture Vocabulary Test, WM = working memory score, Inh. = Inhibit score, Shift = Shift score, EC = Emotional control score, Plan= Plan/Organize score, ISC = Inhibitory Self Control Index, Flex. = Flexibility Index, EMC = Emergent Metacognition Index, GEC= Global Executive Composite, PM = Prospective Memory composite.

<sup>†</sup>.  $p < .10$ , \* .  $p < .05$ , \*\* .  $p < .01$

Because my interest in using the CBQ was primarily to measure dimensions of temperament related to cognitive ability and EF, the three factors of the CBQ (Negative Affectivity, Extraversion/Surgency, and Effortful Control; Putnam & Rothbart, 2006), as well as the subscales that map onto the Effortful Control factor (Attentional Focusing, Inhibitory Control, Low Intensity Pleasure, and Perceptual Sensitivity) and the High Intensity Pleasure and Impulsivity subscales were examined as they were expected to relate to PM and EF ability.

The three factors of the CBQ and subscales of the Effortful Control factor were correlated with various behavioral measures (Table 11). Better PM performance was marginally related to lower impulsivity and high intensity pleasure seeking but was unrelated to other subscales and factors of the CBQ. Positive relations among the EF behavioral tasks and Effortful Control scores seemed to be driven by scores on the Attentional Focusing and Inhibitory Control subscales. Performance on the Backward Digit Span task was positively related to scores on the Inhibitory Control subscale and marginally related to scores on the Attentional Focusing subscale. Better Simon Says performance was significantly related to better Effortful Control, Inhibitory Control, and Attentional focusing, as well as lower Impulsivity scores. Performance on the Card Sort was positively related to Inhibitory Control and Attentional Focusing and negatively related to Extraversion/Surgency, High Intensity Pleasure, and Impulsivity.

**Table 10.** Items Comprising the Behavioral Rating Inventory of Executive Function Prospective Memory Composite and their Correlations with Prospective Memory Performance

Item	Correlation with Behavioral PM
1. When given two things to do, remembers only the first or last.	$r(112) = -.18, p = .06$
2. When sent to get something, forgets what he/she is supposed to get.	$r(112) = -.14, p = .14$
3. Does not complete tasks even after given directions.	$r(109) = -.11, p = .26$
4. Has trouble remembering something, even after a brief period of time.	$r(109) = -.21, p < .05$

Finally, Table 12 shows relations among parent-reports revealing that scores on the BRIEF-P and CBQ were highly related. In particular, higher Effortful Control on the CBQ was related to fewer EF problems as measured by the BRIEF-P whereas higher levels of Extraversion/Surgency on the CBQ were related to more EF problems as measured by the BRIEF-P. CSUS scores were positively related to the Effortful Control factor of the CBQ and all of its subscales. Further, CSUS was negatively related to the Inhibit, Working memory, and Global Executive Composite scores of the BRIEF-P,  $r_s(104) > -.24, ps < .05$ . Children whose parents reported higher levels of social understanding also reported better inhibitory control and working memory ability.

**Table 11.** Correlations between Behavioral Measures and Subscales of the Child Behavior Questionnaire

Tasks	CBQ subscales								
	NA	E/S	EC	AF	HIP	Imp	IC	LIP	PS
Prospective Memory	.07	-.15	.04	.00	-.17 <sup>†</sup>	-.16 <sup>†</sup>	.10	-.02	.03
Retrospective Memory	.13	-.04	-.02	.04	-.08	-.03	.11	-.07	-.16 <sup>†</sup>
Backward Digit Span	.02	-.06	.13	.17 <sup>†</sup>	-.02	.01	.19*	.03	.00
Simon Says	-.05	-.18 <sup>†</sup>	.31**	.34**	-.05	-.17 <sup>†</sup>	.35**	.10	.11
Card Sort	.02	-.20*	.16 <sup>†</sup>	.22**	-.15 <sup>†</sup>	-.17 <sup>†</sup>	.21*	.04	-.02
Episodic Recall	.00	-.03	.14	.23*	.03	-.06	.11	.02	.05
PPVT	.00	-.03	.21*	.25**	.01	-.11	.28**	.11	-.01

*Note:* PPVT= Peabody Picture Vocabulary Test, NA = Negative Affectivity, E/S = Extraversion/Surgency, EC = Effortful Control, AF = Attentional Focusing, HIP = High Intensity Pleasure, Imp = Impulsivity, IC = Inhibitory Control, LIP = Low Intensity Pleasure, PS = Perceptual Sensitivity.

<sup>†</sup>.  $p < .10$ , \* .  $p < .05$ , \*\* .  $p < .01$

**Table 12.** Correlations among Parent-Reported Measures

	CSUS	BRIEF GEC	BRIEF WM	BRIEF Inhibit	BRIEF Shift
CBQ Scales and Subscales					
Negative Affectivity	-.03	.24*	.15	.11	.29**
Extraversion/Surgency	.06	.38**	.19*	.46**	.29**
Effortful Control	.45**	-.43**	-.45**	-.39**	-.21*
Attentional Focusing	.34**	-.47**	-.54**	-.40**	-.15
High Intensity Pleasure	.12	.21*	.04	.33**	.12
Impulsivity	-.13	.30*	.24*	.45**	-.04
Inhibitory Control	.31**	-.58**	-.43**	-.57**	-.42**
Low Intensity Pleasure	.37**	-.03	-.10	.02	.00
Perceptual Sensitivity	.39**	-.15	-.22*	-.17 <sup>†</sup>	-.02

*Note:* CSUS = Overall Child Social Understanding Scale score, GEC = Global Executive Composite, BRIEF = Behavioral Rating Inventory of Executive Function- Preschool.

<sup>†</sup>.  $p < .10$ , \* .  $p < .05$ , \*\* .  $p < .01$

## Discussion

The goal of this study was to investigate the effect of age, OT difficulty, monitoring instructions, and target salience on 4- and 5-year-olds' PM performance. In addition to main effects, interactions among these effects were examined. Individual differences measures of working memory, inhibitory control, and set shifting were taken in order to investigate their relation with PM and to examine differences in the EF-PM relation by condition. Further, parents were asked to report on children's social understanding, EF, and temperament to examine their relations with children's performance on the PM and EF tasks.

### *Summary of Experimental Findings*

Study 2 revealed that 5-year-olds performed better on the PM task than 4-year-olds consistent with Study 1 and previous findings (Ford, et al., 2012; Kvavilashvili, et al., 2001; Mahy & Moses, 2011). The new, adapted version of the PM task was quite difficult for children and thus ceiling effects were not problematic in the sample.

Contrary to prediction, OT difficulty did not have any impact on PM performance despite the difficult OT resulting in worse OT performance than the easy OT. The lack of effect of OT difficulty on PM was surprising as it was anticipated that sorting cards by opposites would disrupt PM as compared to sorting cards by intuitive categories.

Although children in the difficult OT condition sorted the cards less accurately than children in the easy OT condition, it is worth noting that children did very well on card sorting (the OT) in both conditions. It is possible, then, that our manipulation of inhibitory control via card sorting was not strong enough to produce effects on PM. Children appeared to catch on to sorting by opposites quickly, suggesting that the inhibitory demand was reduced almost immediately. This interpretation is supported by the similarity in card sorting performance across the PM task in the easy and difficult OT conditions. In addition, although children did well on the OT in both easy and difficult OT conditions, children's PM performance was relatively poor in both conditions. Therefore, it is possible that the PM task was so challenging that minor changes in card sorting difficulty were not sufficient to affect PM performance. These findings are reminiscent of work that has manipulated the difficulty of the OT by increasing the speed of presentation of the OT and found no effect on PM accuracy (Ward, et al, 2005). Therefore, successful manipulations of OT difficulty do not always translate to worse PM

performance. In addition, given that the effects of this manipulation were in the right direction, it remains possible that the current sample did not have sufficient power to detect this OT difficulty effect.

PM tended to be better for children who were given a monitoring instruction compared to those who were given an instruction to focus on a distractor activity as predicted. A single reminder was given to children that they needed to monitor and refresh their intention throughout the retention interval led to better PM. This suggests that manipulations that aid internal monitoring by way of explicit instruction to think about one's intentions support PM in both 4- and 5-year-olds. Although the current study did not allow for examining exactly *when* and *how consistently* children were thinking about their intention during the delay interval, it suggests that children may have been primed to think about their intentions more often in the monitoring instruction condition resulting in superior PM performance. This finding is reminiscent of the finding that 5-year-olds had superior PM performance after listening to a reminder story about a forgetful spider compared to a control story about a lazy alligator (Kvavilashvili, Ford, & Shum, 2009) suggesting that reminders during the retention interval whether externally or internally generated aid PM. If so, the current results lend support to the monitoring hypothesis (Mahy & Moses, 2011; Hicks, Marsh, & Russell, 2000) that suggests individuals who are given opportunities to monitor their intentions more during a delay do better on later PM. Further, these results suggest that, to an extent, even preschool-aged children can monitor their intentions when given an explicit instruction.

As predicted, children's PM was helped by salient targets compared to non-salient targets suggesting that reducing external monitoring demands had a positive impact on



prospective remembering. This finding suggests that capturing attention with salience (thereby reducing external monitoring) is an effective way to boost PM. Other salience manipulations such as increasing PM target size compared to the OT items have also resulted in better PM in children (McGann, et al., 2005). Thus, my findings support that reducing external monitoring demands by increasing target salience can support PM.

The interaction that emerged between target salience, monitoring, and age suggested that 4- and 5-year-olds are differentially affected by target salience and monitoring instructions. Five-year-olds' PM was poor for non-salient targets when there was no monitoring instruction suggesting that even the older children in the sample had difficulty when external and internal monitoring demands were high. Four-year-olds' PM was helped by salient targets compared to non-salient targets in the monitoring condition but not in the no monitoring condition suggesting that 4-year-olds PM is best under conditions in which internal monitoring support was high and external monitoring demand was low. Therefore, it seems that 5-year-olds' PM suffers most with the conditions under which monitoring demands were high whereas 4-year-olds' PM is most helped under conditions in which monitoring demands were low.

The differential effects of experimental conditions on these two age groups likely was due to the fact that 5-year-olds' PM performance was high enough that a particularly difficult condition could disrupt monitoring processes, whereas 4-year-olds' PM performance was so low that conditions that enhanced monitoring processes helped their PM performance. Interestingly, 5-year-olds' PM in the no monitoring condition for non-salient targets resembled 4-year-old levels of PM performance, and 4-year-olds' PM in the monitoring instruction condition for salient targets resembled 5-year-olds' PM in

general. This finding supports the idea that 5-year-olds may naturally monitor their intentions and the environment so that only the most executively difficult conditions disrupt their monitoring processes. In contrast, 4-year-olds may not be monitoring their intentions or environment except when conditions are conducive and supportive of monitoring processes (where a monitoring instruction is explicitly given and external monitoring demands are reduced by high salience targets).

When the salience of the first target card was considered, it was found that it interacted with the monitoring instruction such that children who received a monitoring instruction *and* saw a salient first target card had better PM than children who saw a non-salient first target. The interaction between first target salience and monitoring is important, as PM for the first target is potentially the purest measure of PM as later PM may rely on a retrospective memory of carrying out the prospective action previously. This finding supports the idea that experimental conditions where cognitive monitoring is enhanced (via an instruction to monitor one's intentions) and external monitoring demands are reduced (via a salient target appearing first) result in better PM performance. It is probable that the monitoring instruction led to greater accessibility or activation of the PM action in mind when a salient target appeared first in the OT.

The tradeoff between PM and OT that has been documented in past studies (Marsh, Hancock, & Hicks, 2002; Marsh, Hicks, & Cook, 2005; Wang, et al., 2008) was not observed in the current study. In fact, better OT performance was associated with better PM (children who better remembered to carry out their intentions performed well on sorting cards into two categories). It is possible that OT and PM performance reflect general cognitive development so that children who were more cognitively advanced

generally did well on both tasks. Against this, the relation between OT and PM performance remained significant after controlling for verbal ability. Alternately, perhaps tradeoffs were present but difficult to detect. More subtle measures such as reaction times may have been necessary to detect PM-OT tradeoffs.

PM and RM performance were positively related in this study in contrast with the majority of the research on 4- and 5-year-olds that shows no relation (Guajardo & Best, 2000; Kvavilashvili, et al, 2001). It is difficult to know whether differences between studies were due to differences in the age groups studied or the use of different RM tasks as others have used free recall RM tasks and the current study used a recognition task. Further, it may be that the addition of lure items to the RM task may have introduced a higher EF demand than previous tasks that have not included such items.

#### *The Role of Executive Function*

Overall, the results revealed strong, positive relations between PM and working memory, inhibitory control, and set shifting. Both inhibitory control and set shifting remained positively related to PM performance after controlling for age and verbal ability. Inhibitory control and set shifting appear to be key abilities in being able to switch flexibly between the OT and PM task. The role of inhibitory control has been emphasized in past work (Ford, et al., 2012; Kvavilashvili, et al., 2001; Wang, et al., 2008) because of its potential role in allowing children to carry out the PM action when it interrupts the OT. It seems likely that children with superior inhibition abilities are better able to pull themselves away from the OT in order to carry out the prospective intention. Similarly, children who have better set shifting ability are less likely to remain fixated on the OT and fail to carry out the PM task due to perseveration on the OT. Although

working memory was related to PM, this relation did not survive after controlling for age and verbal ability. It is not surprising that this relation did not hold as younger children often struggled to even produce two digits in backward order. Past research using the backward digit span task, however, has shown that WM and PM were related even after controlling for age (Mahy & Moses, 2011).

An ANCOVA revealed that the effect of age, monitoring instruction, and target salience disappeared when EF ability and verbal ability were controlled suggesting that these effects were driven by developments in executive ability and general cognitive ability. The three-way interaction between age, monitoring instruction, and target salience remained statistically significant when EF was covaried, suggesting that this interaction may to some extent rely on processes other than those measured by the specific EF tasks used in this study.

Finally, the relations between PM and EF were mixed when they were examined by condition. Inhibitory control was related to PM in most experimental conditions after partialling out age and verbal ability regardless of difficulty level, but working memory and set shifting were not. In order to maximize power, an EF composite was formed and correlated with PM in the four experimental conditions (OT difficulty crossed with monitoring instruction) for salient and non-salient targets. The EF composite was related to PM in every condition except the most difficult conditions (difficult OT and no monitoring instruction). After controlling for age and verbal ability, PM was only correlated with EF in two of the easier conditions. These findings suggest that, in general, children with superior EF skills did better on the PM task. However, this particular PM task was quite challenging, so it is possible that even the so-called easy conditions were

executively demanding. The PM-EF relation did not hold in the most difficult conditions potentially because the task was so challenging that even superior EF did not aid PM performance. The extremely low levels of PM performance in the most difficult condition ( $M = .57$ ) compared to the easiest one ( $M = 1.61$ ) support the idea that children struggled with the PM task particularly when high demands were placed on monitoring.

### *Parent-Report Measures*

Parent-reports of children's social understanding, EF, and temperament provided additional information about children's abilities in two important ways. These reports provided another informant's perspective on children's behavior and added greater ecological validity because parents and guardians provided information about children's abilities in their daily lives.

Children's Social Understanding Scale scores were related to behavioral measures of working memory and inhibitory control, but were unrelated to PM.

Importantly, children's behavioral EF was highly related to parent ratings of EF ability. Surprisingly, parent EF rating was not related to PM. It is likely that the items of the BRIEF were not capturing EF abilities relevant to PM specifically so a PM composite was created by combining scores of four relevant PM-related BRIEF items. Although the composite did not have especially high internal consistency, it correlated positively with PM performance in the laboratory indicating that our PM task had validity in terms of capturing children's daily life PM ability.

PM was marginally related to parent-reported lower levels of high intensity pleasure and lower levels of impulsivity. It seems that children who are less impulsive and less desiring of high intensity pleasure experiences tend to be more capable of

carrying out their intentions. This is perhaps due to lower levels of distraction as these children may not be pulled away from the task at hand by appealing, exciting stimuli in the environment and therefore may be more focused on their own intentions.

### *Limitations*

Although the PM task used in Study 2 was a significant improvement from the one used in Study 1, it resulted in mediocre levels of performance for both 4- and 5-year-old children. More than half of children either forgot to carry out the prospective action completely or carried it out only once out of six possible opportunities. Many 4-year-olds performed at floor on this task likely impacting the ability to detect significant effects of OT difficulty and monitoring instruction on PM. In the future, this task could be modified to reduce its difficulty level in order to better assess some of the manipulations examined here.

Study 2 may have suffered from a lack of power. The fact that the monitoring instruction just failed to reach statistical significance and the pattern of results for OT difficulty was in the right direction but was not statistically significant suggests the presence of power issues. In order to detect the small effect sizes of these experimental manipulations a larger sample size may be necessary. In future studies, it will be important to ensure large sample sizes to examine such small effects.

## CHAPTER IV

### GENERAL DISCUSSION

The goals of this dissertation were to examine the effects of various manipulations of monitoring on children's PM and to investigate the relation between PM and EF under different experimental conditions. Study 1 was designed to test the hypothesis that children could take advantage of a delay period to refresh their intentions via monitoring to improve their PM performance. Filler task difficulty was manipulated in order to investigate whether a difficult task compared to an easy task would disrupt monitoring processes and result in worse PM performance. In addition, links between individual differences in EF, ToM, future thinking, and PM were examined. Study 2 examined three experimental manipulations designed to impact internal monitoring or external monitoring, further investigated relations between EF and PM, and also included parent-report measures in order to investigate relations between PM, ToM, self-regulation, and temperament.

Both studies showed that children's PM improves from 4- to 5-years of age and that manipulations enhancing cognitive monitoring or reducing external monitoring demands result in better PM performance and those that disrupt monitoring result in worse PM performance. Study 1 demonstrated that a difficult task filling the retention interval is detrimental to later PM. Further, it showed that working memory, planning, and advanced ToM significantly predicted PM after a difficult filler task. Study 2 showed that salient PM targets resulted in better PM than non-salient PM targets and an explicit instruction to monitor one's intentions tended to help children's PM compared to when children were given no monitoring instruction. Further, individual differences in

EF were positively related to individual differences in PM with inhibition predicting PM above and beyond age, working memory, set shifting, and verbal ability.

Five-year-olds' superior PM performance compared to 4-year-olds suggests that there are substantial improvements occurring during the early years. Past work has shown PM increases from four to seven years (Kvavilashvili, et al., 2001) and differing effects of PM task manipulations on 4- and 5-year-olds (Mahy & Moses, 2011).

Interestingly, when EF and verbal ability were controlled in Study 2, the effect of age disappeared suggesting that the age differences in PM were largely driven by EF and linguistic ability. Although the size of the age effect was relatively small in both studies, it is important to document PM improvements during these years as many other abilities that may be related to PM also show similar developmental trajectories. For example, this period is filled with cognitive advances such as mastering self-regulation tasks (Carlson, 2005; Jones, Rothbart, & Posner, 2003; Mischel, Shoda, & Rodriguez, 1989), greater understanding of mental states (Wellman & Liu, 2004), increases in reflective awareness (Zelazo & Frye, 1998; Zelazo, 2004), and advances in meta-memory (Joyner, & Kurtz-Costes, 1997). Development of these cognitive abilities suggests potential mechanisms that may drive the development of PM.

#### Monitoring Hypothesis

Taken together these studies seem to support the monitoring hypothesis that children who have more opportunities for cognitive monitoring during a PM task also have superior PM performance. Several findings suggest that monitoring one's intentions is related to PM performance including: (1) a difficult filler task that potentially disrupted cognitive monitoring during the delay interval resulted in worse PM compared to an easy



filler task in Study 1, (2) an explicit instruction to monitor one's intentions during the delay resulted in marginally better PM performance in Study 2, and (3) individual differences in abilities underpinning monitoring such as working memory and ToM ability were related to PM after a difficult filler task in Study 1.

Earlier evidence supporting the monitoring hypothesis showed that 5-year-olds were able to take advantage of a longer delay period to the benefit of their later PM whereas 4-year-olds were not (Mahy & Moses, 2011). These findings were interpreted to suggest that 5-year-olds were refreshing their intentions during the delay (for similar interpretation with adults see Hicks, et al., 2000). Study 1 followed up on this finding by filling the delay interval with a difficult or easy task using the logic that if children are monitoring their intentions during the delay then a difficult task should disrupt that monitoring resulting in worse PM. Results showed that the difficult filler task indeed resulted in worse later PM compared to the easy filler task, supporting the hypothesis that monitoring of intentions may have been occurring during this delay period. Findings both from Study 1 and from previous work in our lab (Mahy & Moses, 2011) suggest that important monitoring processes occur during the delay interval that affect later PM.

An explicit instruction to monitor one's intentions during the delay interval resulted in marginally superior PM in 4- and 5-year-olds' PM suggesting that children of this age are capable of monitoring their intentions when instructed to do so. Additionally, children who were instructed to monitor their intentions also reported seeing more target items than children who were not instructed to monitor their intentions. The findings are impressive given that the monitoring instruction was quite minimal. Further, these findings are consistent with research showing that 5-year-olds' PM is helped by a

reminder story during the retention interval about a forgetful spider (Kvavilashvili, et al., 2009) and 4- and 5-year-olds are capable of basic memory monitoring (Cultice, Somerville, & Wellman, 1983). More recently, Estes (1998) showed that 4- to 6-year-old children have some awareness of their mental activity supporting the idea that children of this age may be capable of monitoring the mind's activity. In addition, Flavell, Green, and Flavell (1998) found that by 5-years of age children seem to be developing an awareness of their mental activity and have some capacity for introspection and reflection (Flavell, 1999; Flavell, Green, & Flavell, 1993; 2000; Zelazo, 2004). These findings suggest the ability to monitor and introspect on the contents of the mind develop in the preschool years. The current findings further support this idea, suggesting that even 4-year-olds may be able to monitor their intentions particularly if they are given an explicit instruction to do so. It is important to reiterate, however, that the finding was only marginally significant and so is in need of replication with a larger sample.

The fact that a simple instruction to think about one's intentions tended to improve later PM performance has important implications for children's real life remembering. A simple reminder to a young child to think about what they have to do may enhance their later PM which could be helpful for teachers and parents alike in scaffolding children's PM. Future work may manipulate the subtlety of such manipulations in order to determine what level of monitoring reminder results in the best levels of later PM performance.

Four- and 5-year-olds' PM was differentially affected by the experimental conditions. Five-year-olds' PM was negatively affected by the no monitoring instruction and non-salient target combination, whereas 4-year-olds' PM was particularly helped by

the monitoring instruction and salient target combination. This finding suggests that 5-year-olds in the majority of conditions were able to monitor their mind and environment for the PM cue successfully, but not in the most difficult condition where these monitoring processes were perhaps most disrupted. In contrast, 4-year-olds' PM was fairly poor in all conditions except the easiest condition suggesting that monitoring processes may have not been occurring spontaneously but may have been occurring when they were given a monitoring instruction and saw salient targets. This supports the monitoring hypothesis in that children's PM is optimal when experimental conditions encourage monitoring. It also supports previous findings that suggest 5-year-olds may automatically monitor their minds when given the chance whereas 4-year-olds may not (Mahy & Moses, 2011), at least until they are given instructions to do so and when target items are salient.

Notably, this 3-way interaction did not disappear after controlling for EF and verbal ability as happened with the effects of age and monitoring. This suggests that unlike the impact of age and monitoring instruction on PM that seemed to be driven by EF and verbal ability, this interaction may have been influenced by other factors such as motivation or other automatic processes. It is possible that 4-year-olds were able to benefit from the salient targets and monitoring instruction because they were motivated to find the animals and this combination of factors made it possible for them to complete the PM task, whereas, 5-year-olds may have lost interest in the PM task when there was no monitoring instruction and non-salient targets resulting in especially poor performance in that condition.

Further evidence for the important role of internal monitoring in PM is that children who have better working memory also have better PM performance after a difficult filler task but not after an easy one. This suggests that only children who were able to keep intentions active in their mind were able to take advantage of a delay interval filled with a demanding executive task. Cowan's model of working memory suggests that information may fade in and out of the focus of working memory (Cowan, 1995; 2005). This model is very similar to a cognitive monitoring process where intentions can be refreshed in mind. Therefore, children with superior working memory may be better able to keep their prospective intentions active in working memory and may be able to take advantage of them when they enter the focus of working memory thus enhancing their PM. Children with better working memory may also have better inhibitory processes that keep relevant items in and irrelevant items out of working memory (Awh & Vogel, 2008) ensuring that the prospective intention is active in mind when it is needed. In Study 2, PM performance was highly related to inhibitory control ability suggesting that inhibition may play a role in keeping relevant items (such as the prospective intention) in the focus of working memory during a PM task.

In addition to working memory, ToM was predicted to relate to PM in Study 1, as children who have a better understanding of the mind may be better able to monitor their mind or at the least be aware that monitoring their intentions may lead to better performance. Findings revealed that better ToM was related to better PM after a difficult filler task only. Ford et al. (2012) recently showed a strong relation overall between PM and ToM (measured by false belief tasks) in a study with 4- to 6-year-olds. Although PM performance was superior in the no interruption condition compared to the interruption

condition, they found that PM and ToM were positively correlated in both conditions. Perhaps task interruption was a relatively easy manipulation in contrast to completing a difficult filler task prior to the PM task.

It seems the link between PM and ToM is perhaps metacognitive in nature as they both rely on some understanding of intentions and the mind. For example, better ToM at 3- or 4-years-old is predictive of better metamemory at 5-years-old (Lockl & Schneider, 2007). Therefore, children with better ToM may recruit additional strategies to remember to carry out their intentions or may be better able to follow instructions to monitor their intentions during a delay because they are more likely to understand that it would potentially aid their later PM.

Relations between PM and ToM support the mental self-projection hypothesis that suggests that similar brain networks underlie various forms of mental self-projection including remembering to carry out future tasks and understanding the minds of others (Buckner & Carroll, 2007). The adult neuroimaging literature shows there is a common neural activation for prospection, ToM, and autobiographical memory in the midline structures in the frontal and parietal lobes also known as the default mode network (Spreng & Grady, 2009). This core network may support self-projection in many different contexts including the ability to mentally project oneself from the present moment into simulation of another time, place, or perspective (Spreng, Mar, & Kim, 2008). Therefore, the relation between PM and ToM can be understood by the similar cognitive processes as well as the common neural networks such as the default mode that these abilities may rely on.

## Manipulations of Task Difficulty

Although Study 1 showed clearly that a difficult executive task filling the retention interval had a negative impact on later PM, manipulating task difficulty during the OT had little effect on PM in Study 2. It is possible that the manipulation of difficulty during the OT may not be as disruptive to forming the intention as manipulation of difficulty during the retention interval. This finding may suggest that difficulty only impacts PM when it interferes with forming, monitoring, or finalizing an intention. It is possible that it is critical to monitor one's intentions *prior* to the appearance of the PM target in order to reap the benefits for PM. This possibility seems somewhat unlikely, however, as past work that has manipulated task difficulty during the OT (Shum, et al., 2008; Ward, et al., 2005; Wang, et al., 2008) resulted in poorer PM performance (either lower accuracy or slower response times). One alternative possibility is that the difficulty manipulation was not strong enough. Importantly, the difficult OT did have a negative impact on OT performance as it resulted in less accurate card sorting so it was not simply that the difficulty manipulation did not work but rather that it was perhaps not powerful enough to negatively impact PM performance. It is possible that the difficult OT was not sufficient to disrupt key monitoring processes involved in PM. For example, children may have quickly adjusted to sorting cards into opposite categories rather than having a lasting demand on inhibitory control as originally predicted. A second alternative possibility is that both conditions were quite hard making it difficult to detect differences in PM. In both conditions, children had to keep in mind two rules to govern their behavior; first, they had to say whether the item was small or large and second, they had to place it in the appropriate box. This alternative is supported

by the relatively low levels of performance on the PM task in both the easy and difficult OT conditions. In order to better investigate the effect of OT difficulty on PM in the future, more subtle measures of OT performance such as PM response latencies may be useful in order to investigate tradeoffs between PM and OT that may be revealed by slowing of reaction times under difficult OT conditions.

#### Executive Exhaustion Account

One goal of Study 2 was to further explore the interpretation that the effect of filler task difficulty in Study 1 was simply due to executive exhaustion rather than an effect that had an impact on children's ability to monitor their intentions. Unfortunately, because the manipulation of OT difficulty in Study 2 did not have an impact on PM and may have been too weak, it is hard to draw any conclusions regarding whether executive exhaustion was at play in Study 1. Because the OT difficulty manipulation did not affect PM, it remains possible that the Study 1 results may have been due to executive exhaustion. However, other data speak against this alternate account. First, because the PM task in both studies had more than a single trial, according to the executive exhaustion account one might expect that PM would decline over the course of the task as children's executive ability would be depleted by the OT. There was no evidence of worsening PM performance over the course of the PM task in Study 1 or 2. In fact, linear trend analyses revealed that children's PM did not change over the task in Study 1 and actually improved over the course of the PM task in Study 2. Second, the fact that later executive measures were unaffected by filler task difficulty in Study 1 and OT difficulty or the monitoring instruction in Study 2 suggest that executive exhaustion was likely not affecting PM performance. Therefore, even though the OT difficulty manipulation in

Study 2 could not address this executive exhaustion account, other data showing that PM did not decrease over time and that difficulty manipulations did not affect performance on later EF tasks suggest that it is rather unlikely that executive exhaustion was responsible for the results of Study 1.

### External Monitoring of the Environment

In addition to manipulations that disrupted or enhanced cognitive monitoring, Study 2 included a manipulation that reduced the need for external monitoring of the environment. Children remembered to carry out their intentions more often when they saw salient target cues compared to non-salient target cues. This finding is supported by past work that shows that increasing the salience of a cue by increasing its perceptual size results in better PM (McGann, et al., 2005). This finding suggests that greater demands on external monitoring result in worse PM, so any changes that result in enhanced target salience support PM. This has practical implications for parents and caregivers of children in that enhancing PM cues in the environment may increase the likelihood that children will remember to carry out the intention. As just one example, a brightly colored or large soap dispenser may aid children's remembering to wash their hands after using the bathroom.

### Differences in Prospective Memory Performance between Studies

Children performed relatively worse on the PM task in Study 2 compared to Study 1. PM performance in Study 1 was very high so the PM task in Study 2 was designed to be more difficult. Three major changes to the original PM task were intended to increase the difficulty of the PM task. First, in contrast to simple card naming, the OT in Study 2 was a card sorting task where cards had to be named and then categorized into



big or small (placed in boxes). Second, a greater number of cards had to be sorted in Study 2 (96 cards) compared to Study 1 (48 cards). Children had to maintain attention during the card sorting for a longer period of time in Study 2. Although PM performance improved across the PM trials in Study 2, children's overall PM score was quite low. Finally, the OT and PM task differed in the relevant dimension in which to consider the target versus distractor items in Study 2 whereas they required the same dimension in Study 1. Study 1 required children to consider the type of object as they named the items depicted. When an animal appeared children might have found it easy because they did not need to switch to think about another dimension but rather could remain focused on what the object was. In Study 2, however, children had to judge whether items were big or small, so in order to recognize the PM targets they had to consider the added dimension of object type in addition to its size. Marsh, Hick, and Hancock (2000) found that, in adults, PM performance was better when the ongoing and PM tasks matched on the type of processing required compared to when they were mismatched. The mismatch between relevant dimensions in the OT and PM task in Study 2 may have contributed to children's worse PM performance. It is also possible, however, that children found Study 1 more interesting or motivating than Study 2. Perhaps young children were more motivated to help Morris a stuffed animal who was present throughout the task rather than an imaginary family who needed help moving their items.

#### Prospective Memory and Retrospective Memory Relation

The relation between PM and RM has revealed mixed findings in the adult and child memory literature (Burgess & Shallice, 1997; Einstein & McDaniel, 1990; Guajardo & Best, 2000; Kvavilashvili, et al., 2001; Maylor, et al., 2002). The current

studies similarly provide mixed findings on the relation between PM and RM with Study 1 finding no relation and Study 2 finding a strong positive relation. It is worth noting that the RM in Study 1 yielded near ceiling level performance and so it was made more difficult in Study 2 by adding lure items that were new, but resembled old items children had seen. Therefore, the RM task in Study 2 yielded more variance and likely had more power to detect relations with PM.

The RM task was a recognition memory measure that relied on encoding items during performance of the OT and therefore was primarily used as an estimate of the depth of processing of the OT task. Therefore, it is not surprising that children who did better on the OT and PM task also had superior RM, as successful RM task performance relied on successful encoding *within* the OT and PM task. In order to avoid problems such as the fact that the OT target items were initially encoded within the PM task and that children were not told that they would later be asked to recognize items from the OT, another measure of retrospective memory was taken in Study 2. The Episodic Recall task was a completely independent task where children were told they would have to freely recall items they named about a minute later. Performance on the Episodic Recall task, however, was unrelated to PM. This difference between the correlations with PM for the RM and Episodic Recall highlights a potential problem with using a RM task so closely tied with the PM task to draw conclusions about the dependence or independence of PM and RM as memory systems. Although RM in the specific PM context may provide useful information about processing of the OT targets as well as the role of RM in PM, in order to speak to the question of independence between these two memory systems it is critical to use unrelated measures of PM and RM. In the future, studies wishing to

address the relation should take independent measures of a battery of RM and PM tasks in order to better measure these constructs.

### Role of Executive Function

These studies make it clear that EFs including working memory, planning, inhibitory control, and set shifting are robustly correlated with PM. Even after controlling for age in months (and verbal ability in Study 2), working memory, planning, and inhibitory control were related to PM performance in these two studies. In Study 1, this relation held only for the difficult filler task condition and not for the easy task condition suggesting that children with better EF did better on a PM task in the face of difficult conditions. However, it is possible that the restriction of range on the PM scores in the easy filler condition in Study 1 could have contributed to lack of relation between PM and EF compared to the difficult filler condition. Replication of this finding with a PM task that yields more variance is necessary.

In Study 2, results were less clear when the conditions varying in difficulty were examined. Overall, relations between PM and EF were stronger in the easier conditions, a somewhat surprising result given the strong PM and EF relations in the difficult condition in Study 1. There are two likely interpretations for these findings. First, it is possible that EF ability is most important during the formation of the intention that occurs during the delay interval. That would explain why better EF related to better PM in Study 1 where difficulty was manipulated during the delay interval. Having better EF ability during a more difficult OT may not have any impact on PM since the intention has already been formed. Second, because PM performance was much worse in Study 2 it is possible that better EF did not help children's performance because they struggled in all

conditions as is evidenced by relatively mediocre levels of performance even in the conditions predicted to be easy (easy OT and monitoring instruction). When an EF composite was formed in Study 2, it was found that PM correlated with the EF composite in all conditions except the most difficult (difficult OT, no monitoring instruction). It is possible that this condition was so challenging for children that even those with better EF could not cope with the demands of the task resulting in no relation between EF and PM.

Inhibitory control emerged as the only significant predictor of PM out of the three EFs measured in Study 2: working memory, inhibitory control, and set shifting. This is consistent with past literature that has pointed to the important role of inhibition particularly in PM tasks that require task interruption (Kvavilashvili, et al., 2001; Wang, et al., 2008), as was the case in the PM tasks of both Study 1 and 2. Study 1 did not measure inhibitory control but inhibition may have been especially important in the PM task in Study 2, as card sorting was a fairly cognitively demanding OT compared to past studies that have used card naming or other simpler sorting tasks as an OT. The measure of inhibition used, the Simon Says task, was similar to the PM task where children had to inhibit the pre-potent response of placing a prospective target card in the box and instead carry out the novel action of ringing the bell. This similarity in task demands could have partly been responsible for the strong, positive relation between inhibitory control and PM performance.

#### Implications for PAM and Multiprocess Models

The differences in the relation between PM and EF depending on the experimental conditions has implications for theoretical models of the role of controlled processes in children's PM. The fact that EF seems to be related to PM performance in

certain conditions and unrelated in others as well as findings that better PM occurs under executively easier conditions, supports the multiprocess model that suggests that controlled processes, although important under some circumstances, are not always necessary for successful PM. The alternative theoretical stance is that controlled processes must be operating for PM to be successful. However, the PAM model is not supported by these findings, as individual differences in EF were not always related to PM in the two studies. Future work should more thoroughly explore the conditions under which controlled, executive processes are necessary for children's PM and where automatic processes play a more substantial role (McDaniel and Einstein, 2000). The extent to which monitoring is controlled or automatic was beyond the scope of this dissertation but is an interesting question nonetheless. It is possible that internal monitoring during the delay interval relies on both controlled and automatic processes. It seems unlikely that internal monitoring occurring during the delay is entirely automatic given that a difficult filler task resulted in worse PM suggesting that it disrupted some controlled processes. Automatic processes may allow for intentions to come to mind effortlessly, however, children's executive ability may determine whether they take advantage of this to the benefit of their PM performance.

In general, children tended to have worse PM in experimental condition that required more monitoring whether internal (as in monitoring their intentions) or external monitoring (as shown by better PM performance for salient targets compared to non-salient targets) suggesting that children's PM relies on executive processes. The current study used manipulations designed to alter children's likelihood to monitor their intentions and the need to monitor their external environment. Further, EFs were

measured as these underlie monitoring processes. However, no direct measure of mind monitoring or external monitoring was taken as monitoring is difficult to measure in young children due to their limited ability to *report* on their mental processes.

#### Parent-Report Measures

Given the positive relation between advanced ToM and PM in Study 1, the lack of relation between CSUS and PM in both studies is somewhat surprising. The most likely explanation for this finding is the CSUS measures multiple facets of social understanding beyond simple belief attribution measured by the Restricted View Task. Therefore, although the expectation was that PM and CSUS would correlate, specifically under difficult PM task conditions, the lack of correlation may not be indicative that PM and ToM are unrelated but instead be a product of how ToM was measured with the CSUS rather than a behavioral measure.

BRIEF-P scores did not predict PM performance which was surprising given that behavioral EF measures were so highly correlated with PM. It is possible that parent's estimation of their child's EF ability is not as accurate as children's behavioral performance in the laboratory. When filling out the BRIEF-P, parents are asked to estimate the number of times in the last six months their child's behavior has been a problem and were given three response options: never, sometimes, and often. As would be expected with a typically developing population, parents mostly selected 'never', so variability on this measure was low which may account for the lack of relation with PM. However, it is important to note that BRIEF-P scores did relate to behavioral measures of EF suggesting that maybe the BRIEF-P items were simply not specific enough to PM ability. Although PM did not correlate with BRIEF scores, four items from the BRIEF-P

that tapped into PM ability were formed into a composite and correlated with behavioral PM performance.

These questions that capture PM concepts from the BRIEF-P provide a starting point for creating a valid parent-report measure on PM that correlates with behavioral performance in the lab. Past attempts to create a parent-report on their children's PM, such as the child version of the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, et al., 2000; Crawford, et al., 2003) have yielded mixed results in terms of whether the PM items in the questionnaire correlated with behavioral PM performance. For example, Kliegel and Jäger (2007) found that parents of children aged 2- to 6-year-olds could adequately estimate their children's PM performance using the child version of the PRMQ. In previous work, however, I found that parent's estimation of their children's PM did not relate to PM performance in the laboratory and parents did not differentiate between the PM and RM scales of the PRMQ (Mahy & Moses, unpublished data). The BRIEF-P PM items ask about fairly general PM abilities compared to the items on the PRMQ that tend to ask about specific failed attempts at prospective remembering (e.g., does your child forget to pass on messages or other information from others such as friends or grandparents?). Therefore, the four items that comprise the PM composite that I used in this study may offer some guidance for future attempts to create an improved, valid parent-report of children's PM.

Several temperamental measures related to individual differences in EF, but only high intensity pleasure and impulsivity showed a trend-level negative relation with PM. These traits suggest that children who are more inwardly focused and less drawn to their external environment are generally better at PM which supports the idea that these same

children may be better able to monitor their intentions in the face of distractions in the environment. McDaniel and Einstein (2000) found that certain individual personality traits such as the tendency to ruminate and greater anxiety were related to superior PM performance. It is interesting to note that both rumination and anxiety are temperamental traits that encourage an individual to focus inwardly on one's thoughts. Similarly, lower impulsivity and lower levels of high intensity pleasure seeking may also be indicative of children who are more focused on their internal thoughts and states rather than being attracted to exciting or risky stimuli in the environment.

#### Future Directions

The finding that monitoring during the delay interval appears to help PM performance is worth further exploration. Study 2 showed that instructing children to think about their intentions at the beginning of the delay interval tended to improve later PM performance, especially when the first PM target is of high salience. These manipulations, however, did not yield insight into how often children actually thought about their intentions during the delay period. Future studies could ask children to report each time they think about their intention during the delay interval to see whether this correlates with PM performance. Alternately, in order to avoid relying on children's ability to report on their mind which is still developing during the preschool years (Flavell, Green, & Flavell, 1998), one could manipulate the number of times that children are asked to think about their intentions during the delay interval in order to examine the effect it has on later PM.

The first study showed evidence for a relation between PM and ToM as previous studies have done (Ford, et al., 2012). It would be interesting to explore these links



further, particularly in the context of metacognition and meta-memory. It seems that there is a link between better understanding of mental states and PM. An interesting question for future work is does knowledge of memory strategies and use of these strategies relate to PM performance? It seems that children with a better understanding of memory strategies such as refreshing their intentions should use them more often potentially resulting in better PM. Past work (Kvavilashvili, 2009, ICPM3) has shown that children are better at predicting their PM ability than their RM ability suggesting they have some insight into their prospective remembering.

These two studies showed a strong, positive relation between EF and PM in young children. However, because of the correlational nature of the study design it is of course uncertain whether EF drives PM development or vice versa. Therefore, an important future direction is to investigate the causal relation between EF and PM. This could be done in two ways: (1) by continuing to vary the level of EF required to succeed in various experimental manipulations (as was done in Study 1 and 2) and (2) by training children on EF ability to see if later PM benefits from such a training. If EF training did have a positive impact on PM then forgetful children and populations that struggle with PM, such as individuals with Autism and ADHD, could undergo interventions that focus on improving their executive abilities.

Evidence from Study 2 suggests that PM is related to self-regulation in the laboratory and certain aspects of temperament in daily life. It would be interesting to examine the traits of forgetful children as it has been argued that poor PM has a negative impact on children's academic and social functioning. This assertion that young children with poorer PM may suffer in their academic functioning also needs to be tested

empirically. A study investigating children's school and social performance and how that is related to PM may reveal important relations. Teacher and parent ratings on academic and social abilities could be combined to see if being forgetful has a negative impact on academic performance after controlling for relevant cognitive variables such as executive abilities, verbal and non-verbal intelligence.

Finally, examining the developmental trajectory of PM longitudinally from the early years into the school years would be of great interest. Such a design would allow for examination of how early forms of PM such as simple tasks one would assign to a toddler predict later more complicated PM tasks that would be given to a school-aged child. Is children's PM stable across time or do children show marked increases or decreases? What cognitive variables are associated with changes in PM ability across childhood? A longitudinal design would allow for disentangling the role of specific EFs in PM as one could predict later PM from various facets of EF in toddlerhood.

### Conclusion

The development of children's PM is an important topic that is greatly understudied. The goal of this dissertation was to investigate the impact of manipulations of an executive nature that specifically impacted internal and external monitoring on PM and to further examine the relation between PM and EF in young children. The findings suggest that PM may be disrupted by manipulations that interfere with cognitive monitoring and improved by manipulations that enhance cognitive monitoring or reduce external monitoring demands. Further, there is a robust correlation among PM and EF. There is still much work to be done in this areas as it has important implications for children's daily functioning and for the development of their independence. Future work

should make links with how PM affects children's functioning in their daily lives as well as continue with experimental designs that probe questions about what affects PM both negatively and positively and how these factors affect its development in later childhood.

## APPENDIX A

### ITEMS OF THE CHILDREN'S SOCIAL UNDERSTANDING SCALE

Final CSUS items are broken down by mental states. Reverse items are marked by (R).

#### *Belief*

1. Understands that telling lies can mislead other people.
2. Talks about how her/his beliefs have changed over time (e.g., "I used to think that drinking from a cup is hard, now I think it's easy.")
3. Talks about people's mistaken beliefs (e.g., "He thought it was a dog but it was really a cat"; "I thought mommy was coming but it was really daddy.")
4. Tries to persuade others that their point of view is incorrect.
5. Is good at playing tricks on others (e.g., acts as if the cookie jar is empty when really it's full).
6. Talks about what people think or believe (e.g., "I think it's raining"; "He thinks it's bedtime.")
7. Talks about differences between her/his beliefs and someone else's (e.g., "You think it's a shark but I think it's a dolphin.")

#### *Knowledge*

1. Realizes that experts are more knowledgeable than others in their specialty (e.g., Doctors know more than others about treating illness).
2. Uses words that express uncertainty (e.g., "We might go to the park"; "Maybe my shoes are outside.")
3. Is good at playing "hide and seek" (e.g., is hard to find, doesn't make give-away noises).
4. Can tell you how she/he found out about things (e.g., "Sally told me about it", "I saw it happen at the park", "I heard it on the radio").
5. Is good at explaining things to younger children.
6. Talks about what people know or don't know (e.g., "I know who it is"; "He doesn't know where his ball is.")

7. Talks about teaching and learning (e.g., says “My dad taught me how to play that game”; “I learned that song at daycare.”)

### *Perception*

1. Talks about the difference between the way things look and how they really are (e.g., “It looks like a snake but it’s really a lizard.”)
2. When talking on the phone, behaves as if the listener can actually see her/him (e.g., assumes that the listener knows what she is wearing). (R)
3. Is good at directing people’s attention (e.g., points at things to get others to look at them).
4. Thinks you can still see an object even if you’re looking in the opposite direction. (R)
5. Thinks that she/he cannot be seen if her/his eyes are closed. (R)
6. Talks about what people see or hear (e.g., “I see a duck”; “She hears a train coming.”)
7. Tells lies that are really easy to discover (e.g., says that she/he didn’t eat a cookie when there’s chocolate all over her/his face). (R)

### *Desire*

1. Talks about the difference between what people want and what they actually get (e.g., “She wanted a puppy but she got a kitten.”)
2. Takes into account what others want (e.g., takes turns, shares toys, compromises with other children regarding which game to play, etc.)
3. Talks about differences in what people like or want (e.g., “You like coffee but I like juice.”)
4. Understands that wishes don’t always come true.
5. Understands that just because you want something it doesn’t mean you really need it.
6. Talks about what people like or want (e.g., “He likes cookies”; “She wants to go home.”)
7. Recognizes that if a person wants something, that person will probably try to get it.

### *Intention*

1. Talks about the difference between intentions and outcomes (e.g., “He tried to open the door but it was locked.”)
2. Has trouble figuring out whether you are being serious or just joking. (R)
3. Understands that hurting others on purpose is worse than hurting others accidentally.
4. Understands the difference between doing something intentionally and doing it by mistake (e.g., someone deliberately taking a toy vs. taking it by mistake).
5. Understands when she/he is being teased or made fun of.
6. Talks about people’s intentions (e.g., “He did it on purpose”; “I didn’t mean to spill it”; “She’s trying to catch the kitten.”)
7. Understands that people can perform the same action for different reasons (e.g., throwing a ball could be done with the intention of playing a game vs. with the intention of hurting someone).

### *Emotion*

1. Understands that different people can have different feelings about the same thing (e.g., one child likes a dog but another child is scared of it).
2. When given an undesirable gift, pretends to like it so as not to hurt the other person’s feelings.
3. Talks about conflicting emotions (e.g., “I’m happy to go on vacation, but I’m sad about leaving friends behind.”)
4. Has difficulty figuring out how you feel from your tone of voice or from your facial expressions of emotions (e.g., has trouble telling the difference between an angry and a sad voice/face). (R)
5. Realizes that if she/he does something bad, others may get mad.
6. Talks about how people feel (e.g., “I am happy”; “She is angry.”)
7. Tries to understand the emotions of other people (e.g., wants to know why you are crying).

APPENDIX B

ITEMS OF THE PROSPECTIVE MEMORY TASK

Order in Stack	Stack 1	Stack 2	Stack 3
1	Television (L)	Lawn mower (L)	Sticky Note (S)
2	Watering Can (S)	Necklace (S)	Bureau (L)
3	Garden Shed (L)	Pillow (L)	Gift (S)
4	Fire Pit (L)	Stereo (L)	Paper clip (S)
5	Shovel (S)	Car (L)	Mask (S)
6	Slippers (S)	Dress (S)	Towel (S)
7	Coffee Table (L)	Piano (L)	Parrot (L)
8	Swing Set (L)	Picture frame (S)	Mailbox (L)
9	Guitar (L)	Computer (L)	Cloth (S)
10	Couch (L)	Bicycle (L)	Jug (S)
11	Bow (S)	Bird House (S)	Table (L)
12	<b>Guinea Pig (S)</b>	Adirondack chair (L)	Toy train (S)
13	Gazebo (L)	Child's Tent (S)	Suitcase (L)
14	Microwave (L)	<b>Goldfish (L)</b>	Moped (L)
15	Mirror (S)	Jeans (S)	Hat (S)
16	Tennis Racquet (S)	Bed (L)	Stapler (S)
17	Box of tissues (S)	Battery (S)	Glove (S)
18	Chair (L)	Soap (S)	Crib (L)
19	Rock (S)	Bird Bath (L)	Toothbrush (S)
20	Wheelbarrow (L)	Refrigerator (L)	Ring (S)

21	Washcloth (S)	<b>Kitten (S)</b>	Globe (L)
22	Badminton Racquet (S)	Cooking pot (S)	Chest (L)
23	Child's Bed (L)	Dresser (L)	<b>Rabbit (S)</b>
24	Fence (L)	Garden Tools (S)	Rocking horse (L)
25	Clay Pot (S)	Soccer ball (S)	Purse (S)
26	Alarm clock (S)	Chopping Block (S)	Garbage can (L)
27	Van (L)	Telephone (S)	Umbrella (L)
28	Iron (S)	Book (S)	Arbor (L)
29	Soccer Net (L)	Garden cart (L)	Recliner chair (L)
30	<b>Dog (L)</b>	Basketball Net (L)	Fireplace (L)
31	Toaster (S)	Lamp (S)	Water bottle (S)
32	Shirt (S)	Barbeque (L)	Backpack (L)

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Note—Animal targets are in bold, L = large item, S = small item.



APPENDIX C

ALL POSSIBLE ORDERS OF SALIENT AND NON-SALIENT TARGETS

Order	Guinea Pig	Dog	Fish	Kitten	Parrot	Rabbit
1	N	N	N	S	S	S
2	N	N	S	N	S	S
3	N	N	S	S	N	S
4	N	N	S	S	S	N
5	N	S	N	N	S	S
6	N	S	N	S	N	S
7	N	S	N	S	S	N
8	N	S	S	N	N	S
9	N	S	S	N	S	N
10	N	S	S	S	N	N
11	S	N	N	N	S	S
12	S	N	N	S	N	S
13	S	N	N	S	S	N
14	S	N	S	N	N	S
15	S	N	S	N	S	N
16	S	N	S	S	N	N
17	S	S	N	N	N	S
18	S	S	N	N	S	N
19	S	S	N	S	N	N
20	S	S	S	N	N	N

*Note*—N = Non-salient target (no red border), S = salient target (red border).

APPENDIX D

ITEMS OF THE RETROSPECTIVE MEMORY TASK

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OLD ITEMS	NOVEL ITEMS	LURE ITEMS
Mask	Plant	Lamp
Bicycle	Garden Fountain	Purse
Bird Bath	Water Slide	Lawn mower
Umbrella	Beach ball	Slippers
Chair	Child's desk	Garden Shed
Bow	Drums	Rocking Horse
Mirror		
Fence		
Hat		
Ring		
Stereo		
Gardening tools		

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## APPENDIX E

### ITEMS OF THE BEHAVIORAL RATING INVENTORY OF EXECUTIVE FUNCTION-PRESCHOOL VERSION

1. Overreacts to small problems.
2. When given two things to do, remembers only the first or last.
3. Is unaware of how his/her behavior affects or bothers others.
4. When instructed to clean up, put things away in a disorganized, random way.
5. Becomes upset with new situations.
6. Has explosive, angry outbursts.
7. Has trouble carrying out the actions needed to complete tasks (such as trying one puzzle piece at a time, cleaning up to earn a reward).
8. Does not stop laughing at funny things or events when others stop.
9. Needs to be told to begin a task even when willing to do it.
10. Has trouble adjusting to new people (such as babysitter, teacher, friend, or day care worker).
11. Becomes upset too easily.
12. Has trouble concentrating on games, puzzles, or play activities.
13. Has to be more closely supervised than similar playmates.
14. When sent to get something, forgets what he/she is supposed to get.
15. Is upset by a change in plans or routine (for example, order of daily activities, adding last minute errands to schedule, change in driving route to store).
16. Has outbursts for little reason.
17. Repeats the same mistakes over and over even after help is given.
18. Acts wilder or sillier than others in groups (such as birthday parties, play group).

19. Cannot find clothes, shoes, toys, or books even when he/she has been given specific instructions.
20. Takes a long time to feel comfortable in new places or situations (such as visiting distant relatives or new friends).
21. Mood changes frequently.
22. Makes silly mistakes on things he/she can do.
23. Is fidgety, restless, or squirmy.
24. Has trouble following established routines for sleeping, eating, or play activities.
25. Is bothered by loud noises, bright lights, or certain smells.
26. Small events trigger big reactions.
27. Has trouble with activities or tasks that have more than one step.
28. Is impulsive.
29. Has trouble thinking of a different way to solve a problem or complete an activity when stuck.
30. Is disturbed by changes in the environment (such as new furniture, things in room moved around, or new clothes).
31. Angry or tearful outbursts are intense but end suddenly.
32. Needs help from adult to stay on task.
33. Does not notice when his/her behavior causes negative reactions.
34. Leaves messes that others have to clean up even after instruction.
35. Has trouble changing activities.
36. Reacts more strongly to situations than other children.
37. Forgets what he/she is doing in the middle of an activity.
38. Does not realize that certain actions bother others.
39. Gets caught up in the small details of a task or situation and misses the main idea.

40. Has trouble “joining in” at unfamiliar social events (such as birthday parties, picnics, holiday gatherings).
41. Is easily overwhelmed or overstimulated by typical daily activities.
42. Has trouble finishing tasks (such as games, puzzles, pretend play activities).
43. Gets out of control more than other playmates.
44. Cannot find things in room or play area even when given specific instructions.
45. Resists change of routine, foods, places, etc.
46. After having a problem, will stay disappointed for a long time.
47. Cannot stay on the same topic when talking.
48. Talks or plays too loudly.
49. Does not complete tasks even after given directions.
50. Acts overwhelmed or overstimulated in crowded, busy situations (such as lots of noise, activity, or people).
51. Has trouble getting started on activities or tasks even after instructed.
52. Acts too wild or out of control.
53. Does not try as hard as his/her ability on activities.
54. Has trouble putting the brakes on his/her actions even after being asked.
55. Unable to finish describing an event, person, or story.
56. Completes tasks or activities too quickly.
57. Is unaware when he/she does well and not well.
58. Gets easily sidetracked during activities.
59. Has trouble remembering something, even after a brief period of time.
60. Becomes too silly.
61. Has a short attention span.

62. Plays carelessly or recklessly in situations where he/she could be hurt (such as playground, swimming pool).
63. Is unaware when he/she performs a task right or wrong.

## APPENDIX F

### ITEMS OF THE CHILD BEHAVIOR QUESTIONNAIRE

1. Seems always in a big hurry to get from one place to another.
2. Gets angry when told s/he has to go to bed.
3. Is not very bothered by pain.
4. Likes going down high slides or other adventurous activities.
5. Notices the smoothness or roughness of objects s/he touches.
6. Gets so worked up before an exciting event that s/he has trouble sitting still.
7. Usually rushes into an activity without thinking about it.
8. Cries sadly when a favorite toy gets lost or broken.
9. Becomes quite uncomfortable when cold and/or wet.
10. Likes to play so wild and recklessly that s/he might get hurt.
11. Seems to be at ease with almost any person.
12. Tends to run rather than walk from room to room.
13. Notices it when parents are wearing new clothing.
14. Has temper tantrums when s/he doesn't get what s/he wants.
15. Gets very enthusiastic about the things s/he does.
16. When practicing an activity, has a hard time keeping her/his mind on it.
17. Is afraid of burglars or the "boogie man."
18. When outside, often sits quietly.
19. Enjoys funny stories but usually doesn't laugh at them.
20. Tends to become sad if the family's plans don't work out.
21. Will move from one task to another without completing any of them.
22. Moves about actively (runs, climbs, jumps) when playing in the house.
23. Is afraid of loud noises.
24. Seems to listen to even quiet sounds.
25. Has a hard time settling down after an exciting activity.
26. Enjoys taking warm baths.

27. Seems to feel depressed when unable to accomplish some task.
28. Often rushes into new situations.
29. Is quite upset by a little cut or bruise.
30. Gets quite frustrated when prevented from doing something s/he wants to do.
31. Becomes upset when loved relatives or friends are getting ready to leave following a visit.
32. Comments when a parent has changed his/her appearance.
33. Enjoys activities such as being chased, spun around by the arms, etc.
34. When angry about something, s/he tends to stay upset for ten minutes or longer.
35. Is not afraid of the dark.
36. Takes a long time in approaching new situations.
37. Is sometimes shy even around people s/he has known a long time.
38. Can wait before entering into new activities if s/he is asked to.
39. Enjoys "snuggling up" next to a parent or babysitter.
40. Gets angry when s/he can't find something s/he wants to play with.
41. Is afraid of fire.
42. Sometimes seems nervous when talking to adults s/he has just met.
43. Is slow and unhurried in deciding what to do next.
44. Changes from being upset to feeling much better within a few minutes.
45. Prepares for trips and outings by planning things s/he will need.
46. Becomes very excited while planning for trips.
47. Is quickly aware of some new item in the living room.
48. Hardly ever laughs out loud during play with other children.
49. Is not very upset at minor cuts or bruises.
50. Prefers quiet activities to active games.
51. Tends to say the first thing that comes to mind, without stopping to think about it.
52. Acts shy around new people.
53. Has trouble sitting still when s/he is told to (at movies, church, etc.).
54. Rarely cries when s/he hears a sad story.



55. Sometimes smiles or giggles playing by her/himself.
56. Rarely becomes upset when watching a sad event in a TV show.
57. Enjoys just being talked to.
58. Becomes very excited before an outing (e.g., picnic, party).
59. If upset, cheers up quickly when s/he thinks about something else.
60. Is comfortable asking other children to play.
61. Rarely gets upset when told s/he has to go to bed.
62. When drawing or coloring in a book, shows strong concentration.
63. Is afraid of the dark.
64. Is likely to cry when even a little bit hurt.
65. Enjoys looking at picture books.
66. Is easy to soothe when s/he is upset.
67. Is good at following instructions.
68. Is rarely frightened by "monsters" seen on TV or at movies.
69. Likes to go high and fast when pushed on a swing.
70. Sometimes turns away shyly from new acquaintances.
71. When building or putting something together, becomes very involved in what s/he is doing, and works for long periods.
72. Likes being sung to.
73. Approaches places s/he has been told are dangerous slowly and cautiously.
74. Rarely becomes discouraged when s/he has trouble making something work.
75. Is very difficult to soothe when s/he has become upset.
76. Likes the sound of words, such as nursery rhymes.
77. Smiles a lot at people s/he likes.
78. Dislikes rough and rowdy games.
79. Often laughs out loud in play with other children.
80. Rarely laughs aloud while watching TV or movie comedies.
81. Can easily stop an activity when s/he is told "no."
82. Is among the last children to try out a new activity.

83. Doesn't usually notice odors such as perfume, smoke, cooking, etc.
84. Is easily distracted when listening to a story.
85. Is full of energy, even in the evening.
86. Enjoys sitting on parent's lap.
87. Gets angry when called in from play before s/he is ready to quit.
88. Enjoys riding a tricycle or bicycle fast and recklessly.
89. Sometimes becomes absorbed in a picture book and looks at it for a long time.
90. Remains pretty calm about upcoming desserts like ice cream.
91. Hardly ever complains when ill with a cold.
92. Looks forward to family outings, but does not get too excited about them.
93. Likes to sit quietly and watch people do things.
94. Enjoys gentle rhythmic activities, such as rocking or swaying.

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