LEIGH, JANET, M. A. The Cost of Event-Based Prospective Memory in Children.
(2008)
Directed by Dr. Stuart Marcovtich. 47 pp.

Prospective memory is remembering to perform an action in the future when a cue is presented. However, processes involved in remembering the future intention (i.e., *preparatory attentional processes*) might hinder performance on activities leading up to and surrounding the event in which an intention must be carried out. The current study was designed to assess whether young children who engage in prospective memory do so at a cost to current cognitive processing. Four-, 5-, and 6-year old children either performed a simple ongoing selection task only (control condition) or performed the selection task with an embedded prospective memory task (experimental condition). Results demonstrated that children in the experimental condition slowed down in phase two due relative to children in the control condition. The results are discussed in terms of the development of executive functioning and more specifically, how working memory and speed of processing my play a role in the cost imposed to an ongoing task by a prospective memory task.

THE COST OF EVENT-BASED PROSPECTIVE MEMORY IN CHILDREN

by

Janet Leigh

A Thesis Submitted to
The Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
2008

Approved by

____

Committee Chair

APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair______________________________

Committee Members____________________________

____

____

____

Date of Acceptance by Committee

____

Date of Final Oral Examination

TABLE OF CONTENTS

Page

CHAPTER

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Executive functions are the processes involved in directing attention, and subsequently deciding what to do with the information gathered by those attentional processes (Bjorklund, 2000). For example, when driving a car, individuals must attend to oncoming traffic, road signs and traffic lights. Therefore, to attend to all relevant information and perform the appropriate actions at the correct time (e.g., stop pressing the accelerator to press the brake), individuals must use executive function processes to switch their attention. However, a task such as driving becomes more complex when individuals must divide their attention by focusing on a concurrent task, like driving and talking on a cell phone. Executive functions play an important role in individuals' ability to switch between tasks while holding information and goals in mind.

Executive function is often discussed in relation to models of working memory. Baddeley and Hitch (1974) proposed a working memory model, in which they maintained that attentional control and memory maintenance play an important role in complex cognition. According to Baddeley and Hitch, working memory allows one to hold a certain amount of information in mind at once, but to collect that information, one must first direct and maintain their attention towards the source. Norman and Shallice (1986; Shallice, 1988) suggested that a *supervisory attentional system* may be responsible for gathering, maintaining, and using information held in working memory, and is activated when individuals need to override a prepotent response. In the driving example, one may typically turn right on a certain road, but to reach the intended destination on this occasion, the individual must turn left instead. WM also aids in goal and representation maintenance, as well as allowing for one to hold in mind action plans to complete goals.

Working memory is thought to be a multi-dimensional construct (Engle & Kane, 2004). Engle and Kane contended that there are three main components of working memory: (a) long-term memory traces that are stored in short term representational formats that are active above threshold, (b) strategies to raise and maintain activation above threshold levels, and (c) executive attentional processes, which are responsible for individual differences in working memory capacity (WMC). The processes involved in executive attention allow for individuals to attend to information that is relevant to the goal under conditions of interference.

Engle and Kane (2004) suggested that WMC is a domain general ability and is predictive of performance on higher-order cognitive tasks. According to Engle and Kane, WMC is an enduring trait of an individual and the source of individual differences on tasks requiring executive attention and higher order functions. Engle and Kane suggested that WMC and higher-order cognition may be predictive of individuals' ability to allocate attentional resources strategically. In this view, those with high span working memory are more skilled at allocating attention between storage and processing components than those who have low span working memory. Low span individuals may not be able to adjust their attentional resource allocation strategies to compensate for the increase in processing load.

Attentional processes and working memory are important when individuals must combat interference from irrelevant distractors (Kane & Engle, 2003). Yet, daily activities often require that we allocate attention to multiple tasks at once, where distractors are irrelevant in regard to one goal but pertinent to another goal. Therefore, it is important to examine how performance on individual tasks is affected when the tasks must be performed concurrently.

Craik, Govoni, Naveh-Benjamin, and Anderson (1996) examined how divided attention impacted encoding and retrieval processes. Participants were given an auditory memory task with each word followed by an arithmetic task, used to eliminate recency effects. After the task, participants were asked to recall the list of words in any order. In addition, participants were given a continuous reaction-time (CRT) task. The CRT task consisted of a visual display on a computer screen and required participants to make a manual response on a keyboard. Four boxes were arranged horizontally on a screen, with an asterisk appearing randomly in one of the boxes. Participants were instructed to press a corresponding key as quickly as possible. The CRT task was performed during the encoding, recall, or both encoding and recall portion of the memory task. There was also a control group who performed the memory task only. Craik et al. found that reaction times on the CRT task were impaired when participants had to divide their attention during retrieval rather than during encoding. They concluded that though retrieval and encoding processes were both impacted when given the concurrent CRT task, retrieval processes are more impaired than encoding processes. In general, this finding demonstrates how the cognitive processing of concurrent tasks is detrimental to one or both tasks.

Divided attention is inherent in prospective memory tasks where participants are instructed to perform an action in the future (Smith, 2006). For example, individuals might have to remember to stop to get gas and thus, interrupt their attention toward driving to remember to get gas. There has been some debate in the prospective memory literature whether performance on the ongoing task is hindered when individuals are given a concurrent prospective memory task (i.e., there is a cost to the ongoing task). Perhaps participants do not need to maintain the intention in working memory allowing participants to allocate attentional resources only when the cue for the prospective memory task is presented. In this case, there should be no cost to the ongoing task. Alternatively, participants may need to maintain the intention in working memory and thus allocate resources to the intention held in working memory as well as to performance on the ongoing task. From this perspective, performance on the ongoing task will be impaired.

Event-based prospective memory is remembering to perform an action in the future (McDaniel & Einstein, 2000). A number of event-based prospective memory frameworks maintain that a representation of both the event and the action are made when forming an intention to perform the delayed intention task (Einstein & McDaniel, 1996; Guynn, McDaniel, & Einstein, 2000) and then the cue for the prospective memory action should elicit the prospective memory action to be performed. McDaniel and Einstein suggest that event-based prospective memory requires attentional processes when the cue is presented, not throughout the ongoing task.

Similarly, Gollwitzer (1999) proposed that individuals form self-instructions that pair the goal with the implementation intention. These are similar to if-then plans (e.g., if I see the store on the way home, I should remember to pick up milk). Henderson, Gollwitzer, and Oettingen (2007) describe implementation intentions as mental associations that are formed between specific situations and goal-directed responses for those situations. The mental association formed in implementation intentions makes goal-directed behavior a more automatic and efficient process. The automaticity of implementation intentions are attributed to the lack of conscious intent needed to maintain the goal over time. Instead, when a critical situation is presented, the intention for the goal-directed behavior is elicited. The ideas presented by Gollwitzer (1999) and McDaniel and Einstein (2000) are consistent in that when individuals form a representation or implementation intentions, the future intention does not require resources and should not affect ongoing task performance.

Webb and Sheeran (2004) have examined the effects of implementation intentions on cue detection. In Experiment 1, they had two implementation intention conditions and three control conditions. In the implementation intention conditions, participant were instructed to form the following plans – “when I see an F, I should add one to my count” or “when I see an F, I will count it on my fingers.” Participants were asked to repeat these instructions to themselves and fully commit themselves to the plan. The control groups were not told to form if-then self-instructions, but were told to either count the F’s to themselves, to count the F’s on their fingers, or to familiarize themselves with the trial sentence for 30 seconds (to ensure that performance was not due to practice or rehearsal effects). These conditions were in place to make sure that counting on one's fingers did not make one count more F's or that a period of rehearsal could not account for the increase in the number of F's counted. As predicted, more F's were counted in the implementation condition. In Experiment 2,Webb and Sheeran examined the extent to which an ongoing task was affected when one formed these implementation intentions. To test this hypothesis, they instructed participants to press the Z key when a single digit appeared on a computer screen and the M key when multiple digits appeared. After a practice phase, half the participants were told to form an implementation intention to press the Z key particularly fast when "3" appeared by itself on a computer screen. The remaining participants were told to stare at a "3" for 15 seconds but were not instructed to make an implementation intention. After these instructions, participants were administered the task. As expected, participants who formed an implementation intention were faster at responding to the "3" than any other of the stimuli. Contrary to Gollwitzer's (1999) claim that when an implementation intention is formed the process becomes automatic, Webb and Sheeran found that participants who formed these implementation intentions had slower responses on all other number stimuli compared to the control condition. Therefore, even when one forms an implementation intention, individuals must divide their attention between performing the ongoing task and monitoring the ongoing task for the cue, resulting in slow performance on the ongoing task.

Prospective Memory in Children

Understanding how prospective memory develops in children is important for many reasons. First of all, it provides a foundation for how these processes develop into adulthood. Under this model, judgement can be made about the nature of the processes involved in performing a prospective memory task. For instance, processes such as EF that adults use to perform a prospective memory task may be relatively undeveloped in children. By understanding the disparity between the capabilities of children and of adults, it can be better understood what processes are essential for optimal performance on a prospective memory task.

A number of studies on prospective memory in children have been conducted, examining various factors that may influence prospective memory performance. The factors include the setting of the experiment (e.g., experimental or naturalistic), the use of memory aids, and how the ongoing task affects performance on the prospective memory task.

Somerville, Wellman, and Cultice (1983) focused on children's prospective memory performance in a naturalistic setting. Mothers of 2-, 3-, and 4-year-old children were instructed to have their children remind them to do something of either high or low interest in the future. Researchers found that all age groups performed poorly (less than 40% recall) in the low interest group, while all children in the high interest condition performed equally well (80% recall), which implies that prospective memory is evident in highly motivated individuals as early as 2 years of age.

In a more controlled study, Guarjardo and Best (2000) examined prospective memory in 3- and 5-year-old children. Subjects were given a computerized prospective memory task, and participated in both the “no cue” and the “external cue” condition (e.g., when the target picture was a duck, children could choose a picture of a duck, a boat or a umbrella as a reminder). Children were shown 6 blocks of 10 pictures and were told that they will need to recall as many pictures as they could at the end of the task. The children were also instructed to press the space bar every time they saw the target picture (e.g., house or duck). As expected, Guarjardo and Best found that 5-year-olds were more successful on the prospective memory task than 3-year-olds, even when children were given an external memory aid. Importantly, when asked about the prospective memory instructions at the end of the task, 3-year olds had difficulty recalling the instructions. This finding suggests that successful completion of a prospective memory task consists of two different memory processes: prospective and retrospective memory. The prospective process involves forming an intention to perform a future action. However, to carry out the intention, one must retrospectively recall the cue and the action (Einstein & McDaniel, 1990, 1996).

In another study, Kliegel and Jager (2007) investigated prospective memory in preschoolers ranging from 2 to 6 years of age. In the ongoing task, children were shown ten cards of common objects and were asked to name each object. The ongoing task was conducted three times with a prospective target (i.e., an apple) occurring on the 8th trial in the first block, the 6th trial in the second block, and the 9th trial in the third block. Children were instructed to place the apple card in a box located behind them. In the memory aid condition, an actual apple was placed on the table as a reminder. In the no memory aid condition, children did not receive a reminder. Kliegel and Jager found that

4-, 5-, and 6-year-olds performed significantly better than 3-year-olds, who were significantly better than 2-year-olds. Although there was a main effect of memory aid, they did not find an interaction between age and memory aid conditions. Lastly, 2-year-old's did not display significant levels of prospective memory, even for participants who were successful on the retrospective memory task. Importantly, Kleigel and Jagar's prospective memory task required children to interrupt the ongoing task to perform the prospective memory task successfully.

Task interruption has been demonstrated to influence success on prospective memory performance in children. Kvavilashvili, Messer, and Ebdon (2001) instructed 4 -, 5-, and 7-year-old children to name the pictures on four decks of 20 cards and were told to hide the prospective memory target card in a special box. The prospective memory target in one condition was the 10th card in each deck while in the other condition the prospective memory card was the 20th card. Kvavilashvili et al. reasoned that task interruption was required for the target card in the 10th position, but not in the 20th position because it would be obvious to the child that there were no cards left. Results showed that children's prospective memory performance was indeed better when the prospective memory target was in the 20th position rather than the 10th position. Kvavilashvili et al. suggested that controlled attentional process are limited and must be allocated to card naming for the duration of the task. On the 10th trial, children are engaged in the card naming task and do not have resources to detect the prospective memory task. Yet, on the 20th trial, there are no more cards, freeing up resources and allowing children to remember to perform the prospective memory action. Therefore, to complete the prospective memory task successfully on the 10th trial, one must elicit the proper inhibitory control mechanisms. Inhibitory control is thought to be an executive function, in which one has to inhibit an established prepotent response to perform the ongoing task. On the 10th trial in this task, children would have to inhibit their tendency to continue the ongoing task to perform the prospective memory action. Kvavilashvili et al.'s results are consistent with the findings of Kerns (2000) who contended that inhibitory mechanisms must be present for one to interrupt the ongoing behavior or task to allow for other intended actions. Kvavlashvili et al. argued that a task requiring minimal attentional resources would maximize children's performance on a prospective memory task because resources could be allocated to ongoing task interruption.

Ongoing Task Performance Costs

Attempts have been made to identify the mechanisms involved in prospective memory performance and how these mechanisms develop with age. Most research has been focused on prospective memory performance (e.g., Kvavilashvili et al., 2001) rather than the cost to ongoing task performance. However, there is evidence in adult populations that ongoing task performance suffers when a secondary prospective memory task is incorporated (e.g., Anderson, Craik, and Naveh-Benjamin, 1998; Craik et al., 1996; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; Smith, 2003; Smith et al., 2007). Assessing ongoing task performance is important for many reasons. Though success on a prospective memory task may be a goal of the individual, successful performance on activities leading up to and surrounding the prospective memory task is also important. Secondly, assessing ongoing task performance when given a concurrent prospective memory goal serves as a measurement of the resources required to perform the prospective memory task by examining the resources that are no longer available for the ongoing task alone.

Park and colleagues (1997) argued that event-based prospective memory tasks may not be automatic as claimed by Einstein and McDaniel (1996) but effortful such that performance on an ongoing task is hindered. In this study, younger and older adults performed both a time-based prospective memory task (i.e., remembering to perform an action at or after a certain amount of time has passed) and an event-based prospective memory task. In Experiment 1, the ongoing task was a recall task. Participants were shown words against a patterned background and were told to monitor continuously so that they remember the last three words. Throughout the task, when participants saw the word “RECALL,” they were to say aloud the last three words they saw. The event-based prospective memory task was that the participant would press the “0” key when a specific pattern appeared as the background (e.g., different plaid backgrounds). In Experiment 2, participants were given the same ongoing working memory task, but were instead given a time-based prospective memory task to perform (e.g., to pull a lever every 1-2 minutes). The findings suggested that both event-based and time-based prospective memory required allocation of cognitive resources, which posed a cost to the ongoing task, although the cost seemed to be more pronounced for event-based prospective memory. The authors speculated that two different processes may be involved. Event-based prospective memory may require more continuous attention, while time-based prospective memory requires a central executive component to disengage from the ongoing task in a timely manner.

In a similar study, Smith (2003) also challenged the assumption that event-based prospective memory is an automatic process. Adult participants were given two blocks of a lexical decision task, where they were shown a string of letters and asked to press the Y key if the string was a word and the N key if the string was not a word. Participants in the experimental condition performed the second block with the additional requirement of an event-based prospective memory task. Specifically, these participants were given a list of six words to memorize and were instructed to press the space bar as soon as any of these words appeared. Participants in the control group were given the prospective memory instructions but were told that they would not need to follow those instructions for the current task. Smith found participants in the control condition had shorter response latencies when completing the lexical decision task in the second block, which was attributed to practice effects. Conversely, participants in the experimental condition had longer response latencies in the second block, suggesting that prospective memory requires an allocation of resources, which negatively affects performance on the ongoing task. Smith suggested that the allocation of resources when performing an event-based prospective memory task occurs because one is engaging in *preparatory attentional* processes.

The PAM (Preparatory Attentional and Memory processes) theory contends that these attentional processes are not automatic (Smith, 2003; Smith & Bayen, 2005; Smith, Hunt, McVay, & McConnell, 2007), but may be outside conscious awareness. In other words, an individual must maintain a state of readiness during the ongoing task and individuals must monitor the ongoing task for the cues related to the prospective memory task to retrieve the intention successfully and perform the action (Einstein & McDaniel, 2005; Smith, 2003). Because individuals must monitor - consciously or unconsciously - the ongoing task for the prospective memory cue, their performance on the ongoing task should suffer.

There is disagreement about the extent to which these preparatory attentional processes are involved. The multiprocess framework (McDaniel & Einstein, 2000) proposes that under certain circumstances, prospective memory should be automatic, posing no cost to the ongoing task. These conditions include when: (a) the action associated with the intention is simple, (b) the action and target are sufficiently encoded in relation to each other, (c) the ongoing task requires that one process the relevant dimension of the target, and (d) the target is salient. To test whether salience of the target event decreased the cost to the prospective memory to the ongoing task, Smith et al. (2007) employed the same design as the Smith (2003) study; however, targets were used that were perceptually or personally salient to individuals. Throughout four experiments, Smith et al. (2007) demonstrated that salient events, such as recognizing one’s own name, still slowed performance on the ongoing task compared to participants who were not given the prospective memory intentions. Smith et al. interpreted these findings as evidence against the multi-process framework, which suggests that under certain conditions, prospective memory intentions are automatic, rather than effortful.

Interestingly, Smith and Bayen (2005) found that WMC predicts the extent to which one is engaged in *preparatory attentional* processes. Smith and Bayen used a counting span task to measure WMC. After the counting span task, participants were given a sentence verification task with an embedded prospective memory task. In the sentence verification task, participants were instructed to respond by pressing the Y key on the keyboard when they thought the sentence was true, and to press the N key when false. The embedded prospective memory task required participants to press the F1 key when they saw any of four specific words. Smith and Bayen found that participants with higher span scores were more likely than those with low span scores to engage in preparatory attentional processes (i.e., exhibited greater cost to the ongoing task). Further, they found that retrospective memory performance that underlies prospective memory performance, measured by recalling the prospective memory targets at the end of the task, was not affected by span performance. However, in Experiment 2, Smith and Bayen found that when increasing the complexity of the sentence verification task by instructing participants to remember the last word in each sentence, accuracy differences emerged between high and low span participants. In particular, high spans tended to respond correctly to more sentences and recalled more ending words than did low spans. Smith and Bayen suggested that counting span measure actually taps into one's ability to divide their attention and the control of attentional processes. Therefore, the ability to engage in *preparatory attentional* processes successfully and complete a prospective memory task may be accounted for by individuals' ability to allocate their attention. Certainly, this finding is counterintuitive, as one would expect that those with greater

WMC would be less impaired because they have a greater number of cognitive resources. However, it seems that individuals who have greater WMCs have more resources to allocate to preparatory attentional processes.

Overall, these studies (i.e., Park et al., 1997; Smith, 2003; Smith & Bayen, 2005; Smith et al., 2007) provide compelling evidence for the claim that event-based prospective memory requires the allocation of attentional resources. However, this finding has only been demonstrated in adult populations. In children, the cost of the ongoing task imposed by a prospective memory task has not been explored. It could be that because children have less attentional resources than adults, children may not demonstrate costs in the way that adults do for a variety of reasons. For instance, young children may be relatively unaware of their cognitive processes compared to adults. Even though adults still demonstrate a cost to an ongoing task when given prospective memory instructions, they have more control over their attentional resources because they are able to allocate their attention strategically. Children lack sufficient control over their attention and may unconsciously allocate attention to prospective memory even when unnecessary. If so, children will demonstrate a greater cost to an ongoing task, which should decrease with age into adulthood. Smith (2003) and Smith et al. (2007) argued that the processes involved in successful prospective memory performance require attentional resources. Though individuals may not consciously be aware of that they are allocating attentional resources towards a target, they still experience a cost to other ongoing activities. The current study will examine the cost of prospective memory to the ongoing task performance in young children. If children do engage in *preparatory* *attentional* processes, their ongoing task performance should be impaired through slower response times or lower accuracy on the ongoing task. As children age, their cognitive capacity increases (Manis, Keating, & Morrison, 1980) and there is an improvement in the efficiency and automaticity in which children are able to allocate their available resources. If children do engage in these attentional processes, older children should have greater resources to divide between the two concurrent tasks (i.e., ongoing task and prospective memory task) and should be less impaired by *preparatory attentional* processes.

A secondary focus of the current study is to assess whether cognitive resources may "free up" after successful execution of the prospective memory task. After successful completion of a prospective memory task, children may become faster and more accurate on the ongoing task. This is consistent with the notion that children are holding a representation in mind until the task is completed, but would be counter to the expectation that latencies will be slower due to a heightened sensitivity to the prospective memory instructions (e.g., Einstein & McDaniel, 2004). Einstein and McDaniel found that when an interruption (i.e., a prospective memory task) to the ongoing task was introduced, there appeared to be task-switching costs resulting in a cost to accuracy, rather than response latency. Assessing this issue in children will aid in understanding the demands of a prospective memory task on children and how their resources are affected even after the successful completion of the task.

To test these hypotheses, 4-, 5- and 6-year-old children received a computerized selection task in phase 1. The selection task served as the ongoing task, requiring participants to press either animal or food pictures. In phase 2, participants received the computerized selection task again. Participants in the experimental condition received additional instructions for a prospective memory task that required participants to perform a unique action when a special picture appeared, whereas children in the control condition only performed the ongoing task. Also, to examine the “free up” hypothesis, children were told that they would only see the prospective memory target once.

To summarize, children in the experimental condition should demonstrate a cost to the ongoing task, with younger children experiencing a greater cost than older children. The secondary hypothesis was that after children in the experimental condition have completed the prospective memory task, they should no longer demonstrate a cost to the remaining trials on the ongoing task because they no longer have to allocate attentional resources to a secondary task. In addition, this study also allows for the examination of accuracy as a measure of ongoing task performance when given a prospective memory task which may be a more sensitive measure of younger children’s performance under divided attention conditions.

CHAPTER II

METHOD

Participants and Design

Ninety-seven 4-, 5-, and 6-year-old children were tested. There were 35 4-year-olds (*M* age = 4.5 years, *SD* = 0.3, 17 girls), 30 5-year-olds (*M* = 5.5, *SD* = 0.3, 16 girls), and 32 6-year-olds (*M* = 6.3, *SD* = 0.2, 16 girls). Eight children were excluded from the analyses (seven 4-year olds and one 6-year old). The sample was approximately 80% Caucasian, 17% African American, and 3% other/unknown. Half of the participants in each age group were randomly assigned to one of two conditions: prospective memory or control condition. The picture category and the location of the pictures were counterbalanced between children. Children either received instructions to press food or animal pictures in the ongoing task and half the children saw the two pictures arranged, as in figure 1a, while the remaining children saw the mirror image of the picture arrangement.

Materials

The task was conducted on a Dell Latitude D600 laptop computer with a Keytec touch screen, and programmed with SuperLab Pro. The stimuli consisted of computer images of animals (approximate size: 7 x 7.6 cm), food items (approximate size: 7 x 7.6

cm), and a smiley face (5.1 x 6.4 cm). There were 15 different food items and 15 different animal pictures (Figure 1a).

Procedure

Phase 1 Training. Children were trained on the selection task. The children were instructed to touch pictures from one category (food items or animals). Children were then asked what type of pictures they should touch and were reminded until the question was answered correctly. The three practice trials were programmed such that the correct pictures had to be selected by the child to complete the training.

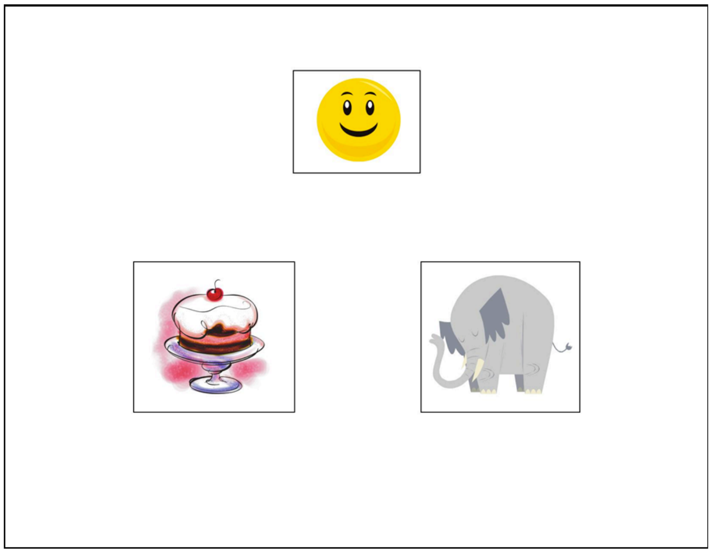
Phase 1 Testing. In phase 1, each child completed 15 trials that were in the same order across all children (see Figure 1a). Each trial consisted of a screen with an animal and food picture beside one another. Between the two pictures at the top of the screen was a smiley face picture (see Figure 1b).

Phase 2 Training. Children in the experimental condition were instructed that they will be playing the computer game again, but this time they were also told that when they see a special picture (i.e., duck for the animal category or apple for the food category) they should not touch the picture, but instead touch the smiley face at the top of the screen. The children were then shown a screen identical to the one that would be seen in phase 2 of testing with the duck and apple. The experimenter touched the smiley face to demonstrate the action the children should perform. Each child was told that it was very important that they remember to press the smiley when they saw the special picture because they would only see it once. They were then asked how many times they would see the special picture and reminded by the experimenter if the child was not able to

Figure 1a. Stimuli used for each trial.

Trial 1
Trial 2
Trial 3
Trial 4
Trial 5
Trial 6
Trial 7
Trial 8
Trial 9
Trial 10
Trial 11
Trial 12
Trial 13
Trial 14
Trial 15

Figure 1b. Example trial showing how pictures were displayed for each trial.



answer the question correctly. Children in the control condition were told only that they will continue to play the selection game and reminded of the instructions from phase 1.

Phase 2 Testing. All children received 15 trials in the same order as phase 1. Note that the apple and duck screen appeared on the 12th trial.

CHAPTER III

RESULTS

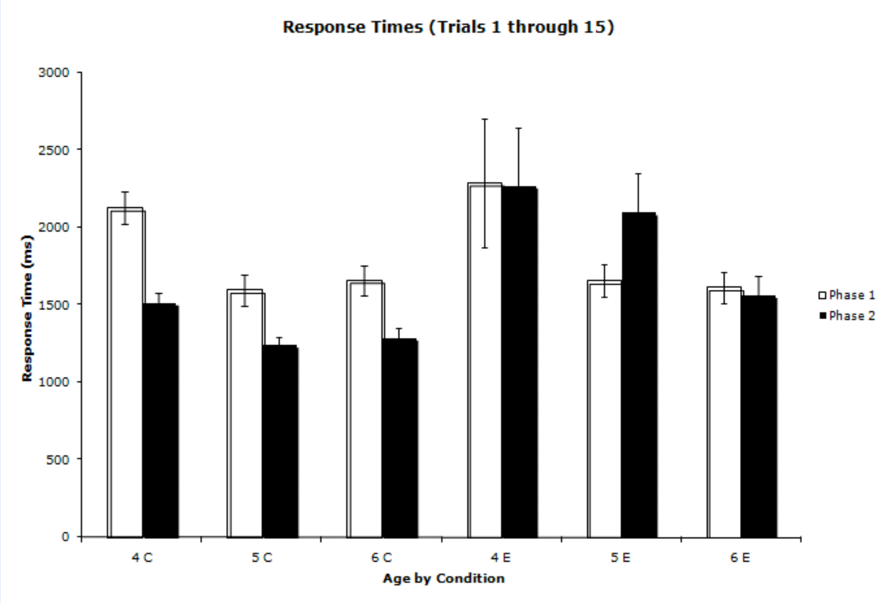
Preliminary analyses revealed no main effects of selection task (animal or food pictures), placement (left vs. right) of stimuli, or sex, nor interactions of these variables with any other variables. Thus, these variables will not be considered further.

Performance on the prospective memory task. Six (67%) 4-year-olds, 9 (69%) 5-year-olds, and 12 (92%) 6-year olds performed the prospective memory task. There were no significant differences in the extent to which children at different ages remembered to perform the prospective memory task when given the prospective memory instructions, χ^2 (2, N = 35) = 0.11, p = .78.

Accuracy on the ongoing task. A 2 (phase: phase 1, phase 2) x 2 (condition: control, prospective memory) x 3 (age: 3-, 4-, 5-year olds) mixed Analysis of Variance (ANOVA) was conducted on ongoing task accuracy performance, where phase was a within-subjects variable. In this and all subsequent analyses, the prospective memory trial was excluded because executing the prospective memory task would affect performance on the ongoing task (McDaniel & Einstein, 2009; Smith, 2003). Accuracy scores were calculated with the total number of correct trials for each phase divided by the total number of trials per phase (14 trials phase) to yield a proportion. There was no effect of phase, F (1, 80) = 1.992, p = .16, or condition, F (1, 80) = .032 , p =. 86. However, there was a trend towards an effect of age, F (2, 80) = 2.417, p = .10, such that 6-year-olds had better accuracy performance than 4- and 5-year-olds. To characterize some of the errors that were made, 8 children (seven 4-year olds and one 6-year old) pressed the smiley face for all trials in phase 2. These children were excluded from the current and all subsequent analyses. Also, 2 children (two 4-year-olds) responded randomly to the ongoing task in phase 2. Lastly, 7 children (one 4-year old, three 5-year-olds, and three 6-year-olds) made simple ongoing selection task mistakes such as selecting the incorrect picture or pressing the smiley face on the incorrect trial.

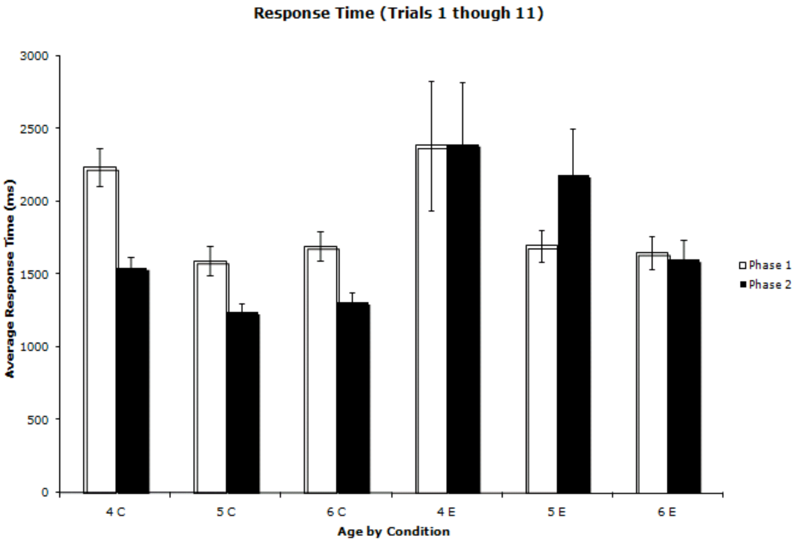
Response latencies on the ongoing task. Analyses were conducted using only response times on correct trials because other processes are thought to be involved in incorrect trials which might slow down response times (cf. Smith & Bayen, 2007). First, the average response times (trials 1-11 and 13-15) was submitted to a 2 x 2 x 3 (phase x condition x age) mixed ANOVA, where phase was a within-subjects variable (see Figure 2). Not surprisingly, there was a main effect of age, *F* (2, 80) = 6.957, *p* = .00. A Tukey's HSD analysis at the .05 level revealed 4-year-olds were significantly slower on ongoing task trials than 5- and 6-year-olds, but 5- and 6-year-olds did not differ from one another. There was also an effect of phase, *F* (1, 80) = 4.720, *p* = .03, and a main effect of condition, *F* (1, 80) = 9.590, *p* = .00. The main effects were qualified by the phase x condition interaction, *F* (1, 80) = 10.054, *p* = .00, suggesting that children in the control condition were significantly faster in phase 2.

Figure 2. Response times for each age group by phase and condition for trials 1 through 15; 4C = 4-year-old control condition; 5C = 5-year-old control condition; 6C = 6-year-old control condition; 4E = 4-year-old control experimental condition; 5E = 5-year-old experimental condition; 6E = 6-year-old experimental condition.



It was hypothesized that the trials after the target may have drastically different response times; therefore, the analyses were also conducted excluding the three trials following the prospective memory target to ensure that the cost in the prior analyses was not an artifact of these trials. A 2 x 2 x 3 (phase x condition x age) mixed ANOVA was conducted on response latency difference scores, where phase was a within-subjects variable. The analyses were conducted using the first 11 trials before the PM target trial (see Figure 3). In this analysis, there was an effect of age, *F* (2, 80) = 6.861, *p* = .00. A Tukey's HSD analysis at the .05 level revealed that 4-year-olds were significantly slower than 5- and 6-year-old children. Five- and 6-year-olds did not significantly differ from each other. There was also an effect of condition, *F* (1, 80) = 9.895, *p* = .00. Phase interacted with condition, *F* (1, 80) = 8.70, *p* = .00, indicating that reaction times for children in the prospective memory condition were longer in phase 2 than the reaction times for children in the control condition. As expected the children in the control condition demonstrated considerable practice effects, speeding up on the ongoing task performance in phase 2.

Figure 3. Response times for each age group by phase and condition for trials 1 through 11; 4C = 4-year-old control condition; 5C = 5-year-old control condition; 6C = 6-year-old control condition; 4E = 4-year-old control experimental condition; 5E = 5-year-old experimental condition; 6E = 6-year-old experimental condition.

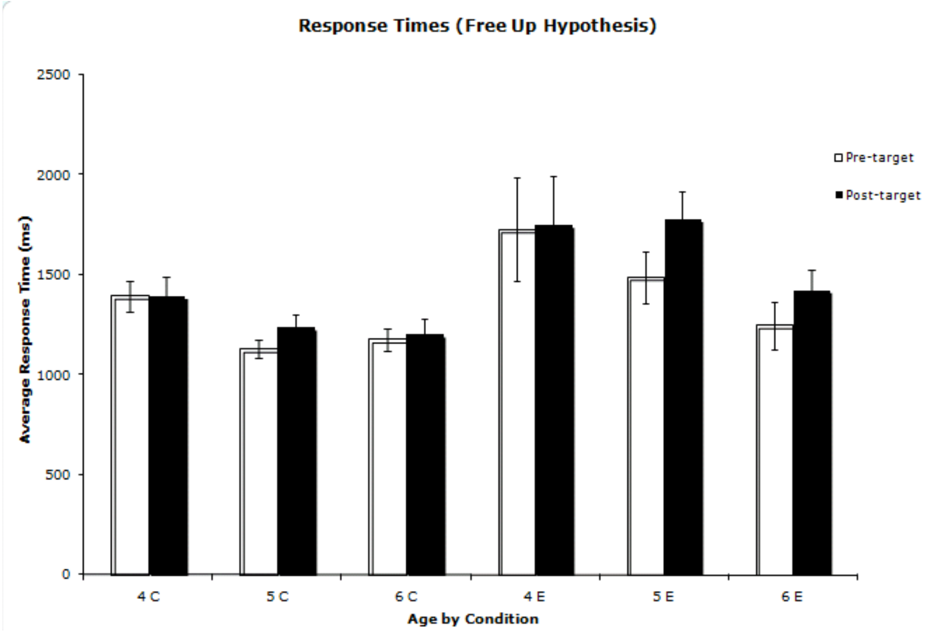


Response times differences between children who remembered and those who forgot to perform the prospective memory task. A 2 x 2 x 2 x 3 (phase x condition x age x remember) mixed ANOVA was conducted on the average response time from phase 1 and the average response time from phase 2. There was no significant main effect of children who remembered and those did not remember to perform the prospective memory instructions, *F* (1, 31) = 2.497, *p* = .12. In other words, children's response times did not differ between those who performed the prospective memory actions and those who neglected to perform the prospective memory instructions.

"Free-up" hypothesis. The analyses for the "free-up" hypothesis examined whether children's performance after the prospective memory target was significantly faster than their performance before the target trial. Included in this analysis were the 3 trials prior to the prospective memory target and the 3 remaining trials following the prospective memory target (see Figure 4). A 2 x 2 x 3 (pre-/post-PM trial x condition x age) mixed ANOVA was conducted, where pre-/post-PM trial was a within-subjects variable. There was an effect of condition, *F* (1, 78) = 12.105, *p* = .00, with response times being slower in the experimental condition and age, *F* (2, 78) = 3.922, *p* = .02. A Tukey's HSD analyses showed that 6-year old children were faster than 4-year olds, but 5- and 6-year olds did not significantly differ. Overall, children in all conditions were slower after the 12th trial (after the prospective memory trial for those in the experimental condition). Also, children in the experimental condition had significantly slower response times after the prospective memory trial. The pre-/post-PM trial by condition interaction was significant, *F* (1, 78) = 4.11, *p* = .05, suggesting that those in the prospective

memory condition were slower after the prospective memory trial than those in the control condition.

Figure 4. Free up hypothesis. Response times for each age group by pre-/post-target trial and condition for trials 9 through 11 and trials 13 through 15 in phase 2; 4C = 4-year-old control condition; 5C = 5-year-old control condition; 6C = 6-year-old control condition; 4E = 4-year-old control experimental condition; 5E = 5-year-old experimental condition; 6E = 6-year-old experimental condition.



CHAPTER IV

DISCUSSION

Prospective memory is needed while in the midst of other activities. The current study was designed to examine how performance on these other activities are affected when children are given a concurrent prospective memory task. Consistent with Smith's (2003) claim that prospective memory will impair ongoing task performance, it was hypothesized that children who were given a prospective memory task would show costs through accuracy as well as response times relative to children who were not given the prospective memory instructions. Results from the current study suggest that children do demonstrate a cost to ongoing task performance by slowed response times but not accuracy on the ongoing task. The current study supports Smith's (2003) claim that prospective memory impairs ongoing task performance. Furthermore, these results challenge Einstein and McDaniel's (1996) claim that a cost should only be demonstrated when a prospective memory cue (i.e., duck or apple) occurs and not throughout ongoing task performance. Though all children who had to perform the prospective memory task demonstrated a cost relative to children who did not have to hold prospective memory instructions in mind, 6-year-olds' pattern of performance was similar to the cost demonstrated by adults (Smith, 2003). Specifically, adults do not slow down in phase 2 performance, but generally do not benefit from practice effects, much like the 6-year-old children in the current study (Smith, 2003; Smith et al, 2007). This similarity exists by way of response time and accuracy, suggesting that by 6-years of age, children begin toengage in *preparatory attentional* processes in the same manner as adults. Conversely, 4-year-old children seem to be benefiting from practice effects. This may be because children are not monitoring for the prospective memory target; therefore, a cost is not imposed to the ongoing task. Five-year-olds seem to be the most impaired by the prospective memory instructions, such that their performance was slower in phase 2 of the prospective memory condition. These pattern of results suggest a developmental shift such that younger children do not monitor for the prospective memory target, instead they are rather reactive when they perform the action. By 5 years of age, children may begin to monitor but have such little experience in doing so, such that monitoring drastically slows performance compared to older children. However, when children reach 6 years of age, they are able to monitor for the ongoing cue without extreme detriments to their ongoing task performance.

If WMC is indicative of the amount of information individuals can attend to, then it may account for the extent to which children are impaired on the task. Specifically, as children become older, they should have greater resources and capacity to perform multiple processes such as monitoring and task switching. Smith and Bayen (2005) found that WMC is predictive of individuals' ability to engage in *preparatory attentional* processes. WMC is thought to play an important role in tasks requiring executive functions such as attention, task switching, and monitoring (Bjorklund, 2000). Each of these skills is critical when performing a prospective memory task as one must maintain attention on current tasks while monitoring for the prospective memory cue. Further, task switching is important to prospective memory, as individuals must switch their responding from the current task to perform a prospective memory task. Dempster (1991) reported that on a digit span task – a typical measure of working memory – children's span increase steadily during childhood. Therefore, as children become older, their WMC expands such that they are able to attend to and store a growing amount of information at once.

Speed of processing may also play a role in the current study. As children age, myelination of nerve cells in the brain may help quicken children's responding to and learning of unfamiliar information (Bjorklund, 2000). Kail (1991, 1997) has found that from 6 to 21 years of age, processing speed increases, which he attributed to a greater number of processing resources that are available as individuals age. Processing resources may be important in such tasks that require individuals to perform and divide their attention between concurrent tasks. In prospective memory tasks, a greater number of resources should allow individuals to attend to an ongoing task while monitoring for a prospective memory cue, doing so with less impairment as they age. Six-year-old children in the current study were less impaired than the younger age groups, which is consistent which a developmental view of processing speed. Older children seem to have more resources available to them, such that adding a prospective memory task impairs performance to a lesser extent than for younger children. Future research should examine this in children to see if a similar pattern exists. On the other hand, it may be that WMC is a less predictive measure for children, which may be implied by the current study.

Children could be considered low-span individuals compared to adults. If children are low-spans, then they should have demonstrated less cost with age, as WMC is thought to develop with age. This would suggest that children's WMC spans are decreasing with age, which is unlikely. To examine this question more closely, a measure of WMC capacity should be collected in conjunction with a prospective memory task.

It was also hypothesized that if children engage in *preparatory attentional* processes, reaction times should become less impaired after the prospective memory task has passed because they are no longer having to monitor for an upcoming cue related to the prospective memory action. This was not supported by the current study. Results showed that reaction time performance became even more impaired than before the target trial. One possible explanation for this finding is that after children are reflecting on their prospective memory performance after the trial has passed (cf. Marcovitch & Zelazo, in press). In other words, when the target trial appears, children are explicitly reminded of the rule, which elicits reflection. Even though the children have been told they will only see the target once and the trial has passed, children cannot help themselves from monitoring and engaging in *preparatory attentional* processes.

The Hierarchical Competing Systems Model (HCSM) provides a useful developmental framework for changes in executive function. The model is used to explain perseverative errors on executive function tasks through the increased likelihood of reflecting on a given response over the lifespan (Marcovitch & Zelazo, in press). Further, this model assumes that goal-directed behavior, for which executive function is involved, is under the control of two systems: a habit system and a representational system. The habit system is under the influence of previous experiences, while the representational system influences the development of reflection in early childhood. Moreover, the representational system is thought to aid in overriding habit-based responses through reflection. In regards to prospective memory and ongoing tasks costs, the cost observed in the current study might be understood from the HCSM framework. In phase 1, participants are given 15 trials for which they build up a habit for performing the ongoing task. However, when participants in the experimental condition in phase 2 are given the instructions to perform the prospective memory task, because they have built up a habit to performing the ongoing task, they may be forced to reflect upon their actions to perform the prospective memory task. This increased reflection may translate to increased reaction times (i.e., cost) on the ongoing task in phase 2 of the prospective memory condition. This model also assumes that the likelihood of reflection increases with age, such that younger children may be less likely to do so than older children. This prediction may also explain age related changes in cost observed in the current study. Four-year-olds seem to demonstrate little cost to the ongoing task when given the prospective memory instructions, whereas 5- and 6-year-olds did demonstrate a cost. Therefore, the cost observed in older children may be due to reflection.

Similarly, Zelazo (2004) proposed that age-related changes in executive function could be understood in terms of ‘levels of consciousness’ (LOC). Further, this model maintains that higher LOC’s are brought about through effortful, resource demanding processes. The Cognitive Complexity and Control (CCC) theory also is a framework that aims to explain developmental changes in executive function (Zelazo, Muller, Frye, &

Marcovitch, 2003). Changes in executive functions from this theory are thought to be a result of improvements in the rule-based structures, where children develop the ability to use more complex, higher-order rules requires that individuals reflect on conflicting rules. Zelazo suggests that to form a higher-order rule to integrate conflicting rules, individuals have to acquire a higher LOC, which he termed as reflective consciousness. Prospective memory may also require the use of rules and higher LOCs. More specifically, if children are to perform a prospective memory task that is embedded in an ongoing task, the prospective memory cues can be construed as a part of the ongoing task or as a cue for the prospective memory action. Therefore, the formation of the higher order rule (i.e. When I see animals, I should press the animal, but if I see a duck, I should press smiley) may require reflective consciousness. Further, because the acquisition and use of higher LOCs are thought to be resource-demanding, the result may be slowed performance on the ongoing task. In the current study, older children in the prospective memory condition had faster reaction times and were less impaired on the ongoing task. These findings are consistent with the LOC model as well as the CCC theory which suggests that, though the use of the processes are demanding, the demands lessen with age, as higher LOCs are more easily acquired.

In a practical sense, if children do experience impairments to their current tasks, then it may be important to minimize the cognitive load by providing memory aids or reminders. The aforementioned study by Kliegel and Jager (2007) found that children as young as 3-years of age performed better on the prospective memory task when given a memory aid. As of yet, there have been no studies that have examined how a memory aid or reminder may improve performance or decrease the cost on a concurrent task that may be imposed when given a prospective memory intention. It may be that the addition of a memory aid may decrease the demand on cognitive resources, therefore, alleviating the impairment to the current task.

Prospective memory is clearly linked to the concept of goal neglect. Duncan et al. (1996) described goal neglect as a “slip of the mind” phenomenon. Goal neglect certainly plays a role in prospective memory. Therefore, when individuals know to perform the prospective memory action but fail to do so at the appropriate time, individuals have engaged in a form of goal neglect (Maylor, 1998). Because of the similarity and the likelihood of goal neglect in prospective memory, it cannot be for certain that prospective memory and goal neglect are not one of the same. However, in regard to the current study, the results suggest that even though children neglect to perform the prospective memory task, they do not display less of a cost than those who did remember to do so. Therefore, neglecting and remembering to perform the prospective memory task may not have differential cost impacts in regard to the ongoing task.

Limitations and Future Directions

There were a number of limitations in the present research. First, children in the control condition did not receive instructions for the prospective memory task. Therefore, the differences examined between the control and prospective memory condition might have been due to the additional instructions about the prospective memory task, rather than the intention to perform the task. However, evidence with adult populations suggests the cost to the ongoing task is not due to participants receiving the instructions (Smith et al., 2007). The cost was only demonstrated when participants were given the instructions and told the carry out the prospective memory task. This still needs to be demonstrated with children to rule it out as a possible alternative interpretation.

In a similar vein, it is also important that one examines the nature of *preparatory attentional* processes in children. For example, it may be that children are more reactive rather than proactive in their monitoring (cf. Chatham, Frank, & Munakata, 2008). One reason that costs might exist in children is that they are retaining intentions in short-term storage but not necessarily proactively monitoring the ongoing task for the prospective memory cue. To address this question, one can draw upon the work of Smith et al. (2007) and utilize a similar design where there is a control condition (no instructions), a prospective memory instruction condition (instructions only, no intention), and a prospective memory condition (instructions and intention). If children are reactive, then children in the prospective memory instructions condition and the prospective memory condition should not differ. Chatham et al. might argue that though the prospective memory condition and the prospective memory instructions condition are displaying a cost on the ongoing task compared to the control condition, this cost might be due to remembering the instructions, not to monitoring for the prospective memory cue. A second possibility may be that children do proactively monitor. A pattern of results that might support this alternative hypothesis would be if children in the prospective memory condition demonstrated a greater cost to the ongoing task than children in the prospective memory instructions condition. Also, both of these conditions should be slower on the ongoing task than children in the control condition. Therefore, it may be that remembering the instructions does impose a cost to the ongoing task in the prospective memory instructions condition, but the intention and the resources needed to monitoring the ongoing task for the prospective memory cue imposes an even greater cost.

Another limitation of the current study may be that a salient cue, the smiley face, was presented on all trials. It is possible that may have slowed down children who were instructed to attend to it. A task that does not require the presence of this salient cue on each trial may be more appropriate (Smith, 2003; Smith et al., 2007). For instance, a task that requires children to press a button on the keyboard may be less salient and impose less of a cost to the ongoing task. It may be that because children have a smaller WMC in general, they displayed a cost because the stimulus (i.e., smiley face) was present on all trials, which required attention and may have placed a greater demand on their working memory. However, there was not a cost imposed on the control condition even though the smiley face was present. This may be because children in the control condition were not told why the smiley face was present, therefore, it was not a salient cue for those children.

In previous studies on prospective memory, the environmental context has proved to have significant effects on performance on a prospective memory task. A study by Ceci and Bronfrenbrenner (1983) found that children performed better on a time-based prospective memory task when in a familiar environment rather than a laboratory contrived setting. Similarly, Somerville et al. (1983) found that children as young as 2-

years of age could perform a prospective memory task in a familiar setting while highly motivated. The cost may only occur in artificial lab tasks, and not in real world situations.

Conclusions. The current study was aimed at determining whether prospective memory in children takes up cognitive resources and imposes a cost to activities surrounding a prospective memory task. Like adults, as children become older, they engage in *preparatory attentional* processes and display a cost to the ongoing task. These findings add to a growing body of research on prospective memory in children and the development of processes that may impose cognitive cost to activities surrounding prospective memory tasks.

REFERENCES

Anderson, N. D., Craik, F. I. M., & Naveh-Benjamin, M., (1998). The attentional demands of encoding and retrieval in younger and older adults: 1. Evidence from divided attention costs. *Psychology & Aging*, *13*, 405-423.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. A. Bower (Ed.), *The Psychology of Learning and Motivation.* Vol. 8. (pp. 47-89). New York: Academic Press.

Bjorklund, D. F. (2000). *Children's thinking: Developmental function and individual differences.* (3rd ed.). Belmont, CA: Wadsworth/Thompson Learning.

Ceci, S. J., & Bronfenbrenner, U. (1985). "Don't forget to take the cupcakes out of the oven": Prospective memory, strategic time-monitoring, and context. *Child Development, 56*, 152-164.

Chatham, C.H., Frank, M.J., & Munakata, Y. (2008). Reacting vs. planning: A developmental shift in the temporal dynamics of cognitive control. Manuscript submitted for publication.

Craik, F. I. M., Govoni, Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General, 125*, 159-180.

Dempster, F. N. (1991). Inhibitory processes: A neglected dimension of intelligence. *Intelligence, 15*, 157-173.

Duncan, J. (1995). Attention, Intelligence and the frontal lobes. In M. S. Gazzaniga (Ed.). *The cognitive neurosciences* (pp. 721-733). Cambridge, M. A.: The MIT Press.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. *In: Prospective memory: Theory and applications*. Brandimonte, M., Einstein, G. O., & McDaniel, M. A.; Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, 115-141.

McDaniel, M. A., Einstein, G. O., Graham, T. & Rall, E. (2004). Delaying Execution of Intentions: Overcoming the Costs of Interruptions. *Applied Cognitive Psychology, 18*, 533-547.

Einstein, G.O., & McDaniel, M.A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 717–726.

Engle, R. W., & Kane, M. J. (2004). Executive attention, working memory capacity, and a two-factor theory of cognitive control. *The Psychology of Learning and Motivation, 44*, 145-199.

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist, 54*, 493-503.

Guajardo, N. R., & Best, D. L. (2000). Do preschoolers remember what to do? Incentive and external cues in prospective memory. *Cognitive Development, 15*, 75-97.

Guynn M. J., McDaniel, M. A., & Einstein, G. O. (2001). Remembering to perform actions: A different type of memory? In H. D. Zimmer, R. L. Cohen, M. J. Guynn, J. Engelkamp, R. Kormi-Nouri, & M. A. Foley (Eds.), *Memory for action: A distinct form of episodic memory* (pp. 25-48). New York: Oxford University Press.

Henderson, M. D., Gollwitzer, P. M., & Oettingen, G. (2007). Implementation intentions and disengagement from a failing course of action. *Journal of Behavioral Decision Making, 20*, 81-102.

Kail, R. (1991). Developmental change in speed of processing during childhood and adolescence. *Psychological Bulletin, 109*, 490-501.

Kail, R. (1997). Phonological skill and articulation time independently contribute to the development of memory span. *Journal of Experimental Child Psychology, 67*, 57-68.

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*, 47-70.

Kerns, K. A. (2000). The cybercruiser: An investigation of development of prospective memory in children. *Journal of the International Neuropsychological Society, 6*, 62-70.

Kliegel, M., & Jager, T. (2007). The effects of age and cue-action reminders on event-based prospective memory performance in preschoolers. *Cognitive Development, 22,* 33-46.

Kvavilashvili, L., & Fisher, L. (2007). Is time-based prospective remembering mediated by self-initiated rehearsals? Role of incidental cues, ongoing activity, age, and motivation. *Journal of Experimental Psychology: General, 136*, 112-132.

Kvavilashvili, L., Messer, D. J., & Ebdon, P. (2001). Prospective memory in children: The effects of age and task interruption. *Developmental Psychology, 37*, 418-430.

Manis, F. R., Keating, D. P., & Morrison, F. J. (1980). Developmental differences in the allocation of processing capacity. *Journal of Experimental Child Psychology, 29*, 156-169.

Marcovitch, S., & Zelazo, P. D. (in press). A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science*.

Maylor, E. A. (1998). Changes in event-based prospective memory across adulthood. *Aging, Neuropsychology, and Cognition, 5*, 107-128.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14*, S127-S144.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.) *Consciousness and self-regulation: Advances in research and theory.* Vol. 4. (pp. 1-18). New York: Plenum Press.

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. P. (1997). Effect of age on event-based and time-based prospective memory. *Psychology and Aging, 12*, 314-327.

Shallice, T. (1988). *From neuropsychology to mental structure.* Cambridge, UK: Cambridge University Press.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 347-361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 756-777.

Smith, R. E., Hunt, R. R., McVay, J. C., & McConnell, M. D. (2007). The cost of event-based prospective memory: Salient target events. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*, 734-746.

Somerville, S. C., Wellman, H. M., & Cultice, J. C. (1983). Young children's deliberate reminding. *Journal of Genetic Psychology, 143*, 87-96.

Ward, H., Shum, D., McKinlay, L., Baker-Tweney, S., & Wallace, G. (2005). Development of prospective memory: Tasks based on the prefrontal-lobe model. *Child Neuropsychology, 11*, 527-549.

Webb, T. L., & Sheeran, P. (2004) Identifying good opportunities to act: Implementation intentions and cue discrimination. *European Journal of Social Psychology, 34*, 407–419.

Zelazo, P. D. (2004). The development of conscious control in childhood. *Trends in Cognitive Science, 8*, 12-17.

Zelazo, P. D., Muller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development, 68*, Serial No. 274.