Executive Function and Prospective Memory: The Effect of Inhibitory Control and Working Memory Load

by

Audrey Brown

A thesis submitted to the Faculty of Graduate and Postdoctoral Affairs in partial fulfillment of the requirements for the degree of

Master

In

Cognitive Science

Carleton University

Ottawa, Ontario

Abstract

This study examined the impact of a dual-task load on four- and five-year-olds' event-based prospective memory (PM), as well as the relation between PM and two executive function skills: working memory (WM) and inhibitory control (IC). Children completed an ongoing task (OT), which required pointing to pictures of animals in each image array. Embedded in this task was the PM task, which required children to ring a bell when they saw a picture of a cat. To manipulate the effect of dual-task load, children were assigned to one of three conditions: Control (OT and PM); WM-load (OT, PM, simultaneously with WM task); or IC-load (OT, PM, simultaneously with IC task). Five-year-olds outperformed four-year-olds on the PM task. There was no effect of condition on children's PM performance. Furthermore, WM and IC did not predict PM performance after controlling for age and language ability. Limitations and future directions are discussed.

Acknowledgements

I would like to begin by thanking my advisor, Dr. Deepthi Kamawar. It has been an absolute pleasure working with her this year. Her knowledge and passion for child development research has been invaluable. I am so grateful for all of her guidance, time and support throughout this year, from helping me design the study to her quick and constructive feedback on the many drafts of this thesis.

Secondly, I would like to thank Dr. John Logan, Dr. Steven Prus and Dr. Randall Gess for agreeing to be on my committee. I would also like to thank, Dr. Kasia Muldner, for helping me with my statistical analyses. Her knowledge of statistics and willingness to help and answer questions were greatly appreciated and were instrumental to this thesis.

In particular, I would like to thank my lab mate Sarah for her friendship and support throughout the year as well as Brooke and Haley for the role they played in the data collection and entry for my thesis. I would also like to thank the children who participated in my study as well as the schools and daycares who welcomed me. This research would not have been possible without you.

In conclusion, I would like to thank my family and friends who have supported me throughout my academic career, and for encouraging me to pursue my Master's degree. Thank you!

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Executive Function and Prospective Memory: The Effect of Inhibitory Control and Working Memory Load

Daily life is filled with demands on our ability to think about, and plan, for the future. The ability to remember to carry out specific intended actions in the future is often referred to as Prospective Memory (PM; Einstein & McDaniel, 1990; Guajardo & Best, 2000; Kvavilashvili, Messer, & Ebdon, 2001). PM is an important aspect of cognitive development (Einstein & McDaniel, 1990). As humans age, they shift from relying on others, such as parents, teachers or caregivers, to relying on themselves to remember future intentions (in the near and distant future). Failures in PM can result in a range of consequences from relatively benign, such as forgetting to wish your friend a happy birthday when you see them (a social norm violation), to more consequential, such as forgetting to meet a deadline at work or take prescribed medication at a particular time. It is clear this skill is essential for an individual's developing autonomy (Kvavilashvili et al., 2001). Recent research has begun to investigate the cognitive skills that may contribute to early-developing PM ability, and this is the focus of the current thesis.

It is important to distinguish PM from retrospective memory (RM), which is defined as the ability to remember externally prompted past information, such as people's names or information required for a history test (Kvavilashvili et al., 2001; Wang, Kliegel, Liu, & Yang, 2008). While PM involves the RM component of remembering *what* the intended action entails (e.g., what you wanted to tell your friend or buy from the store), the two are said to represent distinct forms of memory (e.g., Einstein, Holland, McDaniel, & Guynn, 1992; Wang et al., 2008). The main differences between these two forms of memory are time orientation (i.e., future versus past) and involvement (internally prompted versus externally prompted; Kahn, Sharma, & Dixit 2008). Furthermore, the two are dissociable within the context of PM. A person may recognize that they were supposed to do something when they encounter the target event, however, they may not be able to remember what specifically they were supposed to do, thereby indicating a failure of RM.

PM is a broad construct, and within it, researchers have distinguished between two main types: (1) event-based PM, which involves completing a specific action in response to a specific external cue or event (e.g., remembering to wish your friend a happy birthday when you see her); and (2) time-based PM, which involves remembering to perform an intended action after a specified period of time or at a particular point in time (e.g., remembering to pick your kids up from school at 3:00 pm or in 15 minutes; Einstein & McDaniel, 1990). While both types of PM warrant consideration, the development of event-based PM will be the focus of this thesis and PM will be used to refer to event-based PM, unless otherwise specified.

Previous research has demonstrated that the trajectory of PM follows an inverted U-shape pattern throughout the lifespan (e.g., Mattli, Schnitzspahn, Studerus-Germann, Brehmer, & Zöllig, 2014). PM develops during the early preschool period (e.g., Ford, Driscoll, Shum, & Macaulay, 2012; Guajardo & Best, 2000; Kliegel & Jäger, 2007; Mahy & Moses, 2011) and continues to improve across childhood (e.g., Kvavilashvili et al., 2001; Yang, Chan & Shum, 2011) and adolescence (e.g., Wang, Kliegel, Yang, & Liu, 2006). PM abilities remain relatively stable across young and middle adulthood (e.g., Kliegel, Mackinlay, & Jäger, 2008) before declining in older adults (e.g., Henry, MacLeod, Phillips, & Crawford, 2004).

The specific age at which PM abilities first emerge has yet to be clearly determined. Naturalistic studies have found evidence of PM abilities in children as young as two-years-old (e.g., Somerville, Wellman, & Cultice, 1983), whereas lab-based studies demonstrate that PM abilities begin at three-years of age (e.g., Guajardo & Best, 2000; Wang et al.,2008). Kliegel and Jäger (2007) argue that Somerville et al.'s (1983) results may be due to the lack of experimental control and a small number of participants. Nonetheless, it is clear that children begin to demonstrate PM ability during the preschool years.

Researchers have noted that PM is a complex skill, and that in order be successful, one must: (1) monitor for and recognize a target event; (2) recall and execute the intended action; and (3) complete the first two items while engaging in other ongoing activities (e.g., Kahn et al., 2008; Wang et al.,2008). For example, if one had the prospective memory to wish a friend a happy birthday at school, one would have to: (1) look for and recognize that particular friend when she walked by; (2) remember the intended action and say, 'Happy Birthday'; and (3) do all of this while also walking to classes, interacting with others, etc. Put this way, it is clear that there are a number of cognitive skills necessary to succeed in the implementation of a PM (Executive Function, discussed below). Not surprisingly, researchers have explored the contribution of such skills to people's PM ability (e.g., Bartlett, 2016; Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy, Moses, & Kliegel, 2014). More recently, researchers have begun investigating the role of Executive Function in the development of PM in young children. The current thesis contributes to this endeavour.

Prior to turning to research examining children's developing PM and the role of Executive Function, I begin with a brief summary of typical PM paradigms in the adult and developmental literature. I will then discuss factors that influence children's PM abilities, and lastly, I will give a brief review of theoretical models of PM that implicate cognitive processes in the successful execution of PM.

In the adult literature, which is where the majority of PM research has focused, a typical lab-based PM paradigm involves requiring participants to perform some ongoing task in which a PM task has been embedded. The PM involves interrupting performance of the ongoing task and performing an action that is different than, and typically unrelated to, the ongoing task demands. The ongoing task is intended to approximate people going about their daily lives within which a future intention is embedded. With adults, PM is often examined using a lexical decision making task as the ongoing task (e.g., Harrison, Mullet, Whiffen, Ousterhout & Einstein, 2014; Meiser & Schult, 2008; Smith, 2003). In such tasks, individuals are shown a series of strings of letters, presented one string at a time, on a computer screen. Individuals must press one key on the keyboard when they see strings of letters that form a word and a different key when they are presented with non-words. While they are completing this, there is also an embedded PM task. The PM task requires participants to press a third key when they see a particular word (as indicated in the task instructions). For example, they may be asked to push a third key when they see the word 'level'.

From such work, we know that typically developing adults perform above chance on PM tasks under normal conditions (e.g., Harrison et al., 2014; Meiser & Schult, 2008), indicating that adults are generally successful at remembering to complete actions in the future. However, by manipulating the cognitive demands of the task such as by making the ongoing task more difficult (e.g, Marsh, Hancock, & Hicks, 2002; Marsh, Hicks, & Cook, 2005; Meiser & Schult, 2008) or adding additional tasks (e.g., Harrison et al., 2014; Marsh & Hicks, 1998), adults' PM abilities are negatively impacted. This suggests that PM skills utilize limited cognitive resources that when taxed by other tasks reduce the resources available to allocate to the PM task (Meiser & Schult, 2008). This has implications for real-world settings: we are more likely to forget to do something when we are engaged in a highly demanding task or multiple tasks at once.

For a variety of reasons, the lexical decision making task is not an appropriate task for young children. Thus, in research with young children, the ongoing task typically involves something much simpler, such as children naming objects pictured on cards, or sorting cards into two categories (e.g., small and large items; Bartlett, 2016; Kvavilashvili et al., 2001; Mahy et al., 2014). The embedded PM task involves performing a different action when children see a particular card (e.g., an animal), such as refraining from naming the object (e.g., Wang et al.,, 2008), placing the card in a different box (e.g., Bartlett, 2016; Mahy & Moses, 2011), or ringing a bell (e.g., Mahy et al., 2014).

For example, Mahy et al. (2014) examined four- and five-year-olds' PM abilities by telling children that a family had just moved into their new house and needed help sorting items. The items were pictured on cards and had to be sorted by size: small and large. Children were instructed to place small items into one box and large items into another box. To approximate reality, large items took up more space on a card than did the small items. For the PM task, children were told that the family was looking for their pets and if they saw any cards ('target cards') with animals they should ring a bell located on a table behind them.

In the PM literature, there is relatively little work focusing on preschool-aged, or young, children. Studies with very young children have examined the development of PM in more real-world environments where the PM cue is present in the child's usual environment. In a naturalistic study by Somerville et al. (1983), children were verbally instructed to complete a series of tasks in the future such as remind their caretaker to purchase candy when they went to the store, where the PM cue was going to the store, or remind their caretaker to get the laundry, where the PM cue was when daddy got home. The length of time (short vs. long delay) and interest (buying candy vs. getting the laundry) were manipulated as well as the cue context (e.g., "going to the store", "after your nap" or "when daddy gets home"). They found that children as young as two years of age (n = 10) were capable of recalling tasks of high-interest (e.g., reminding caregiver to buy candy at the store) after a short delay, independently without prompts, 80% of the time. These results suggest that if an intended PM target event is particularly salient or of personal interest, young children are capable of succeeding.

In another naturalistic study by Slusarczyk and Niedzwienska (2013), two- to six-years-olds were instructed to complete a series of tasks during their normal kindergarten play, for example, to place their coloured pencils on the windowsill when they were finished drawing or to ask the experimenter for candy the next they saw her. Consistent with Somerville et al. (1983), Slusarczyk and Niedzwienska (2013) found that two-year-olds were capable of PM when the task was highly motivating. Furthermore, older children performed better than younger children.

In contrast, in a laboratory-based study, Kliegel and Jager (2007) failed to support the finding that two-year-olds are able to carry out an intended action in the future. Children were required to name pictures on a series of cards (e.g., chair) for the ongoing task. The PM task required children to place cards picturing apples in a box located either behind them or in front of them. Kliegel and Jager observed evidence of some PM abilities in three-year-olds, with age-related improvements between three and four years of age. There was no significant difference in performance for four-, five-, and six-year-olds. The lack of variability in performance across these age groups may be due to the PM task being relatively easy.

These findings support other laboratory-based (e.g., Guajardo & Best, 2000; Wang et al., 2008) and naturalistic studies (e.g., Guajardo & Best, 2000) which have found age related improvements in PM abilities across the preschool period (e.g., Guajardo & Best, 2000; Wang et al., 2008). Kliegel and Jager (2007) argue that Somerville et al.'s (1983) results may be due to the lack of experimental control and a small number of participants. In contrast, Kvavilashvili et al.(2001) found little difference between four- and five-year-olds' PM abilities and argue that major improvements occur after the preschool period (i.e., between five and seven years of age). Lastly, Leigh and Marcovitch (2014), found age-related improvements in PM performance between four- and six-years-old. However, there was only one PM trial and even the youngest children remembered the PM action 69% of the time.

In sum, although there is some discrepancy in the literature concerning the onset of PM abilities, which may be due to varying PM task demands across studies, most researchers agree that PM emerges sometime during the early preschool period and continues to improve into adolescence.

The basic child-based PM paradigm has been adapted in order to examine the effect of different factors, such as motivation or memory aides, on PM performance. For example, in a study by Kliegel and Jager (2007) two- to six-year-olds were required to name a series of cards (ongoing task) and remember to place cards picturing an apple (PM cue) in a box located in front of them (memory aid condition) or behind them (no memory aid condition). Children's PM performance, remembering to place the apple card in the box, was better in the memory aid condition compared to the no memory aid condition. This suggests that under certain circumstances, children are more successful at executing PM tasks.

These task manipulations, although not the focus of this thesis, are useful because they demonstrate conditions under which young children are more successful at PM which can then be applied to real-world situations to help facilitate children's successful PM. I will give a brief overview of the different manipulations that have been found to influence children's PM before turning to the literature examining the role of particular cognitive abilities in the development of PM in young children.

One manipulation of interest to researchers is how motivation influences children's PM abilities. Studies have found that if the PM task is particularly important to the child (e.g., getting a piece of candy or a sticker) then children are more successful at completing the PM action compared to when the task is of low importance (e.g., reminding their parent to get the laundry out of the wash; Causey & Bjorklund, 2014; Kliegel, Brandenberger, & Aberle, 2010; Slusarczyk & Niedzwienska, 2013; Somerville et al., 1983). For example, Causey and Bjorklund (2014) found that three-to four-and-a-half-year-olds were more successful at remembering to complete highly motivating PM tasks (i.e., get a sticker out of a bag) than low motivating PM tasks (i.e., change the sign on the door at the end of the session). Similarly, Kliegel et al. (2010) found a significant interaction between age and motivation such that there was no difference in PM performance for five-year-olds for the high-motivation and low- motivation conditions. However, three-year-olds performed significantly better on the PM task in the high-motivation condition (i.e., remind the experimenter to give them a gift) compared to the low-motivation condition (i.e., remind the experimenter to write their name on the task booklet). These results suggest that children are more successful at PM when the task to be completed is of interest to them (Causey & Bjorklund, 2014; Kliegel et al., 2010).

Kliegel et al. (2010) maintain that in younger children, the cognitive processes necessary for successful PM are still developing. Furthermore, younger children perform similarly to older children in the highly motivating condition, perhaps because being motivated results in them recruiting more cognitive resources for the task.

Bartlett (2016) also found a significant interaction between age and motivation, however it was not in the expected direction. While four-year-olds' PM performance did not significantly differ in the low-versus high-motivation conditions, three-year-olds performed significantly *worse* in the high-motivation condition compared to the low-motivation condition. Bartlett (2016) suggests that this may be due to the task instructions being more complex in the high-motivation condition. Furthermore, the PM task in the high-motivation condition may have been too exciting and instead distracted children from completing the task successfully.

In sum, researchers suggest that highly motivating tasks require fewer cognitive resources in order to successfully maintain the PM task in mind and monitor for the PM cue because the task is of high interest to the child and therefore the information may be more strongly encoded in mind (e.g., Bartlett, 2016; Guajardo & Best, 2000; Somerville et al., 1983).

A similar manipulation of interest is the effect of cue salience on children's PM performance. Mahy et al. (2014) examined whether cue salience would have an impact on four- and five-year-olds PM performance. Mahy et al. (2014) found that more salient cues (i.e., target cards with a red border) led to greater PM performance than non-salient cues (i.e., no border). The red border was meant to draw children's attention to the target card (PM cue) as distinct from the rest of the cards and increase their chances of detecting the PM cue. Mahy et al. (2014) argue that more salient cues are more noticeable in the environment and therefore require fewer cognitive resources in order to successfully detect the target PM cue and subsequently complete the PM action.

Another manipulation that has been found to bolster preschoolers' PM abilities involves supporting their ability to maintain a goal. Researchers have manipulated goal maintenance by varying the placement of the target cues within the ongoing task. A few studies have examined whether have the target cue in the middle or at the end of the ongoing task influences PM performance (e.g., Ford et al., 2012; Kvavilashvili et al., 2001; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008). These studies were interested in whether interrupting the ongoing task in order to perform the PM task influences children's PM performance. Results revealed that children were more successful at completing the PM task when the target cue was at the end of the ongoing task (i.e., no interruption) compared to when the target cue was in the middle of the ongoing task (i.e., interruption; Ford et al., 2012; Kvavilashvili et al., 2001; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008).

The researchers argue that the no interruption condition requires less inhibition because they do not need to disengage from the ongoing task in order to complete the PM task and therefore young children, with underdeveloped IC, are more successful at completing the PM task in this condition (Ford et al., 2012; Kvavilashvili et al., 2001; Slusarczyk & Niedzwienska, 2013; Wang et al., 2008). However, Bartlett (2016) argues that because children were aware that they were at the end of the task in these studies, then perhaps better performance in the no-interruption conditions was due to children realizing that they had not applied the PM rule yet. Bartlett aimed to clarify the relation between goal maintenance and PM. Bartlett examined the influence of early versus late exposure to target cues on preschoolers' PM performance. She found no significant effect of goal maintenance. Contrary to what was predicted, children did not perform better when they were exposed to the target cue early in the ongoing task compared to late. These results appear to support Bartlett's (2016) claim that the reason for the significant effect of goal maintenance in previous studies may be due to children realizing it was the end of the task. However, Bartlett (2016) argues that perhaps the cue placement in the late condition was simply not late enough to produce a difference.

These manipulations are important because of their real-world applications. If the factors that improve children's PM are known, it may be possible to facilitate successful PM such as by placing external reminders for children, or increasing the incentive to complete certain tasks, but not so much that it becomes a distractor. Taken together, these studies demonstrate that under certain circumstances, young preschoolers perform similarly to older preschoolers on PM tasks. I now turn to the literature examining the cognitive mechanisms that underlie the development and successful execution of PM abilities.

As mentioned above, of recent interest to researchers is the role of other cognitive abilities in the development and implementation of PM among young children. More specifically, researchers have examined the role that Executive Function (EF) plays in the development of individuals' PM ability. EF is a term used to refer to a variety of higher order psychological processes associated with the regulation of thoughts, behavior and emotion (e.g., Kerr & Zelazo, 2004). Researchers note that PM and EF demonstrate similar developmental trajectories, with significant improvements occurring between three- and five-years of age (e.g., Garon, Bryson, & Smith, 2008; Guajardo & Best, 2000; Kerr & Zelazo, 2004; Kliegel & Jäger, 2007; Kvavilashvili et al., 2001; Mahy & Moses, 2011). This has led some researchers, such as Ward, Shum, McKinlay, Baker-Tweney, and Wallace (2005), to argue for a prefrontal cortex (PFC) model in the development of PM which states that it is the maturity of prefrontal cortex, which is responsible for the development of EF abilities, that contributes to PM improvements. However, neurological research is outside of the scope of the present thesis. Instead, I will begin by reviewing the relevant EF skills, then summarize and critically analyze the literature on the relation between EF skills and the development of PM abilities. I will then discuss the manipulation of interest, the dual-task paradigm, and critically summarize the existing studies using this approach to examine the relation between EF and time-based PM.

Lastly, I will describe how the current study aims to address the gaps in the existing literature as well as outline the methods and hypotheses of the current study.

Executive Function and Prospective Memory

Research has suggested that Executive Function (EF) skills play a role in the development of PM abilities (e.g., Bartlett, 2016; Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014).   EF is a term used to refer to a variety of higher order psychological processes associated with the regulation of thoughts, behavior and emotion (Kerr & Zelazo, 2004). There is debate in the literature as to what processes involve EF, however, most researchers agree that EF includes, but is not limited to, working memory (Baddeley, 2003), cognitive flexibility (Jacques & Zelazo, 2001), and inhibitory control (Carlson & Moses, 2001, Garon et al., 2008; Hooper, Luciana, Conklin, & Yarger, 2004; Hughes, 1998; Zelazo, Qu, & Kesek, 2010; Zelazo & Cunningham, 2006).

Researchers claim that executive skills are necessary for successful PM due to the various task demands, in that it requires individuals to allocate cognitive resources to two separate tasks simultaneously (e.g., Einstein, Smith, McDaniel, & Shaw, 1998; Mahy et al., 2014; Smith, 2003). Recall that in a typical PM paradigm, successful PM requires allocating attentional resources to performing the ongoing task while also monitoring for the PM target cue in the environment, and then executing the PM intention. Not surprisingly, researchers argue that young children's failures in PM may be due in part to their underdeveloped EF skills (e.g., Garon et al., 2008; Kerr & Zelazo, 2004; see Mahy et al., 2014). Previous research has found that young children have difficultly dividing resources between two simultaneous EF tasks (e.g., Irwin-Chase & Burns, 2000) due to limited EF resources. Relatedly, Leigh and Marcovitch (2014) found that children were slower at executing an ongoing card selection task when there was an embedded PM task, than when performing the ongoing task alone.

The EF skills of interest for the current study are working memory and inhibitory control. So, I will begin by describing these two skills and then discuss why these skills are considered important for PM, before reviewing existing literature examining the relation between EF skills and PM abilities in young children.

Working memory (WM) is the ability to temporarily store information, while also manipulating it (Baddeley, 2003). During the preschool period, there are significant improvements in how much information children are able to hold in mind, with improvements to working memory ability continuing after the preschool period (e.g., Gathercole, 1998; Rasmussen & Bisanz, 2005). It is an essential skill for complex cognitive tasks such as reasoning, problem solving, and learning (Baddeley, 1992, 2003). Baddeley's (1986) model of WM argues for a central executive and two slave systems. The central executive is responsible for regulating the flow of information to and from the two slave systems, the phonological loop and the visual-spatial sketchpad. The phonological loop is responsible for the interpretation and storage of auditory information, namely phonological WM, while the visual–spatial sketchpad is responsible for the interpretation and storage of visual–spatial information, also known as visuo-spatial WM (Baddeley, 1986).

It is clear to see a role for WM, as a typical PM paradigm requires the storage of phonological information provided by the experimenter, in order to remember both the ongoing and PM task instructions. A commonly used measure of phonological WM in preschool children is the Visual Backward Word Span (Carlson, Moses, & Breton, 2002). For this task, children are shown a series of cards picturing familiar objects that the experimenter names aloud, such as “cat”, “grapes”, before placing the cards face-down on the table. Children are asked to repeat the series of words, but in backwards order (e.g., “grapes”, “cat”), with the sequences increasing in length, by one, after every two trials. Children receive one point per correctly repeated sequence (Vendetti, Kamawar, Astle, & Podjarny, 2015). Though the task involves visual images, it is a measure of phonological WM because the information to be stored and recalled is language-based in nature.

Another commonly used measure of phonological WM with preschoolers is the Auditory Backward Digit Span. For this task, the child is asked to repeat a list of digits presented verbally by the experimenter, but in backwards order where children receive one point per correctly repeated sequence (Garon et al., 2008). For example, if the child hears, “3, 7”, they have to say, “7, 3”. Both of these tasks require children to keep verbal information in mind (i.e., either the verbal label for the image or the verbal label of the digit), while also manipulating that information into a different order than it was initially presented.

It is worth mentioning that although the majority of the developmental literature uses Baddeley’s model as a framework when discussing WM, there are alternative models of WM. For example, Cowan’s Embedded Processes Model of Working Memory maintains that there is only one location for storing memory (e.g., long term memory), and that working memory represents a subset of this location consisting of information that is activated or the focus of attention or conscious awareness (Cowan, 1999). In this case, the ongoing and PM task demands would be constantly activated information that fades in and out of attentional focus. Similarly, the Object-Oriented Episodic Record (O-OER) model maintains that all information is temporarily stored as amodal, abstract representations in one location independent of the type of stimuli (e.g., visual/spatial or auditory; Jones, Macken, & Murray, 1993). Therefore, regardless of the type of information, either ongoing or PM task demands, according to the O-OER model, the information will be stored in the same location and activated when needed. While the theoretical claims for the models of WM differ, the current thesis is focusing on the relation between PM and WM, as PM requires the temporary storage of information. The current study was not designed to test or compare the claims of these models.

Another key component of EF that is of interest is inhibitory control (IC), which is the ability to suppress a dominant or prepotent response (Carlson & Moses, 2001). Such a skill is valuable in many aspects of problem solving, because solutions often require one to stop thinking about the problem (or some object) in the usual way, or require one to do things differently than they have been done before. In order to do that, one must *inhibit* the usual, prepotent response. Researchers have further divided IC into two different types: Delay IC and Conflict IC (Carlson & Moses, 2001). This division reflects the fact that the response required after inhibiting a prepotent response can be one of two things. Delay IC involves supressing a dominant response over a period of delay, until a time when it is appropriate to express the prepotent response, such as is required in the well-known Marshmallow task (Mischel & Ebbesen, 1970). In contrast, Conflict IC involves suppressing a dominant response while performing a response that runs contrary to it; for example, avoiding the desired junk food and instead choosing a healthy snack to eat. Conflict IC is of particular importance to PM because in order to effectively complete a PM action, an individual must inhibit the current response (performing the ongoing task action) and instead carry out the PM action, which typically conflicts in some way with the ongoing task response (e.g., ringing a bell instead of pointing to a picture).

One of the most common tasks used to measure Conflict IC in young children is the Day/Night Stroop-like task (Gerstadt, Hong, & Diamond, 1994). This task requires children to respond “day” to a picture of a moon with stars and “night” to a picture of the sun. Children less than five years of age display difficulty in performance on this task, however performance increases significantly with age (Gerstadt et al., 1994). After six years of age there is little difference in accuracy, with older children performing at ceiling (Gerstadt et al., 1994). Performance on this task is related to performance on measures of IQ (e.g., Brocki, Nyberg, Thorell, & Bohlin, 2007) and on measures of working memory (e.g., Brocki et al., 2007; Vendetti et al., 2015).

While there exists a number of Conflict IC tasks for use with young children, such as the Black/White task (Vendetti et al., 2015), children’s accuracy approaches ceiling on these measures by about five years of age (e.g., Gerstadt et al., 1994). Recently, a new measure of Conflict IC, the *Happy/Sad task,* was developed by Lagattuta, Sayfan, and Monsour (2011). For this task individuals were asked to respond “sad” to a happy face and “happy” to a sad face. The happy/sad faces were simple line drawings that differed on only one detail, the direction of the mouth. When compared to the Day/Night task, 4-to-11-year-olds and adults made more errors and took longer to respond on the Happy/Sad task. Thus, unlike other Conflict IC measures, this novel task effectively measures IC across different age groups without experiencing floor or ceiling effects. Therefore, this task is suitable for use with a wider age range than the other Conflict IC tasks and is the one employed in this thesis.

Interest in the relation between EF and PM stems from research with adults. Studies show that EF abilities are significantly correlated with, or significantly predict, PM performance across adulthood (e.g., Kidder, Park, Hertzog, & Morrell, 1997; Martin, Kliegel, & McDaniel, 2003; Ward et al., 2005). This relation has also been found in school-aged children (e.g., Spiess, Meier, & Roebers, 2015; Yang et al., 2011) and across adolescence (e.g., Shum, Cross, Ford, & Ownsworth, 2008). Adding to these studies, individuals with cognitive impairments display similar deficits in both PM and EF across different age groups. Furthermore, EF abilities positively correlate to PM performance in this population (Tam & Schmitter-Edgecombe, 2013; Ward, Shum, McKinlay, Baker, & Wallace, 2007; Yi et al., 2014). Taken together, these studies lend support for the role of EF abilities in PM development.

There are two theoretical models that implicate EF processes in PM, namely the Preparatory Attentional and Memory Processes (PAM) model and the Multiprocess model. Before turning to the research, I will review them here, but only very briefly as the current study was not designed to test or compare the claims of these theories. The PAM model maintains that controlled processes are engaged during the ongoing task before the presentation of the PM cue in order to monitor for and detect the PM cue (Smith, 2003; Smith & Bayen, 2004). In contrast, the Multiprocess model maintains that controlled process are engaged only under certain circumstances (McDaniel, Robinson-Riegler, & Einstein, 1998). Certain task demands engage these processes (e.g., task importance, difficulty of the task). While these models disagree about when cognitive processes are engaged, both models agree that effortful cognitive processes are involved in the successful execution of PM.

Recently there has been a focus on the development of PM across the preschool years. Due to the recency of this area of research, there have been relatively few studies that have examined the contributions of EF to PM development directly in preschool-aged children. In this literature, there has been a focus on the role of WM and IC in the development PM abilities. I will begin by summarizing the existing literature as well as describe how the present study aimed to add to the current literature.

Mahy and Moses (2011) examined the role of EF in relation to PM performance with children aged four-to six-years by manipulating the number of target cues (e.g., animal vs. animal and cars) and length of delay between task instructions and task onset (one vs. five minutes). Children were introduced to Morris the Mole who has poor daytime vision and needs help naming the pictures on cards. Children completed an ongoing card game in which they had to name familiar items pictured on four stacks of cards. For the PM task, they were told that Morris is afraid of animals, so whenever they saw a picture of an animal they should hide it in a box located behind them. Children in the two target condition were also told that Morris loves cars and whenever they saw a picture of a car they should place it in the box in front of them. As a measure of IC, children completed the Day/Night task (Gerstadt et al., 1994), which requires children to respond “day” to a picture of a moon and “night” to a picture of a sun, over a series of trials. As a measure of WM, they used the Backward Digit Span subscale taken from the

WISC-III (Wechsler, 1991). In this task, children are asked to repeat strings of digits of increasing length, but in backwards order.

Mahy and Moses (2011) found that WM performance predicted PM performance even when controlling for age, indicating that, independent of age, greater WM abilities contribute to better PM performance. However, there was no significant relation observed between IC performance and PM. These results suggest that WM abilities may play a greater role in successful PM than IC.

This study is not without limitations. First, given that age and language ability account for individual differences in PM and EF, these variables should have been controlled for during analysis. Secondly, only one task was used to measure each of IC and WM. Given that there is shared variance between these two constructs it would be useful to use multiple measures of each, and then perform a principal components analysis (PCA), for example, in order to account for the shared and extraneous variance and achieve a "purer" measure of the construct of interest. That factor could then be used in subsequent analyses. Furthermore, Vendetti et al. (2015) found that the task used as a measure of IC, the Day/Night task, is better related to other measures of WM, and not IC (due to memory-related task demands). Therefore, Vendetti et al. (2015) argue that the Day/Night task is not an accurate measure of IC and perhaps underestimates children's IC abilities. Lastly, children performed near ceiling on the Day/Night task, which may have limited the ability to detect a relation between IC and PM performance. Taken together, these factors may have contributed to the lack of the relation between IC and PM.

More recently, Ford et al. (2012) also examined the role of EF in children's PM performance. Children, aged four to six years, named a series of animals (ongoing task), but refrained from naming and instead hid any pictures of dogs (PM task). There were two dependent variables as measures of children's PM abilities: (1) children's ability to refrain from naming the target card ("withhold naming"); and (2) children's ability to remove the target card and hide it on a stool behind them. The PM task clearly requires children to disengage from the ongoing task requirements and perform a different, unrelated task. There were four stacks of cards, with the PM target card placed in the middle or end position to manipulate task interruption (i.e., to manipulate the effect of interrupting the ongoing task to complete the PM task).

Children also completed a measure of phonological WM (the Backward Word Span based on that devised by Carlson, Moses, & Breton, 2002) and a battery of Conflict IC measures including the Day/Night task (Gerstadt et al., 2014), the Hand Shape Game (children had to point their finger when the experimenter made a fist and vice versa; Luria, Pribram, & Homskaya, 1964), the Tapping Game (children tapped one when the experimenter tapped twice on a small drum and vice versa; Luria et al., 1964), the Whisper Test (children had to whisper the names of familiar characters pictured; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996) and, the Pig/Wolf Test (children were instructed to follow the instructions of one puppet, the pig, and ignore the instructions of the other puppet, the wolf; modeled on the Bear/Dragon Test described by Carlson & Moses, 2001). A composite IC score was created by standardizing and averaging scores across the IC measures. Children's verbal ability was assessed using the Receptive Vocabulary subtest of the Wechsler Preschool and Primary Scale of Intelligence – Australian, Third Edition (WPPSI-III Australian).

Children's overall PM performance was significantly and positively correlated with IC and WM. WM and IC was found to predict children's ability to "withhold naming" the PM target pictures. In contrast, children's ability to remove the target card was not related to IC or WM. This suggests that perhaps removing the target card was easier than withholding naming the target card and therefore required less EF resources. This may be due to the fact that naming the cards is a feature of the ongoing task, therefore it requires IC to inhibit the prepotent response to name the card.

Unlike Mahy and Moses (2011), Ford et al. (2012) included multiple measures of IC leading to a more robust measure of IC, which perhaps accounts for the different findings across the two studies. Furthermore, Ford et al. (2012) controlled for age and language ability in their analyses. Given that children's language, PM and EF abilities show age related improvements, not controlling for these factors may have masked potential relations. However, using a composite score does not remove variance that is accounted for by other skills. Furthermore, only one measure of WM was used. A more preferred method would to employ a battery of both WM and IC tasks then use a principal component analysis to extract the common variance across tasks measuring the same skill, which results in a more accurate measure of the skill of interest to use in subsequent analyses.

In a subsequent study, Mahy et al. (2014) examined the relation between WM, IC, and PM performance. Four- and five-year-old children completed an ongoing card sorting task where they sorted household items by size (easy) into boxes labeled small and large or into the opposite box (difficult). The PM task was to help a family find their pets and were asked to ring a bell when they saw animal cards. PM target cue salience was manipulated by the presence or absence of a red border around target cards (within participants). The red border was meant to draw children's attention to the target card as distinct from the rest of the cards and increase their chances of detecting the PM cue. Children completed the digit backward subscales from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; Wechsler, 1991) as a measure of WM, Simon Says as a measure of IC (children had to perform a series of actions but only if the experimenter said "Simon Says…." before the action; Carlson, 2005), and the Peabody Picture Vocabulary Test – Third Edition (PPVT-III, Dunn & Dunn, 1997) as a measure of verbal ability.

Results revealed that IC predicted a significant amount of variance in children's PM performance for non-salient cues after controlling for age and language ability. However, this relation was only marginally significant for salient cues. The researchers argue that highly salient cues are less cognitively demanding because they require less monitoring and attention due to being more noticeable and therefore require less inhibition of the ongoing task to shift to the PM intention to detect the target cue (Mahy et al., 2014). Furthermore, IC performance fully mediated the relation between age and PM performance. In contrast, WM did not significantly predict variance in children's PM performance for either cue type.

The lack of relation between WM and PM performance may have been due to low performance overall on the PM task, reducing the power to observe a relation between these skills. Furthermore, only one measure of WM was used, perhaps not fully representing children's WM abilities. Using multiple measures of WM would result in a clearer representation of the constructs of interest. Mahy et al. (2014) propose two potential explanations for the discrepancy in results with Mahy and Moses (2011). First, there was a lack of variance in children's Day/Night task performance in the previous study which may have obscured potential relations between IC and PM performance. Secondly, the current PM task may have more difficult than the one used by Mahy and Moses (2011) because the PM task, to identify animals, required a different level of analysis than the ongoing task, making size judgements. In sum, this study adds to the previous studies that have found a relation between EF skills and preschoolers' PM performance.

Causey and Bjorklund (2014) have also investigated the role of EF in the development of children's PM performance. The researchers aimed to replicate and extend the previous work in this area. The researchers also varied whether children carried out the PM intention themselves or reminded the researcher to do it (referred to as *agency*) and whether the PM was of high or low importance to child (*incentive*) to determine the influence of these differing task demands on children's PM performance. In a 2x2 within-participants design, preschoolers, ages 35–53 months were instructed for the agency-self condition to either retrieve a sticker out of a bag (high incentive) or change the sign on the door (low incentive) at the end of the session. For the agency-other condition, children were instructed to remind the experimenter to retrieve the sticker or change the sign. At the end of the session, children were given three cued opportunities to carry out the PM task.

EF was assessed using a battery of tasks measuring WM and IC. To measure WM, participants completed: (1) the Digit Span task (Wechsler, 1981); (2) the Forward Trail-Making task, children point to a series of animals in the same order as the experimenter (Salthouse et al., 2000); (3) the Backward Trail-Making task, same as the Forward Trial-Making task except children pointed to the animals in reverse order from the experimenter (Salthouse et al., 2000); and 4) a 1-Back task, children were asked to name shapes one at a time presented in a book one page at a time and to inform the experimenter if they saw the same shape repeated two pages in a row (adapted from Mäntylä, Carelli, & Forman, 2007). To measure IC, participants completed: (1) a modified Simon Says task, children followed the commands of one puppet but not the other (Strommen, 1973); (2) the Day/Night Stroop task (Gerstadt et al., 1994); and (3) the Dimensional Change Card Sort task (DCCS; Frye, Zelazo, & Palfai, 1995). EF scores were standardized and averaged across tasks to create a single composite EF score.

Agency was not found to affect PM performance, therefore the researchers collapsed across the agency variable for subsequent analyses. It was found that EF predicted PM performance on both the low-and high-incentive tasks. These findings suggest that, independent of the motivation manipulation, EF skills contribute to children's PM abilities indicating that children with higher EF (composite scores) were more successful at completing the PM task than children with lower EF.

The benefit of using multiple measures of EF and creating an EF composite score is that it provides a more robust measure of EF. However, by collapsing across the EF skills, it becomes impossible to parse apart which component of EF (e.g., WM or IC) is contributing to performance. Furthermore, Causey and Bjorklund (2014) failed to control for age and language ability in their analyses, which is important given that these two factors account for individual differences in PM performance (e.g., Ford et al., 2012; Mahy et al., 2014).

These studies suggest that EF skills play a role in the development of PM. However, given some of the methodological limitations of these studies (discussed above), Bartlett (2016) sought to further examine the relation between EF, WM and IC, and three- and four-year-olds' PM abilities. A secondary goal was to investigate the effect of goal maintenance and motivation on PM performance. Children were asked to name aloud a series of cards then sort those cards into two boxes, food items and non-food items. The PM task was to sort cards with bananas into a separate box located behind the child. Children in the low motivation condition simply had to place the banana card into the box. Children in the high motivation condition were given a coin to turn on a piggy bank from which a toy monkey emerged and grabbed the coin. To manipulate goal maintenance, some children received the initial PM target cards early in the ongoing task while others received the PM target cards later. PM performance was measured by totaling the number of times children successfully remember to put the cards picturing bananas into the separate box.

Children also completed a series of EF measures and a measure of language ability. Two were measures of IC, the Black/White Stroop (Vendetti et al., 2015) and the Standard Dimensional Change Card Sort (modified from Zelazo, 2006, as in Podjarny, 2015). Three were measures of WM, the Auditory Backward Digit Span (modified from Carlson et al., 2002), the Visual Backward Word Span (Carlson et al., 2002) and Self-Ordered Pointing (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). The scores from these measures were used to create a single composite EF factor through Exploratory Factor Analysis. Using a step-wise regression analysis, the EF factor was found to account for a significant amount of variance in PM performance, collapsed across conditions, even after controlling for age and language abilities. These results demonstrate that EF skills predict PM performance, above and beyond the contributions of age- or language-related improvements, indicating that children with higher EF abilities are more successful at PM. Further, EF was found to fully mediate the relation between age and PM performance meaning that age-related differences in EF explain the relation between age and PM. In other words, independent of age, children with higher EF abilities display greater PM performance.

These results are consistent with previous studies which have found a positive relation between children's PM performance and EF abilities (Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). Unlike in previous studies (Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014), where researchers only used one measure of WM or IC, Bartlett (2016) and Causey and Bjorklund (2014) used multiple measures of both WM and IC, which in turn make the findings more reliable. Furthermore, unlike Causey and Bjorklund (2014) and Mahy and Moses (2011), Bartlett (2016) found this relation after controlling for age and language abilities when examining EF and PM, which is important given the existing relation between these factors.

It is clear that research has found a relation between EF skills and the development of PM abilities across the preschool period (e.g., Bartlett, 2016; Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). However, many of the existing studies examining EF and PM are mainly correlational in nature. While these studies are valuable in demonstrating the cognitive mechanisms that underlie PM, they limit the conclusions that can be made concerning the relation between EF and

PM. Therefore, the first aim of the current study was to further examine the relation between EF skills, working memory and inhibitory control, and children's PM performance, using a novel, dual-task approach. The current study also aimed to further investigate the relation between EF and PM in children while addressing limitations outlined above by controlling for age and language ability in analyses as well as using multiple measures of IC and WM and performing two separate PCA to include in analyses. The age group of interest for the current was children ages 48-72 months old, as children during this age period undergo notable development both in PM and in EF. I now turn to the use of a dual-load design and what it can reveal.

Cognitive Load and Prospective Memory

The manipulation employed in the current thesis is the use of a secondary task, which is performed while *simultaneously* performing the ongoing and PM tasks, in order to examine the effect of a dual-load on an individual's PM performance. Using a secondary task experimentally manipulates the cognitive resources available to allocate to ongoing and PM task performance. By manipulating the nature of the cognitive resources being taxed, researchers can see how this affects PM performance and allows them to draw inferences about the cognitive mechanisms being employed for PM. This design has been used in both the adult and child PM literature. However, the existing studies examining the effect of a secondary task on children's PM performance focuses solely on time-based PM. Therefore, the second aim of current study was to add to the existing literature by examining the impact of a secondary task on children's event-based PM performance.

In the forthcoming section, I will briefly present what had been found in the adult literature in order to demonstrate the value of this approach. I will then discuss the two existing studies with children examining the impact of a secondary task on children's time-based PM and present how the current study aims to contribute to this area of research.

Harrison et al.(2014) investigated the effect of a dual-load on undergraduates' spontaneous retrieval of a PM intention. The ongoing task was a lexical decision making task which involved indicating whether strings of letters formed words or non-words by pressing one of two buttons. The PM task involved pressing a different key when a particular target word appeared (i.e., "level"). All participants completed the ongoing and PM tasks under no-load and dual-load conditions. In the no-load condition, participants completed the ongoing and PM tasks only. In the dual-load condition, while engaged in the ongoing and PM tasks, participants also completed a random number generation task, during which participants were asked to say random numbers between 0-9 when they heard a beat of a metronome. They measured the participants' ability to remember to press a different key when the target word appeared (i.e., PM performance).

The researchers found that adult's PM performance was significantly worse in the dual-load condition compared to the no-load condition. The authors argue that the secondary task interferes with individuals' ability to monitor for and detect the PM target cue and the spontaneous retrieval of the intended action (Harrison et al., 2014). This suggests that perhaps the random number generation task was particularly taxing on participants' WM abilities, impeding their abilities to hold in mind and update information related to the PM task, suggesting that successful PM requires WM abilities.

It is worth noting that this study replicated Marsh and Hicks (1998) original findings. Other studies with adults have found similar patterns of results, where adding a high cognitively demanding task impairs PM abilities (e.g., Einstein et al., 1998; McDaniel, Howard, & Butler, 2008; McDaniel & Scullin, 2010).

Taken together, these studies demonstrate that adding a secondary task impairs PM performance in adults. It is expected that PM performance is impaired because the secondary task is taxing limited cognitive resources (i.e., WM abilities) that are necessary to allocate for successful PM. While the adult literature warrants consideration, the goal of the current study was to use this dual-task approach to examine the contributions of EF to children's event-based PM. Two studies to date have investigated the effect of a secondary task on children's time-based PM abilities children. The secondary tasks used in these studies are aimed to tax a particular cognitive resource (WM or IC) to determine the effect on PM performance.

Mahy et al. (2015) investigated the role of IC in the development of children's time-based PM by manipulating IC resources available during time-based PM task performance. Children, aged five-, seven-, nine-, and eleven-year-old, performed an ongoing driving simulation task called Dresden Cruiser (developed by Kerns, 2000). During this computer-based task, children had to drive a vehicle in a two-dimensional road without hitting other cars (the ongoing task). Children were assigned to different levels of the ongoing task based on their baseline performance (number of crashes), in which they completed the ongoing task with no other demands. There were five difficulty levels of the Dresden Cruiser that children were assigned to that varied how many other cars were present on the road per minute (ranging from 25 to 65 cars per minute). Roughly, older children had to complete the task at a higher difficulty level than did younger children. The time-based PM task was to remember to re-fuel their car when the fuel tank was less than 1/4 full which occurred every 50 seconds. The fuel gauge was not visible, so children had to press a button to display the fuel gauge in order to see it. Thus, children had to remember to periodically check whether they needed to refuel. Given that there was no external cue for the PM task, children were required to internally monitor the passage of time in order to be successful. PM performance was measured by the number of correct refuels out of a total of four possible (in the time available).

Children completed the Dresden Cruiser task under two conditions, no- and dual-load. In the no-load condition, children completed only the Dresden Cruiser task. In the dual-load condition, children completed the Dresden Cruiser task along with a secondary task that affected the cognitive resources available for PM task performance. More specifically, while performing the PM task, children simultaneously completed a task that required Conflict IC. For this task, children were asked to verbally categorize common words into three categories (i.e., male, female, object). In order to create an inhibition demand, words belonging to the male category were spoken by a female voice, and words in the female category were spoken by a male voice. For example, children heard "brother" spoken in a woman's voice, where the correct response was 'male', or "queen" spoken in a man's voice, where the correct response was 'female'. To prevent children from ignoring the content of the words and just saying the opposite of the speaker's gender, some words were gender-neutral (e.g., "book"), and in those cases, the correct response was 'object'. Therefore, children had to inhibit attending to the gender of the voice in order to perform well.

All children performed two blocks of the Dresden Cruiser with the order of no-load (just the PM task) or dual-load (both the PM and secondary task) blocks counterbalanced across participants. It was found that children performed significantly better on the ongoing and PM tasks in the no-load condition compared to the dual-load condition, independent of age. In addition, consistent with previous research, children's ongoing and time-based PM task performance improved with age (e.g., Kern, 2000), with older children outperforming younger children. The authors interpreted this to mean that time-based PM improves with age and that children as young as five-years-olds are able to complete time-based PM tasks.

In sum, adding a secondary task that taxed children's IC skills impaired PM performance, suggesting that this skill is necessary for successful PM. However, further analyses revealed that the negative impact of the secondary task on PM performance can be accounted for by differences in ongoing task performance. Therefore, the secondary task led to decreased ongoing task performance but did not impact PM performance directly. However, this finding may be confounded by the fact that children were assigned to different levels of the ongoing task based on their baseline performance. Therefore it is difficult to determine if it was solely the secondary task that impaired ongoing task performance or if different levels of the ongoing task placing differential demands on the children.

In a related study, Voigt et al. (2014) examined the effect of a WM load on children's time-based PM performance using a dual-load design. Voigt et al. (2014) used the same ongoing and PM task as Mahy et al. (2015) with participants aged five- to fourteen- years-old. However, the secondary task in the dual-load condition was a WM task, specifically, a 1-back task. For this task (a relatively simple version of an n-back task), children heard a series of words and were to respond "yes" if a given word matched the previously heard word, during a predetermined response window. For the younger participants (five- and six-year-olds), the words had to be identical (e.g., *cat*, followed by *cat*). For the older children, the task was made more challenging by requiring them to say 'yes' if the words were from the same category (e.g., *cat* followed by *horse*, but not *cat* followed by *book*). The response window following the presentation of each word was longer for younger than older children (4 s vs 2 s). Children completed two blocks, low load (ongoing and PM task) and high load (ongoing, PM, and working memory task), with the order counterbalanced across them.

The researchers found that older children performed better than younger children on the WM task, ongoing task, and PM task. Ongoing and PM task performance was better in the low-load condition than the high-load condition for all age groups. This finding supports previous claims regarding the role of executive processes in PM task performance. Interestingly, there was an age by condition interaction such that older children performed significantly worse in the high-load condition compared to the low load condition, where younger children's performance did not significantly differ between conditions. This ran contrary to the prediction that WM load would have a greater negative impact on younger children's performance (Voigt et al., 2014). The authors argue that this may be due to the high control account, which maintains that there is a greater involvement of controlled processes in PM for older, compared to preschool-aged, children. According to this account, older children use a more cognitively demanding proactive, and arguably more effective, strategy for the PM task whereas younger children use less cognitively, or resource, demanding reactive strategies. Therefore, by adding a secondary task, older children's resources are taxed more than younger children. This is contrasted with the low control account, which assumes that younger children use more cognitively demanding processes for successful PM and older children rely on more automatic processes. However, this appears to be out of line with the results which found that older children's PM performance was more negatively impacted by the secondary task.

The results from this study may have been limited by the fact that the ongoing and secondary tasks differed across age groups making it difficult to determine whether the findings are a result of age-related differences in WM and PM ability or from the different tasks placing differential demands on each age group. Furthermore, younger children's PM performance in the low-load condition was low overall (M = 1.36, SD = 1.39) suggesting that the PM task was already cognitively demanding for young children, therefore adding a secondary task did not have an effect on performance.

In sum, adding a cognitive load using a dual task paradigm impairs children's time-based PM performance. Specifically, adding a secondary task that taxes IC or WM abilities negatively impairs children's performance on ongoing and time-based PM tasks. This adds to previous research which has found a relation between EF and the development of PM abilities, as well as to studies with adults that have found that adding a secondary task impairs event-based PM performance.

To my knowledge there are no current studies examining the effects of a secondary task on children's event- based PM performance. Research with adult participants suggests that adding a cognitive load using a secondary task negatively impacts both time-based and event-based PM (Khan et al., 2008). However, time-based PM performance was more adversely affected by the cognitive load than event-based PM, most likely due to the increased difficulty of time-based PM which requires internal time monitoring and self-initiation (Khan et al., 2008). In addition, to date, no study has examined the effect of secondary tasks taxing both WM and IC within the same study. The current study aims to address these issues.

Present Study

The main purpose of the present study was to examine the role of executive function, specifically WM and IC abilities, in young children's event-based prospective memory ability using a dual-task load.

For the current study, young children completed an event-based PM paradigm in one of three between-subject conditions. In the Control condition, children completed the PM paradigm only. In the WM-load condition, children completed the Auditory 1-back task simultaneously with the ongoing and PM task (modified from Voigt et al., 2014) and finally, in the IC-load condition, children completed the Verbal Labelling task simultaneously with the ongoing and PM task (modified from Mahy et al., 2015). Children also completed multiple measures of IC and WM, and a measure of general language ability.

For the PM paradigm, children were asked to point to the picture of an animal on each page for the ongoing task (each page contained one animal and one non-animal image; see Appendix N). The embedded PM task required children to ring a bell located behind them when they saw a picture of a cat. Additionally, children in the dual-load conditions had to complete an additional EF task while completing the PM and ongoing task, with the specific EF skill varying by dual-load condition. Children in the WM-load condition completed the Auditory 1-back task simultaneously with the ongoing and PM task (modified from Voigt et al., 2014). Children in the IC-load condition completed the Verbal Labelling task simultaneously with the ongoing and PM task (modified from Mahy et al., 2015). Children in the Control condition completed just the ongoing and PM task. These tasks were introduced stepwise to make learning each of them easier, given the young age of participants (details below).

A second aim of this study was to investigate the extent to which WM and IC predicts children's PM performance. Previous research has found a positive relation between children's PM abilities and EF skills (Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). However, due to mixed results and methodological issues it is difficult to make definitive conclusions. To address this, in the current study, children also completed three measures of IC, the Verbal Labelling task the Happy/Sad task, and Simon Says, and three measures of WM, the Auditory 1-back task, the Auditory Backward Digit Span and the Visual Backward Word Span. Given the shared variance between IC and WM, two PCA analyses (one for each construct) were conducted on multiple measures of IC and WM in order to provide a more robust representation of the constructs of interest. The PCA is used to express more than one measure as a single factor in order to achieve a more accurate representation of the construct of interest by extracting the core skill measured by multiple tasks and removing any variance due to extraneous skills. These factor scores were used in analyses investigating the extent to which WM and IC abilities predict children's PM performance. Furthermore, previous studies did not account for verbal and age related differences, which is problematic given the relation between these variables and PM ability, therefore the current study controlled for these variables when investigating the relation between WM, IC and PM performance.

Hypotheses

I hypothesized that:

1) Children in the Control condition would outperform children in the dual-load conditions on the ongoing task and the embedded PM task. I expected that ongoing and PM task performance in the dual-load conditions would not differ significantly from each other, as previous research has found a positive relation between both WM and IC and PM (Causey & Bjorklund, 2014; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). Furthermore, adding a secondary task taxing WM or IC both impaired children's time-based PM performance (Mahy et al., 2015; Voigt et al., 2014). Given this, there was no prediction of whether IC or WM contributes more to children's event-based PM.
2) There would be an interaction between age and condition, such that five-year-olds would outperform four-year-olds, but only in the dual-load conditions. This is based on previous research that has found little age related differences in four-and five-year-olds PM performance (Kliegel & Jager, 2007; Mahy & Moses, 2011) and older children having more cognitive resources available to allocate between two tasks (e.g., Garon et al.,2008).
3) WM and IC factor scores (derived from Principal Component Analyses) would predict PM task performance, even after controlling for age and language ability. Such a finding would be consistent with previous research which has reported a

positive relation between EF and PM after controlling for age and language ability (Bartlett, 2016; Causey & Bjorklund, 2014).

4) There would be a stronger correlation between WM and IC factor scores and PM performance in the dual-load conditions compared to the Control condition after controlling age and language ability. This was expected because individuals with higher WM and IC abilities should be better able to cope with the demands of the secondary task in the dual-load conditions. Furthermore, WM and IC would be more engaged during the dual-load conditions because the task is more cognitively taxing. This is in line with previous research that found that EF abilities were more strongly related to PM performance during a high cognitive demand task (Shum et al., 2008; Ward et al., 2005).
5) WM factor scores and IC factor scores would mediate the relation between age and PM performance. This was based on Bartlett (2016) who found that EF fully mediated the relation between age and PM performance.
6) Auditory 1-back and Verbal Labelling performance would be poorer during the ongoing and PM task relative to Baseline performance in the relevant dual-load conditions.

Method

Participants

Participants for this study included 71 children, ages 48-72 months old (*M* = 59.62, *SD* = 7.93), 38 female and 33 male. This age group was chosen for the current study because previous research has demonstrated significant improvements in PM (Mahy & Moses, 2011; Mahy et al., 2014) and EF (e.g., Carlson, 2005; Garon et al.,

2008) abilities over this period. Participants were recruited from schools and daycares in Ottawa and surrounding areas. One child was also recruited via flyers posted in the Ottawa area. Informed consent was obtained from both the daycare coordinator/school principal and the parents of the children who participated. Verbal assent was obtained from the children themselves. Children were tested individually while at the daycare/school in a separate, quiet area (as determined by the daycare coordinator/school principal). Children were able to discontinue testing at any time, and they were monitored for any signs of distress (if they appeared stressed or unhappy, they were gently returned to their classrooms). Children received stickers as a token of appreciation at the end of the session, regardless of whether or not they completed all measures (with their teacher's permission).

Procedure

Participants completed the tasks over two sessions, each session lasting approximately 20-30 minutes. In the first session, children completed the following tasks in a fixed order: the Happy/Sad task, and the PM paradigm. In the second session, children completed the following tasks in a fixed order: the Auditory Backward Digit Span, Simon Says, Verbal Labelling task/Auditory 1-back task (depending on condition), the Visual Backward Word Span and the Peabody Picture Vocabulary Test-III. A fixed order is required in order to effectively examine individual differences in IC and WM to ensure that all individuals are experiencing each measure in relatively the same context (Carlson & Moses, 2011)

Measures

Prospective Memory Paradigm. The PM paradigm included an ongoing task with an embedded PM task and for the dual-load conditions, a secondary task (see Appendix M for protocol). This task is based on a combination of the methodologies used by Mahy et al. (2015), Voigt et al. (2014) and Leigh and Marcovitch (2014).

Ongoing Task (OT). Modified from Leigh and Marcovitch (2014), children were shown a series of pictures, presented two at a time (side-by-side on a single page; see Appendix N). One of them was an animal (e.g., rabbit) and one of which was a non-animal (e.g., toy truck). Children were instructed to point to the picture of the animal on each page. The experimenter demonstrated one trial, then children received two practice trials with feedback before the test trials. The position of the animal picture was presented in a fixed random order on either the left or right side of the page. There were a total of 45 trials of this type, divided into three sets (set 1, set 2, and set 3) of 15 trials. When initially introducing children to the OT task, there were no prospective memory items. However, when children received the OT and PM tasks together (see Figure 1 below), six of the 45 trials required the prospective memory response.

Prospective Memory Task. The prospective memory task was embedded in the OT. More specifically, children were told that whenever they saw a picture of a cat, that instead of pointing to the picture (because it is an animal) they should ring the bell located behind them (see Appendix O). Within each of the three sets of 15 OT trials, 13 were non-target and 2 were target PM trials. The placement of the target trials differed by set (set 1, set 2, and set 3) and were trials 3 and 8, trials 6 and 11, and trials 9 and 14, respectively.

Secondary Tasks. Children were randomly assigned to one of three conditions, a working memory (WM) load condition (dual-task condition), an inhibitory control (IC) load condition (dual-task condition), or a Control condition (single-task condition). Children in the dual-load conditions completed an EF task simultaneously with the OT and PM task, while children in the Control condition did not have to complete an additional task. Children in the WM-load condition completed the Auditory 1-back task as their additional task, while children in the IC-load task completed the Verbal Labelling task. Prior to receiving the tasks in conjunction with the OT and PM tasks, participants received these tasks in isolation. This served two purposes: it provided children the opportunity to understand what the task required in the absence of other task demands, and it provided a measure of their performance on this task for use in planned analyses (e.g., as a measure to be used in subsequent principal component analyses, described as ‘baseline 1-back’ or ‘baseline verbal labelling’ in Figure 1). I describe these two tasks here, with the remaining EF measures appearing later.

*Auditory 1-back task (*Pelegrina et al., 2015; Schleepen & Jonkman, 2009; modified from Voigt et al., 2014; see Appendix L). Children in the WM-load condition received the Auditory 1-back task as their secondary task. The n-back task is designed to measure an individual’s WM. The *n* refers to how many items back the individual is required to hold in mind at a time. For the current study, the Auditory 1-back version was used, indicating that individuals must hold in mind one item back from the current item at a time.

In this task children heard a series of common colour words presented one at a time via earphones, each followed by a four second response window (consistent with

Voigt et al., 2014). Children were instructed to respond “yes” if the word matched the previously heard word (e.g., yellow, yellow), but to not respond if the words did not match (e.g., blue, green). Children received 10 practice trials (two target, eight non target trials) with feedback. They then received 40 test trials with no feedback, eight of which were target trials (20% target, 80% non-target), as in Voigt et al. (2014). Target items were three to five trials apart, and each of the four colours (i.e., yellow, red, blue, green) appeared twice as a target trial, but did not appear in a row.

Though it was planned for all children to receive the same number of trials when they received this task as a secondary task, it turned out that they varied in terms of how long they took to complete the PM task. Therefore, to ensure that children received the secondary task for the duration of the PM task, the number of the Auditory 1-back trials presented varied on a child-to-child basis. In other words, the longer a child took to complete the PM task, the more trials of the Auditory 1-back task they received. Therefore, the absolute number of correct trials would not accurately reflect children’s performance. Instead, the percentage correct score was calculated in order to compare performance across children. This score was derived by dividing the number of trials presented by the number of correct responses (per child) and was used as a measure of children’s WM.

Verbal Labelling task (modified from Mahy et al., 2015; see Appendix K). Children in the IC-load condition received the Verbal Labelling task as their secondary task. The Verbal Labelling task is designed to measure an individual’s ability to inhibit their prepotent response. More specifically, in this task, children are required to inhibit identifying the gender of the voice speaking a given word, and instead identify the gender associated with the word spoken.

In this task, children heard a series of familiar English words (e.g., king, sister, shoe), each belonging to one of three categories (i.e., boy, girl, or object), via earphones. Some were spoken by a male voice while others were spoken by a female voice. The experimenter presented pictures of each word, and labelled them to familiarize children with the sound of each word. Words were presented via earphones, each followed by a five second response window. Children were asked to verbally indicate the category of each word. In order to increase the inhibitory demands of the task, Mahy et al. (2015) designed it such that words belonging to the 'girl' category were spoken by a male voice while words belonging to the 'boy' category were spoken by a female voice. Therefore, children must ignore the gender of the voice in order to respond accurately. Object words, read sometimes by a female voice and other times by a male voice, which required the response "thing", were included in order to prevent children from adopting the strategy of responding with the opposite gender of the voice without processing the meaning of the words. The experimenter demonstrated two words from each category. Children received 12 practice trials with feedback (four words from each category) then 42 test trials with no feedback (14 words from each category).

Again, though it was planned for all children to receive the same number of trials when they received this task as a secondary task, they varied in terms of how long they took to complete the PM task. Therefore, to ensure that children received the secondary task for the duration of the PM task, the number of Verbal Labelling task trials varied by child. Once again, the number of trials presented was varied on a child to child basis.

Again, a percentage correct score was calculated in order to allow for comparisons across children. This score was calculated by dividing the number of trials presented by the number of correct responses (per child), and was used as a measure of children's IC.

Given the relatively young age of the participants, and the complexity of each task, children were introduced to the ongoing task and the dual task (for the WM- and IC-load conditions) individually, and then together, before they received them with the prospective memory task (see Figure 1). The initial administration of the IC or WM measure (labeled as the 'Baseline 1-back' or 'Baseline verbal labelling' in the figure below) was counted toward that child's EF battery.

Procedure.

Figure 1 shows a diagram of the order in which tasks were performed.

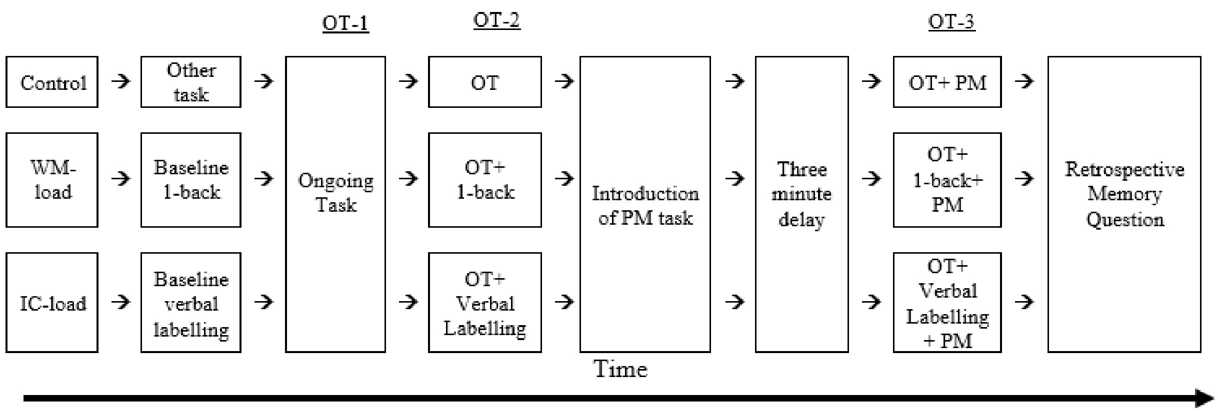

Figure 1. Schematic of the order of tasks in the PM paradigm by condition

Note: OT = ongoing task, PM = prospective memory

First, children were introduced to the secondary task, Verbal Labelling task for the IC-load condition and Auditory 1-back for the WM-load condition. Children in the Control condition received the Auditory Backward Digit Span at this point (but it did not appear in conjunction with any other measures).

Next, children were introduced to the ongoing task. The experimenter demonstrated one trial, then children received two practice trials with feedback before the test trials. Children then completed 15 trials (one set) of the ongoing task with no feedback (OT-1). Next, children performed the ongoing task and the secondary task (OT-2) simultaneously without the PM task (see Appendix M for the instructions children heard). As this task was originally designed, during this phase children were to complete 30 trials (two sets) of the ongoing task and 15 trials the Verbal Labelling task for the IC-load condition (five words from each category) or 18 trials of the Auditory 1-back for the WM-load condition (four target trials). However, as discussed above, the number of trials presented for the secondary task varied based on the length of time taken to complete the PM task. Children completed 10 to 30 trials of the Verbal Labelling task for the IC-load condition (three to ten words from each category) or 18 to 36 trials of the Auditory 1-back for the WM-load condition (four to eight target trials). Children in the Control condition completed the ongoing task only.

The embedded PM task was then introduced. Children were then instructed to draw for three minutes. This delay between PM task instructions and onset of the ongoing task is consistent with previous works (e.g., Mahy et al., 2014) and allows for some ‘forgetting’ to ensure that PM performance is due to spontaneous remembering. Children then completed 45 trials of the OT with the embedded PM task (OT-3). The OT was divided into three sets of 15 trials, each with 13 non-target and 2 target PM trials. The placement of the target trials differed by set (set 1, set 2, and set 3) and were trials 3 and 8, trials 6 and 11, and trials 9 and 14, respectively.

Children in the Control condition received just the ongoing task and PM task. However, children in the WM-load condition received the ongoing task, PM task and the Auditory 1-back task simultaneously. Children in the IC-load condition received the ongoing task, PM task and the Verbal Labelling task simultaneously. Children were originally supposed to receive 27 trials (5 target trials) of the Auditory 1-back task in the WM-load condition and 24 trials (8 words from each category) of the Verbal Labelling task in the IC-load condition. However, as discussed above, the number of trials presented for the secondary task varied based on the length of time taken to complete the PM task. Children completed 17 to 40 trials of the Verbal Labelling task for the IC-load condition (approximately 5 to 13 words from each category) or 27 to 40 trials of the Auditory 1-back for the WM-load condition (5 to 8 target trials). After children completed all test trials, retrospective memory for PM task instructions was confirmed. Specifically, children were asked, "What were you supposed to do when you saw a picture of a cat?" This was included to ensure that children remembered the PM task instructions and that failure to perform the PM action was not due to a lapse in children's RM. Children who failed to answer this question were excluded from analyses.

Ongoing task performance was measured by assessing children's accuracy in pointing to the animal on non-target trials. Children received one point for every trial they correctly point to the picture of the animal for a maximum score of 15 in OT-1, 30 in OT-2 and a maximum score of 39 in OT-3 (6 of 45 trials are PM target trials; see Figure 1). Consistent with Leigh and Marcovitch (2014), children's PM performance was measured by the number of times children correctly rang the bell behind them when they saw a picture of a cat. Children received one point for each correct target trial for a maximum score of 6.

Working Memory Tasks.

Children received three WM measures: the Auditory 1-back, the Auditory Backward Digit Span, and the Visual Backward Word Span. These tasks were used because they have shown variability in the age group of interest. These tasks measure an individual's ability to hold phonological information in mind and manipulate that information.

Auditory 1-Back (Pelegrina et al., 2015; Schleepen & Jonkman, 2009; modified from Voigt et al., 2014). See above. All children completed this task, however children in the WM-load condition received this task before the PM paradigm and their score served as their score on this measure. All other children received this task after the PM paradigm.

Auditory Backward Digit Span (Vendetti et al., 2015; see Appendix P). Children were introduced to a stuffed monkey named Willy. They were told that that whatever the experimenter says, Willy says backwards. The experimenter then demonstrated by saying "5-8", then making Willy say "8-5". Children were then be instructed to do the same as Willy and repeat the numbers the experimenter says, but in backwards order. Children received two practice trials with feedback, with each trial string consisting of two numbers. Children then completed up to 10 test trials with no feedback. Test trials were divided into sets consisting of two trials each. Trials within a set contained strings of numbers of the same length, starting at two numbers, however across sets, number strings increased by one, up to a maximum length of six numbers. Children progressed to the next set if they got at least one trial correct in the previous set. Testing stopped when children got both trials incorrect within a given set or when the child completed both trials with six numbers. Children received one point for each correct test trial for a maximum score of 10.

Visual Backward Word Span (Carlson et al., 2002; see Appendix Q). For this task, children were shown a series of cards picturing familiar objects (e.g., cat, grapes). The experimenter first demonstrated the task by naming the object on two cards one at a time before placing the cards face down on the table from left to right. The experimenter then named the cards in reverse order while pointing at the respective cards. Children then received two practice trials containing two cards each. Children then completed up to eight test trials with no feedback. Test trials were divided into sets consisting of two trials each. Trials within a set contained the same number of cards, starting at two cards, however across sets, the number of cards increased by one, up to a maximum length of five cards. Children progressed to the next set if they got at least one trial correct in the previous set. Testing stopped when children got both trials incorrect within a given set or when the child completed both trials with five cards. Children received one point for each correct test trial for a maximum score of eight.

Inhibitory Control Tasks.

Children received three measures of IC: the Verbal Labelling task, the Happy/Sad Task, and the Simon Says task. These tasks were used because they have shown variability in the age group of interest. These tasks, although they differ in terms of whether the information is presented orally or visually, measure children's ability to inhibit a dominant, prepotent response and perform a different, conflicting response instead.

Verbal Labelling task (Mahy et al., 2015). All children completed this task, however children in the IC-load condition received the task before the PM paradigm and their score served as their score on this measure. All other children received this task after the PM paradigm (see above for details).

Happy/Sad Task (Lagattuta et al., 2011; see Appendix R). Protocol was modeled on the Black/White Stroop used by Vendetti et al. (2015), but the stimuli were modeled on Lagattuta et al. (2011). For this task children were presented with a series of cards picturing either a happy or sad faces. Children were instructed to say “sad” when they saw a picture of a happy face, and “happy” when they saw a picture of a sad face. Children completed up to three practice trials with feedback, and then 21 test trials without feedback. Children’s responses were recorded (on paper) and children received an accuracy score out of 21.

Simon Says (modified from Carlson, 2005, as in Mahy et al., 2014; see Appendix S). For this task, children were told that they would be asked to perform a series of actions but that they should only perform the task if the experimenter says “Simon Says….” before the action. If the action was not preceded by “Simon Says…” children were instructed that they should not perform the action and just sit still. The experimenter then demonstrated the task by showing the children that if they heard “Simon says touch your knees”, that they should touch their knees but if they heard “touch your knees”, then they should just sit still. Children received up to three practice trials to perform the action (or lack of action) with feedback. Children then completed 10 test trials with no feedback. There were five trials of each type. The measure of interest was children's ability to inhibit movement on the five no action trials. Children received a score of 0 for performing the commanded movement, 1 for partial movement, 2 for an incorrect movement, and 3 for no movement for a score out 15.

Language Task.

Peabody Picture Vocabulary Test – Third Edition and Fourth Edition (PPVT-III, Dunn & Dunn, 1997; PPVT-4, Dunn & Dunn, 2007; see Appendices T and U). The PPVT-III and PPVT-4 are standardized measures of children's receptive language ability. Children's performance on these tasks was controlled for as all tasks require children to understand verbal instructions and respond verbally. For these tasks, children were presented with an array of pictures and were asked to point to the picture that best matches the word that the experimenter says. Children received six (PPVT-III) or two to four (PPVT-4) practice trials with feedback then tests trials arranged in sets of 12 of increasing difficulty. Children began at a set at which they got 11 or 12 pictures correct and ended when they got eight or more incorrect within a set. A raw score was computed for each child by subtracting the total number of errors from the total number of items completed, and this score was used in all analyses.

The first 21participants received the PPVT-III. However, due to the Ottawa-Carleton Research Ethics Board requirements the remaining participants received the PPVT-4 (n = 50). According to the PPVT-4 test manual, the two versions are highly similar in their assessment. More specifically, across age groups, a test of 322 individuals demonstrated a strong positive relation between the two editions, with correlations ranging from .81 to .91 (Average r = .84) (Dunn & Dunn, 2007). Because the PPVT was used as a control measure only, it is not expected that the change in editions had an impact on results.

Results

Participants

A total of 77 children participated in this study. Of them, five were excluded from analyses for refusing to complete Session 2 (2 in Control condition, 2 in WM-load condition and 1 in IC-load condition; 2 girls). One child did not understand the PM task instructions and therefore was excluded from analyses (Control condition; girl). Furthermore, only one six-year-old participated (72 months), therefore her data was excluded from analyses because it was not an accurate representation of the age group (IC-load condition). One child did not complete the Auditory Backward Digit Span because he would not speak (Control condition; boy), while another did not complete the Verbal Labelling task because he would not speak (WM-load condition; boy). These last two participants were excluded pairwise for each relevant analysis. A total of 68 participants completed all tasks (23 in Control condition, 23 in WM-load condition, 22 IC-load condition). All other analyses included the full sample of 70 participants[1].

Exploratory Data Analysis

All analyses were conducted using IBM SPSS Statistics for Windows, Version 24.0. First, analyses were conducted to determine whether there were differences in participants across Conditions for non-PM tasks. Performance on the Happy/Sad task and the Visual Backward Digit Span were significantly different across conditions (see Table V1 in Appendix V). Bonferroni post-hoc comparisons indicated that for the Happy/Sad task, individuals in the WM-load condition performed significantly worse than did participants in the Control condition, $t(46) = 2.58$, $p = .037$. In addition,

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[1] It should be noted that due the sample size, the power of the analyses will be low.

participants in the WM-load condition performed significantly worse than the IC-load condition for the Visual Backward Digit Span, $t(44) = 2.82$, $p = .019$. No other comparisons were significant. The remaining measures did not differ by condition. There were no age- or sex-related differences among participants across the three conditions (see Table V1 and V2 in Appendix V for descriptives by Condition). See Table 1 for descriptive statistics on these measures.

Table 1.

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

	Total Sample			4-year-olds			5-year-olds		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Prospective Memory	70	3.87	2.62	33	2.82	2.72	37	4.81	2.15
Ongoing Task (OT-3)	70	37.20	3.73	33	37.12	3.46	37	37.27	4.00
Working Memory									
Auditory 1-back	70	94.93	5.11	33	93.86	5.52	37	95.88	4.57
Visual Backward Word Span	70	1.87	1.24	33	1.55	0.94	37	2.16	1.40
Auditory Backward Digit Span	69	1.14	1.33	32	0.53	0.92	37	1.68	1.42
Inhibitory Control									
Verbal Labelling	69	80.85	16.87	32	75.37	20.50	37	85.59	11.22
Happy/Sad	70	12.43	5.92	33	10.82	5.85	37	13.86	5.68
Simon Says	70	8.21	5.78	33	5.30	5.35	37	10.81	4.90
PPVT	70	79.89	20.58	33	70.24	17.83	37	88.49	19.19

Note. Prospective Memory Total (0-6), Ongoing Task (0-39), Auditory 1-Back (0-100), Visual Backward Word Span (0-8), Auditory Backward Digit Span (0-10), Verbal Labelling (0-100) Happy/Sad (0-21), Simon Says (0-15), PPVT (20-160).

The effect of PPVT version on children's performance was examined and there was no significant difference in scores between PPVT-III ($M = 73.75$, $SD = 13.35$) and

PPVT-IV (*M* = 82.34, *SD* = 22.50). Therefore, PPVT version was collapsed across for all subsequent analyses.

The normality of the distributions of children's performance on the PM, WM, IC and vocabulary were assessed using skewness and kurtosis values (see Table V3 in Appendix V). Skewness and kurtosis values for all measures, except for the Verbal Labelling task, fell within the acceptable range of ±2 and therefore were considered normal (Tabachnick & Fidell, 2006). The Verbal Labelling task was negatively skewed, therefore scores were reversed coded before performing a square root transformation, then reversed back after the transformation (Field, 2009, p.155). The skewness and kurtosis values of the transformed variable fell within the normal range (see Table V3 in Appendix V). The transformed variable is used in subsequent analyses.

Effects of Age and Condition

The first hypothesis was that children in the Control condition would outperform children in the dual-load conditions on the ongoing task and the embedded PM task. The second hypothesis was that there would be an interaction between Age and Condition, such that five-year-olds would outperform four-year-olds on the PM task, but only in the dual-load conditions. These hypotheses were addressed together using two ANOVA analyses. Recall that performance on the Happy/Sad task and the Visual Backward Digit Span were significantly different across conditions. An ANCOVA was not performed with these variables as the covariates because when conditions differ on a covariate "entering the covariate into the analysis will not 'control for' those differences" (Field, 2009, p. 398). I will, however, address the between-group differences when discussing the overall pattern of results.

The first ANOVA was a 2 (Age Group: 4-year-olds vs. 5-year-olds) x 3 (Condition: control vs. WM-load vs. IC-load) analysis of variance (ANOVA) with PM performance (out of 6) as the dependent variable. The descriptive statistics for total PM performance based on age and condition are presented in Table 2. The second analysis was a 2 (Age Group: 4-year-olds vs. 5-year-olds) x 3 (Condition: control vs. WM-load vs. IC-load) analysis of variance (ANOVA) with children's ongoing task performance (OT-3; out of 39) as the dependent variable.

Table 2.

Prospective Memory Performance by Condition (out of 6)

	N	Mean	SD
Age (in years)			
4	33	2.82	2.72
5	37	4.81	2.15
Condition			
Control	24	4.17	2.60
WM-load	24	4.33	2.37
IC-load	22	3.05	2.80

Before turning to the results of both tests, the three assumptions of ANOVA were assessed. First, the normality of children's PM performance score was examined using skewness and kurtosis. The values fell within the accepted range of ±2 and therefore the data was considered normally distributed (Tabachnick & Fidell, 2006). The presence of outliers was also examined by creating z-scores for children's PM scores. These scores were compared to the accepted range of ±2.58 (Iglewicz & Hoaglin, 1993) and it was determined that no outliers were present.

Lastly, the assumption of homogeneity of variance was evaluated using Levene's test of Homogeneity of Variances. Levene's test was significant, $F(5, 64) = 7.20$, $p < .001$, therefore this assumption was violated and equal variances cannot be assumed. However, according to Jaccard (1998), the 2-way ANOVA is robust to this violation because the within-cell sample sizes are approximately equal.

Next, the assumptions for the second ANOVA were examined. The normality of children's ongoing task performance score was examined using skewness and kurtosis. The values were negatively skewed therefore scores were reversed scored and a square root transformation was performed. The transformed values fell within the accepted range of ±2 and therefore the data was considered normally distributed (Tabachnick & Fidell, 2006). The presence of outliers was also examined by creating z-scores for children's ongoing task scores. These scores were compared to the accepted range of ±2.58 (Iglewicz & Hoaglin, 1993) and three outliers emerged[2]. Lastly, the assumption of homogeneity of variance was evaluated using Levene's test of Homogeneity of Variances. Levene's test was not significant, $F(5, 64) = 1.47$, $p = .21$, therefore equal variances was assumed.

Based on the analyses, and in contrast to the first hypothesis, no significant difference in PM performance across the three conditions was found, $F(2,64) = 1.97$, $p = .148$, $\eta_p^2 = .058$ (see Table 1). Similarly, there was no significant difference in ongoing

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[2] A second exploratory ANOVA was conducted, removing the three outliers, yielded the same pattern of (non-significant) results.

task performance across the three conditions, $F(2,64) = 0.12$, $p = .89$, $\eta_p^2 = .004$ (see Table 3).

Interestingly there was there was a significant main effect of Age on PM performance, indicating that five-year-olds ($M = 4.81$, $SD = 2.15$) successfully remembered to ring the bell when they saw a picture of cat more often than did the four-year-olds ($M = 2.82$, $SD = 2.72$), $F(1,64) = 11.88$, $p = .001$, $\eta_p^2 = .157$. In contrast, four- and five-year-olds did not significantly differ in performance on the ongoing task, $F(1,64) = 0.19$, $p = .67$, $\eta_p^2 = .003$ (see Table 3).

Table 3.

Ongoing Task (transformed) Performance by Condition (out of 6.25)

	N	Mean	SD
Age (in years)			
4-years-old	33	5.44	1.12
5-years-old	37	5.56	1.14
Condition			
Control	24	5.58	0.79
WM-load	24	5.43	1.37
IC-load	22	5.49	1.19

Note. Ongoing task scores were transformed and are out of the square root of 39.

The second hypothesis predicted that there would be a significant interaction between Age Group and Condition for PM performance. This hypothesis was not supported, $F(2,64) = 0.09$, $p = .914$, $\eta_p^2 = .003$, as five-year-olds outperformed four-year-olds on the PM task regardless of condition. Lastly, there was no significant interaction between Age and Condition for ongoing task performance, $F(2,64) = 0.24$, $p = .79$, $\eta_p^2 = .007$.

Relation Between PM and Executive Functioning

First, the correlations between children's PM performance and measures of WM and IC were examined. Zero-order correlations between PM, age, WM, IC and language are displayed in Table 4. Children's PM performance was significantly correlated with age (in months), $r(70) = .33$, $p = .005$, Simon Says, $r(70) = .26$, $p = .028$, and marginally correlated with PPVT, $r(70) = .23$, $p = .058$ (all two-tailed).

Table 4.

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

Measure	1	2	3	4	5	6	7	8	9
1 PM	---	.33*	-.01	.10	.02	.20	.26*	.14	.23
2 Age (in months)		---	.33**	.47**	.24*	.41**	.53**	.20	.45**
3 AOB (WM)			---	.39**	.44**	.31**	.17	.35**	.19
4 ABDS (WM)				---	.39**	.48**	.57**	.41**	.34**
5 VBWS (WM)					---	.30*	.33**	.23	.17
6 VL_T (IC)						---	.49**	.37**	.48**
7 SS (IC)							---	.35**	.46**
8 HS (IC)								---	.21
9 PPVT									---

Note. PM = Prospective Memory (n = 70). AOB = Auditory 1-Back (n = 70). ABDS = Auditory Backward Digit Span (n = 69). VBWS = Visual Backward Word Span (n = 70). VL_T = Verbal Labelling (transformed; n = 69). SS = Simon Says (n = 69). HS = Happy/Sad (n=70). PPVT = Peabody Picture Vocabulary Test (n = 70). * p < .05. ** p < .01

To test the third hypothesis, which stated that that WM and IC would predict PM task performance, two Principal Component Analyses (PCA) were conducted (one for each cognitive skill). The first PCA included the three measures of WM: the Auditory 1-

back, the Visual Backward Word Span and the Auditory Backward Digit Span. The suitability of the PCA was examined. As can be seen in Table 4, all three measures were inter-correlated. The overall Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.66 which according to Kaiser (1974) is 'mediocre' to 'middling'. Bartlett's Test of Sphericity was statistically significant, $\chi^2(3) = 30.23$, $p < .001$, indicating that the data was suitable for reduction. The PCA revealed one factor that had an eigenvalue greater than one. The WM factor score explained 60.59% of the total variance of the three measures of WM. The component loadings are displayed in Table W1 in Appendix W.

The second PCA included the three measures of IC: the Verbal Labelling task (transformed), Simon Says and the Happy/Sad task. The suitability of the PCA was examined. As can be seen in Table 4, all three measures were inter-correlated. The overall Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.65 which according to Kaiser (1974) is 'mediocre' to 'middling'. Bartlett's Test of Sphericity was statistically significant, $\chi^2(3) = 30.77$, $p < .001$, indicating that the data was suitable for reduction. The PCA revealed one factor that had an eigenvalue greater than one. The IC factor score explained 60.29% of the total variance of the three measures of IC. The component loadings are displayed in Table W2 in Appendix W.

Next, a four-stage hierarchical multiple regression was conducted with total PM performance (out of 6) as the dependent variable. Age (in months) was entered in the first step, PPVT score entered in the second step, WM factor in the third step and IC factor in the fourth step. The scores were collapsed across condition given that there were no between-condition differences on the PM task.

Before continuing, the assumptions of the linear regression were examined. The Durbin-Watson statistic indicated that the residuals were independent (d = 1.72). Furthermore, examination of the standardized residuals indicated that there were no outliers (Iglewicz & Hoaglin, 1993). Inspection of the correlations between predictor variables as well as the variance inflation factor (VIF) and tolerance statistics indicated no perfect multicollinearity. Lastly, the assumption of homoscedasticity was examined using plots of standardized residuals versus standardized predicted values. Visual inspection of the plots demonstrated heteroscedasticity.

The regression statistics are presented in Table 5.

Table 5.

Regression Analyses for PM Performance (Collapsed Across Conditions)[3]

		B	SE	β
Step 1	Age	0.102	0.047	0.313*
Step 2	PPVT	-0.001	0.018	-0.006
Step 3	Working Memory	-0.557	0.378	-0.217
Step 4	Inhibitory Control	0.568	0.411	0.220

* $p < .05$.

Age, language, WM and IC accounted for 14.3% of the variance in PM ($R^2_{adjusted}$ = .088), $F(4,63) = 2.62$, $p = .043$. Contrary to hypothesis three, which stated that WM and IC factor scores (derived from Principal Component Analyses) would predict PM task performance, even after controlling for age and language ability, they did not independently predict PM performance. Furthermore, the overall model was carried by age which accounted for 10.3% of the variance in PM.

[3] A second regression examined the results when Inhibitory Control was entered in the third step and Working Memory was entered in the fourth step. Inhibitory Control still did not account for a significant amount of variance in PM performance.

An exploratory regression analysis was conducted to examine whether WM and IC would predict PM task performance without controlling for age and language ability. WM and IC factor scores were entered as the predictor variables with total PM performance (out of 6) as the dependent variable. WM and IC accounted for 7.3% of the variance in PM ($R^2_{adjusted}$ = .044), F(2, 65) = 2.55, p = .086. IC, but not WM, independently predicted children's PM performance, t(67) = 2.22, p = .03, and accounted for 6% of the variance in PM.

To examine the fourth hypothesis, which was that there would be a stronger correlation between WM and IC factor scores and PM performance in the dual-load conditions compared to the Control condition after controlling for age and language ability, a series of partial correlations were conducted (see Tables 6-8).

Table 6.

Partial Correlations Between Measures of PM, Working Memory Factor Score, and Inhibitory Control Factor Score, Controlling for Age and PPVT (Control Condition)

Measure	1	2	3
PM	---	.01	.04
IC		---	.59**
WM			---

Note. PM = Prospective Memory (n = 24). IC= Inhibitory Control Factor Score (n = 24). WM= Working Memory Factor Score (n =23). ** p < .01.

Table 7.

Partial Correlations Between Measures of PM, Working Memory Factor Score, and Inhibitory Control Factor Score, Controlling for Age and PPVT (WM-load Condition)

Measure	1	2	3
PM	---	.02	-.15
IC		---	.14
WM			---

Note. PM = Prospective Memory (n = 19). IC= Inhibitory Control Factor Score (n = 19). WM= Working Memory Factor Score (n = 19).

Table 8.

Partial Correlations Between Measures of PM, Working Memory Factor Score, and Inhibitory Control Factor Score, Controlling for Age and PPVT (IC-load Condition)

Measure	1	2	3
PM	---	.25	-.08
IC		---	.52*
WM			---

Note. PM = Prospective Memory (n = 18). IC= Inhibitory Control Factor Score (n = 18). WM= Working Memory Factor Score (n = 18). * $p < .05$.

In both the IC-load condition and the Control condition, but not the WM-load condition, IC and WM factor scores were significantly inter-correlated. There was no significant correlation between IC and WM factor scores and PM performance, regardless of condition. Upon visual inspection of the correlation coefficients it appears that there is a stronger relation between children's PM performance and IC and WM factor scores in the dual-load conditions. However, follow-up Fisher's r to z transformation analyses indicated that the observed differences were not significant. Thus, there was no support for the fourth hypothesis.

To test the fifth hypothesis, that WM factor scores and IC factor scores would mediate the relation between age and PM performance, two mediation analyses were conducted. For the first model, Age was a significant predictor of WM (factor score), β = 0.76, $t(69) = 3.43$, $p = .001$. However, WM (factor score) was not a significant predictor of PM performance, β = - 0.27, $t(69) = -0.91$, $p = .36$. Since b path was not significant, it can be interpreted to mean that no mediation occurred.

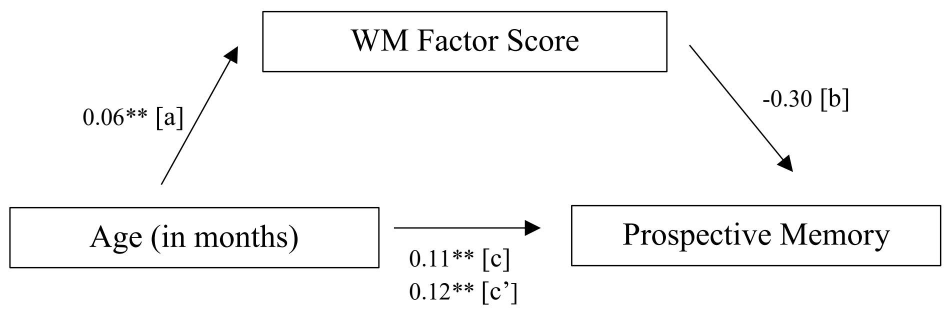

Figure 2. Mediation model for the relation between age (in months) and prospective memory performance through working memory performance. ** $p < .01$.

For the second model, Age was a significant predictor of IC (factor score), β = 0.88, $t(69) = 3.93$, $p < .001$. However, IC (factor score) was not a significant predictor of PM performance, $\beta = 0.3$, $t(69) = 0.85$, $p = .40$. Again, since b path was not significant, it can be interpreted to mean that no mediation occurred. Thus, there was no support for the fifth hypothesis.

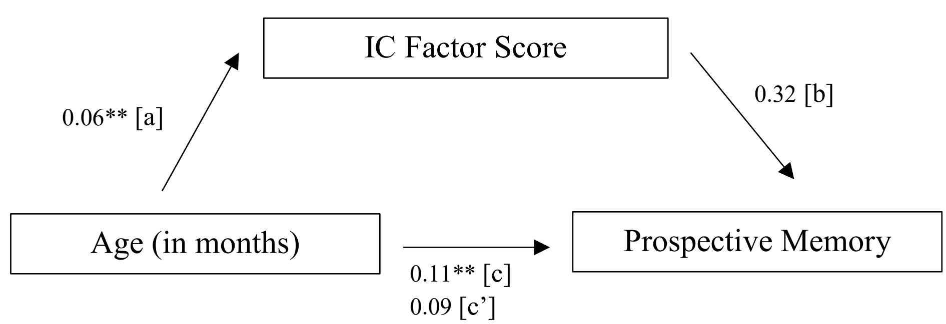

Figure 3. Mediation model for the relation between age (in months) and prospective memory performance through inhibitory control performance. * $p < .05$. ** $p < .01$.

Secondary Task Performance

To test the final hypothesis that performance on the Auditory 1-back and Verbal Labelling tasks would be poorer during the ongoing and PM task, relative to Baseline performance in the relevant dual-load conditions, two paired-samples t-tests were conducted (one for each task). Before conducting the analyses, the assumption of normality of the differences distributions was examined. The skewness (-0.13) and kurtosis (-1.59) of the Verbal Labelling (*untransformed*) differences distribution fell within the accepted range and therefore can be assumed normal. However, the differences distribution of the Auditory 1-back task was negatively skewed, therefore a square root transformation was used on both Baseline and OT-3 scores. The skewness (0.99) and kurtosis (0.73) of the transformed differences then fell within the accepted range to be assumed normal.

Consistent with the hypothesis, children's performance on the Verbal Labelling task was poorer during the ongoing and PM task ($M = 42.43$, $SD = 42.13$) relative to Baseline performance ($M = 84.31$, $SD = 11.40$), $t(21) = 5.18$, $p = .001$. Similarly, children's performance on the Auditory 1-back was poorer during the ongoing and PM task ($M = 5.65$, $SD = 1.85$) relative to Baseline performance ($M = 7.74$, $SD = 1.27$), $t(23) = -5.29$, $p < .001$.

Discussion

The main purpose of the present study was to examine the role of executive function, specifically WM and IC abilities, in young children's event-based prospective memory ability, using a dual-task load design. For the PM paradigm, children were asked to engage in the ongoing task, which required them to point to the picture of an animal on each page (each page contained one animal and one non-animal image; see Appendix N). The embedded PM task required children to ring a bell located behind them when they saw a picture of a specific item, namely a cat. Children completed the event-based PM paradigm in one of three between-subject conditions. In the Control condition, children completed the PM paradigm only. In the WM-load condition, children completed a WM task (the Auditory 1-back task) simultaneously with the ongoing and PM task (modified from Voigt et al., 2014). Finally, in the IC-load condition, children completed an IC task (the Verbal Labelling task) simultaneously with the ongoing and PM task (modified from Mahy et al., 2015). A second aim of this study was to investigate the extent to which WM and IC performance correlate to children's PM performance. Children completed a series of WM and IC measures which were used to create two composite scores, one for each skill, to examine the relation between EF and PM. Overall, the results revealed little support for the hypotheses. However, I will address each one before turning to limitations of the current study and future directions.

Effects of Age and Condition

The first hypothesis predicted that children in the Control condition would outperform children in the dual-load conditions on the ongoing task and the embedded PM task. This hypothesis was not supported. There was no difference in performance on the ongoing task and the embedded PM task by condition, indicating that children performed similarly across all conditions. The failure to find a difference was not due to ceiling or floor effects, and children's performance for both the ongoing task and the PM task showed variability (see Table V1 in Appendix V). This finding is inconsistent with previous research that found that adding a secondary task taxing WM or IC both impaired children's time-based PM performance (Mahy et al., 2015; Voigt et al., 2014). This study is, however, the first to examine the effect of adding a secondary task on children's *event-based* PM performance, so this factor may have affected the results.

The discrepancy in the findings may be due to differential task demands of time-based versus event-based PM. This claim is supported by Khan et al.'s (2008) study with adults, which found that although both time- and event-based PM were negatively impacted by adding a cognitive load, time-based PM performance was *more* adversely affected by the cognitive load than event-based PM. They argue that this was most likely due to the increased difficulty of time-based PM which requires internal time monitoring and self-initiation (Khan et al., 2008). Therefore, it is possible that perhaps the dual-load manipulation in the current study was not difficult enough to impact event-based PM.

In addition, in the current study, children were able to take as long as they wanted to remember to point to the animal (the ongoing task), which likely reduced the cognitive challenge. In contrast, the driving task (Mahy et al., 2015; Voigt et al., 2014) which was employed in the previous dual-task studies continued with the secondary task and continued even if children had not responded. This difference likely contributed to the lack of findings in the current study. In retrospect, it may have been preferable to use a more standardized ongoing, and PM task with a specific trial length and response window. Future work could address this, as this could be accomplished by using a computerized version, as in Leigh and Marcovitch (2014), that is auto-timed. Doing so may increase the cognitive load of the PM task because there is a time limit associated with the response. This modification would be in line with the other dual-load manipulations used with time-based PM (Mahy et al., 2015; Voigt et al., 2014). Perhaps, under these conditions, event-based PM performance would be impacted by the dual-task load as has been found with time-based PM (Mahy et al., 2015; Voigt et al., 2014).

This interpretation is supported by the finding that on the secondary tasks children performed significantly better at baseline (i.e., when the task was administered by itself) than when they had the PM and ongoing task simultaneously (OT-3). Therefore, it is possible that children succeeded on the PM task because they ignored the secondary task and prioritized the ongoing and embedded PM task. Furthermore, anecdotal evidence suggests that many children only responded to the secondary task when reminded, and only did so for a few trials following the reminder. This may be due to the secondary tasks being simply too difficult for children and children not having enough cognitive resources to attend to the multiple tasks, so they selectively attended to the PM task. Therefore, it is possible then that for the children who failed to respond to the secondary task during OT-3, the PM paradigm was no more difficult than in the Control condition, as they were treating it as a single-load task. This was particularly true for the Verbal Labelling task, which was considered to be more difficult than the Auditory 1-back, as it required children to make a response after every word whereas for the Auditory 1-back children only had to make a response every three to five words in order to be successful. For the Verbal Labeling task, 31.8% of children received a score of zero during OT-3 [4]. For the Auditory 1-back, 4.2% of children received a score of zero. Thus, the dual-load conditions may not have been taxing children's cognitive resources in the initially expected manner which makes it difficult to draw definitive conclusions concerning the

[4] Seven children out of 22. During testing this pattern was not obvious as the administration of conditions were interspersed. Furthermore, performance on this task was bimodal with approximately 30% of children scoring 90% correct or higher.

impact of a dual-task load on preschoolers PM performance, as well as the relation with EF abilities. Future work should use simpler secondary tasks and perhaps emphasize the importance of attending to the secondary task to further examine the relation between cognitive load and EF abilities among this age group. Another way would be to include older children using the current secondary tasks to see if the tasks were simply too difficult for the younger children. Such work could tell us if adding a cognitive load taxing EF does in fact impair children's event-based PM as has been found with time-based PM (Mahy et al., 2015; Voigt et al., 2014), under different conditions.

Another factor that may have affected the results is the age differences across the studies. Mahy et al. (2015) examined the effect of a dual-load on five-, seven-, nine-, and eleven-year-olds' time-based PM, and Voigt et al. (2014) included five-to fourteen-year-olds. In contrast, the current study included a younger age group, four- and five-year-olds. The secondary tasks used in the current study were modelled off those used by Mahy et al. (2015) and Voigt et al. (2014) for their youngest participants, therefore it is possible that the secondary tasks were simply too difficult for the younger age group in the current study. In addition, it is possible that the dual-task load was too demanding for younger children. It is also important to note that Mahy et al. (2015) and Voigt et al. (2014) varied the secondary task demands across age groups, whereas for the current study the secondary task demands were the same across age groups. Therefore, it is difficult to make comparisons across studies.

Lastly, it is important to note that there were unexpected between group differences on two measures of EF: the Happy/Sad task and the Visual Backward Word Span. Children in the WM-load condition performed significantly worse on these measures, indicating that the groups were not equally matched on these measures. Furthermore, WM and IC factor scores did not correlate for this group. This is in contrast to previous research which suggests that WM and IC share variance (e.g., Ford et al., 2012). As mentioned, an ANCOVA was not performed with these measures as the covariates because when conditions differ on a covariate "entering the covariate into the analysis will not 'control for' those differences" (Field, 2009, p. 398). It is difficult to determine what impact, if any, these group differences may have had on the results. These group differences suggest that children in the WM-load condition were not well matched with the children in the Control and IC-load conditions, despite there being no significant differences in gender and age across conditions. Therefore, this may have reduced the power to find a relation between EF and PM. Upon examination of the mean performance by condition for the PM task, the WM-load condition had the highest PM scores and the IC-load condition had the lowest, although there were no significant differences across conditions (see Table V1 in Appendix V). However, given the between group differences on measures of EF, it becomes difficult to interpret the lack of difference in PM performance. Though, given that EF skills did not predict PM performance in the current study, the differences in EF skills across the groups may not have impacted PM performance. Furthermore, PM performance in the IC-load condition may be lowest because the secondary task, the Verbal Labelling task, was arguably more difficult than the secondary task in the WM-load condition, the Auditory 1-back, as it required a response after every word compared to a response every three to five words. It is possible that had the samples been better matched, a different pattern of results may have been observed.

The second hypothesis predicted that there would be an interaction between age and condition, such that five-year-olds would outperform four-year-olds on the PM task, but only in the dual-load conditions. This hypothesis was based on previous research that has found little age-related differences in four- and five-year-olds' PM performance (Kliegel & Jager, 2007; Mahy & Moses, 2011), with older children having more cognitive resources available to allocate between two tasks (e.g., Garon et al., 2008). There was a significant effect of age for the PM task, with five-year-olds remembering to ring the bell when they saw the cat more often than did the four-year-olds. However, there was no significant interaction between age and condition, as five-year-olds outperformed four-year-olds across all conditions and performance of both age groups did not vary by condition. It is not surprising that there was no interaction effect given the lack of condition main effect. Children appeared to prioritize the PM task over the secondary tasks in the dual-load conditions which led to the PM paradigm being similar in difficulty regardless of condition. Lastly, there was no main effect of age, nor interaction between age and condition, for the ongoing task, indicating that four-and five-year-olds performed similarly on the ongoing task across conditions.

The finding that five-year-olds outperformed four-year-olds on the PM task is consistent with previous work which has found age-related improvements in PM performance between these age groups (e.g., Mahy & Moses, 2011; Mahy et al., 2014). However, there are discrepancies in the literature for age-related improvements in PM performance between four- and five-year-olds. For example, Kliegel and Jager (2007) and Kvavilashvili et al. (2001) found no difference between these age groups' PM performance. These discrepancies may be due to different task demands across studies.

For example, Kliegel and Jager (2007) asked children to name pictures on a series of cards (e.g., chair) for the ongoing task. The PM task required children to place cards picturing apples in a box located either behind them or in front of them. This task included only one PM target cue (i.e., one apple) as opposed to multiple target cue (i.e., multiple pictures of different cats) and provided an external reminder of the PM action by placing the box in front of the child. Therefore, the PM task used by Kliegel and Jager (2007) may have been relatively easier than the task used in the current study which may explain why they failed to find an age effect while the current study found that five-year-olds outperformed four-year-olds on the PM task. For the current study, there were multiple different cats used as the PM target cue and children were not given a practice trial for the PM task (consistent with other work, e.g., Bartlett, 2016; Mahy & Moses, 2011; Mahy et al. 2014). In addition, children were not given any external reminders of the PM task as the bell was located behind them (also consistent with other work, e.g., Bartlett, 2016; Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014). These factors may have contributed to the PM task being more difficult for younger children who may have failed to recognize every cat as the target cue and did not have an external reminder of the PM action.

Relation Between PM and Executive Functioning

The third hypothesis predicted that WM and IC factor scores (derived from Principal Component Analyses) would predict PM task performance, even after controlling for age and language ability. This hypothesis was not supported. Though the WM and IC tasks were inter-correlated (respectively), and the data was appropriate to derive a factor score, the WM and IC factor scores did not independently predict PM task performance after controlling for age and language ability.

Age was the only variable that independently predicted PM task performance in the current thesis. As discussed earlier, this is consistent with previous research which has found a relation between age and PM in preschool aged children (e.g., Guajardo & Best, 2000; Kerr & Zelazo, 2004; Kliegel & Jäger, 2007; Kvavilashvili et al. , 2001; Mahy & Moses, 2011).

Previous research in this area has demonstrated mixed results concerning the relation between EF and PM performance. Some research has reported a positive relation between EF and PM after controlling for age and/or language ability. For example, Mahy and Moses (2011) found that WM performance, but not IC, predicted four-to six-year-olds' event-based PM performance even when controlling for age. In contrast, Mahy et al. (2014) found that IC, but not WM, predicted a significant amount of variance in four- and five-year-old children's event-based PM performance after controlling for age and language ability. In addition, Ford et al. (2012) found that both WM and IC predicted four-to six-year-olds' event-based PM performance. Furthermore, many studies used only one measure of IC or WM (Ford et al., 2012; Mahy & Moses, 2011; Mahy et al., 2014) or failed to control for age and language ability (Causey & Bjorklund, 2014; Mahy & Moses, 2011), which may have influenced the observed relations between EF skills and PM. The current study was valuable in that it addressed these issues by using multiple measures of IC and WM and conducting two Principal Component Analyses (PCA), one for each cognitive skill, in order to provide a more robust representation of the constructs of interest. In addition, age and language ability were controlled for in the regression analyses. However, the current study failed to demonstrate that WM and IC predict PM performance in four- and five-year-old children when controlling for age and language ability. This is in contrast to Bartlett's (2016) findings that an EF factor score (derived from five EF measures) predicted PM performance in three- and four-year-olds, above and beyond the contributions of age- or language-related improvements.

It is important to note for the current study that an exploratory regression analysis revealed that IC, but not WM, independently predicted children's PM performance when age and language ability were not controlled. However, this finding should be interpreted with caution given that these two factors account for individual differences in PM performance (e.g., Ford et al., 2012; Mahy et al., 2014). Furthermore, when age and language are entered in the analysis the relation between IC and PM performance disappears, which suggests that the two are related due to age-related improvements in both skills.

A possible explanation for the lack of relation between EF and PM performance, when controlling for age and language ability, may be due to how the PM performance was measured in the current study. For the current study, children were scored as correct on the PM trials if they remembered to ring the bell when they saw a cat even if they pointed to the picture of the cat, or started to point, before ringing bell. This scoring method is consistent with other studies that scored children as correct if they completed the PM task even if they completed a portion of the ongoing task requirements (e.g., Bartlett, 2016; Mahy & Moses, 2011, Mahy et al., 2014). These studies have reported a relation between PM and EF skills. However, it is possible that scoring the PM trials in a different way for the current study may have led to a different pattern of results. For example, Ford et al. (2012) found that WM and IC predicted children's ability to "withhold naming" the PM target pictures. In contrast, children's ability to remove the target card was not related to IC or WM. This suggests that perhaps removing the target card was easier than withholding naming the target card and therefore required fewer EF resources. This may be due to the fact that naming the cards is a feature of the ongoing task, therefore it requires IC to inhibit the prepotent response to name the card. The current study did not record both measures of PM, and so cannot address this possibility. Future work should examine the differences in how PM performance is measured across studies and how this particular demand may influence the relation with different EF skills.

The fourth hypothesis predicted that there would be a stronger correlation between WM and IC factor scores and PM performance in the dual-load conditions compared to the Control condition, after controlling for age and language ability. This was expected because individuals with higher WM and IC abilities should be better able to cope with the demands of the secondary task in the dual-load conditions. Furthermore, WM and IC would be more engaged during the dual-load conditions because the task is more cognitively taxing. This hypothesis was not supported. This finding is in contrast with previous research that found that EF abilities were more strongly related to PM performance during a high cognitive demand task (Shum et al., 2008; Ward et al., 2005). However, in the present study the dual-load manipulation did not impact children's PM performance. As discussed above, it appears that in the two dual-load conditions, many children prioritized the ongoing and PM task over the secondary task. Therefore, the results suggest that the PM paradigm was no more difficult in the dual-load conditions than in the Control condition, as they were treating it as single-load task.

The current study did find that in the Control and IC-load conditions, WM and IC factor scores were positively correlated. This finding is consistent with previous research which suggests that WM and IC skills share variance in this age group (e.g., Ford et al., 2012). Miyake et al. (2000) proposed an integrative model of EF where there is a common, underlying EF mechanism with partially dissociable components, such as WM and IC. This is supported by the finding that different measures of EF are inter-correlated (see Table 4). Furthermore, WM and IC develop around the same time with significant improvements occurring in children three-to five-years-old (e.g., Garon et al., 2008). Interestingly, this relation was not observed in the WM-load condition. Recall that there were unexpected between group differences on two measures of EF, the Happy/Sad task and the Visual Backward Word Span. Children in the WM-load condition performed significantly worse on these measures, indicating that the groups were not well matched on these measures. This may explain why there was no observed relation between WM and IC factor scores in this condition.

The fifth hypothesis predicted that WM factor scores and IC factor scores would mediate the relation between age and PM performance. This was based on a study by Bartlett (2016) that found that EF fully mediated the relation between age and PM performance. Furthermore, Mahy et al. (2014) found that IC fully mediated the relation between age and PM performance. This hypothesis was not supported. While age was related to WM and IC factor scores as well as PM performance, there was no evidence of a mediation effect. This finding is not surprising given that WM and IC factor scores did not independently predict PM performance during the regression analysis. In other words, the findings from the present study indicate that age-related differences in EF did not contribute to PM performance and that age alone accounted for differences in PM performance. Independent of age, children with more advanced EF skills were no more successful than those with less developed EF skills. Given that only two studies to date have reported that EF mediates the relation between age and PM in preschoolers, future work is required in order to determine under what circumstances this occurs. Such work should examine whether EF mediates the relation between age and PM performance when the PM task is more difficult by manipulating motivation (as in Bartlett, 2016) or the number of PM target cues to keep in mind. Furthermore, future work could attempt to examine this relation using a dual-task paradigm, as in the current study, to increase the difficulty of the PM task. However, future work of this nature should either modify the secondary tasks to make them easier for younger children or include older children.

Secondary Task Performance

The final hypothesis predicted that Auditory 1-back and Verbal Labelling performance would be poorer during the ongoing and PM task relative to Baseline performance in the relevant dual-load conditions. This hypothesis was supported. Children’s performance on the Verbal Labelling task was poorer during the ongoing and PM task relative to Baseline performance. Similarly, children’s performance on the Auditory 1-back was poorer during the ongoing and PM task relative to Baseline performance.

As mentioned above, it appears that the dual-load demands did not affect PM performance, instead it affected the secondary tasks. Thus, it appears that children prioritized the ongoing and PM task over the secondary task in the dual-load conditions. Anecdotal evidence suggests that children may have found the ongoing and embedded PM task more fun than the secondary tasks. For example, some children asked if the secondary tasks were almost done during the baseline phase. Furthermore, many children wanted to name the animals during the ongoing task or appeared excited when they saw the pictures of cats and could ring the bell. Another possibility is that the secondary tasks were overly taxing for children. Therefore, they may have selectively allocated more attentional resources to the PM task, while ignoring the secondary task. This is in line with Marcovitch, Boseovski, Knapp, and Kane's (2010) 'theory of goal neglect' which maintains that young children fail to carry out task demands despite understanding and remembering the task instructions, and this is due to their limited working memory capacity. The secondary tasks were modified from Mahy et al. (2015) and Voigt et al. (2014). The youngest age group in these studies was five-year-olds, therefore this was the first time these tasks were used with four-year-olds. Therefore the secondary tasks, in conjunction with the ongoing and PM task, may have been too challenging for younger children. Future work should examine a larger age range which includes older children, which would be in line with the existing work examining the impact of a dual-task load on children's time-based PM. While this would limit the ability to examine the relation between event-based PM and EF skills due to the lack of EF measures suitable for a larger age range, it would be valuable in further examining the effect of a secondary task on children's event-based PM.

Other work could employ an easier secondary task in order to further examine the impact of a dual-task load on preschoolers' event-based PM. For example, in order to tax

WM, two numbers could be presented and children would respond ‘yes’ when the numbers matched (e.g., “6, 6”) and not respond when the numbers did not match (e.g. “4, 5”). This would eliminate the need for children to continuously update information in mind as with the Auditory 1-back, and decrease the WM demands of the secondary task while still adding a cognitive load. In order to tax IC, children could be asked to say the opposite word. For example, respond “up” when they hear “down” or “yes” when they hear “no”. Or, as indicated earlier, children could be encouraged to ‘do their best’ on both tasks, to reduce them prioritizing one task over the other. Such future work may be able to further examine the impact of a dual-task load on preschoolers’ event-based PM in an attempt to further understand the relation between EF skills and PM performance in young children. Using a secondary task is valuable because it experimentally manipulates the cognitive resources available to allocate to ongoing and PM task performance. By manipulating the nature of the cognitive resources being taxed, researchers can see how this affects PM performance and allows them to draw inferences about the cognitive mechanisms being employed for PM. This would add to previous work which has examined the impact of a dual-task load on children’s time-based PM as well as research that has found a relation between EF skills and event-based PM performance.

Limitations and Future Directions

While the present study is valuable in that it was the first to examine the relation between EF skills and event-based PM using a dual-task paradigm with young children, there are a number of limitations that need to be acknowledged. First, as mentioned, children were allowed to take as long as they wanted to make a response on the ongoing and embedded PM task and was limited by the researcher flipping the pages. In contrast, the secondary tasks had a set response window that was consistent across children. As a result, when children received the secondary task with the ongoing and embedded PM task in the dual-load conditions, it was necessary to vary, on a child by child basis, the number of trials of the secondary task that were presented to ensure that children received the secondary task for the duration of the ongoing and PM task. Therefore, it was necessary to look at these scores as percentage correct scores. It is difficult to know what impact this may have had on the participants' performance because children did not all receive the same number of trials of the secondary task, nor at the same points during the ongoing and PM task. This difference may have impacted the difficulty of the tasks. Furthermore, as a result of this factor, the time elapsed from the first PM target trial to the final one, and between target trials, would have varied between children. This is important considering Mahy and Moses (2011) found that the elapsed time before the presentation of the first target cue impacted four-to six-year old's PM performance. As mentioned earlier, future research could use a more standardized ongoing and PM task with a specific trial length and response window. This could be accomplished by using a computerized version as in Leigh and Marcovitch (2014) instead of just flipping pages by the researcher. This would be a good way to ensure that children were receiving the same number of trials of the secondary task at the same points during the ongoing and PM task. This would also allow for another index of performance, reaction time, to be considered when analyzing performance.

A second limitation is that children did not receive a practice trial for the embedded PM task. This was done because multiple different cats were used as the PM cue, therefore I did not want children searching for any one particular cat as the cue and ignoring others. It was also expected that most children would be familiar with cats. However, it is possible that some children did not recognize cats as the PM cue and therefore failed to ring the bell on the PM trials. Future work should include a practice trial in order to ensure children are familiar with the PM cue. This could be done by showing all possible PM cues (e.g., all six cats; similar method employed by Bartlett, 2016) or by picking one particular picture or object for the PM cue. This would be in line with other studies with young children that have used one particular target cue (e.g., an apple; Kliegel & Jager, 2007).

Lastly, a few children, approximately five or six, confused other animals (e.g., bunny, squirrel) with cats during the ongoing task and rang the bell on non-PM trials. These trials were simply scored as incorrect during the ongoing task. Furthermore, some children wanted to name the animals, which could have interfered with responding to the secondary task. Future work should use animals that look less similar to the target animal, as a few children were confused by other small furry animals. Alternatively, different pictures and a target cue that is more distinctive for children could be used. For example, Bartlett (2016) used bananas as the target cue whereas the other food items could not be easily mistaken for bananas. In order to discourage naming the pictures, future work could emphasize in the instructions that it is important to just point to the pictures. In addition, older children may be able to follow the task instructions more closely.

Summary and Conclusion

The current study adds to previous research examining preschoolers' event-based PM ability, using a novel, dual-task paradigm. First, consistent with previous research, this study found that five-year-olds demonstrated stronger PM skills than did four-year-olds. Second, contrary to what was predicted, there was no significant effect of condition on children's PM performance. However, as discussed, perhaps this manipulation did not have an impact on performance because children prioritized the PM task while ignoring the secondary task. This is evidenced by the significant difference in performance on the secondary tasks during baseline compared to OT-3. This was the first study examining the effect of a dual-task load on preschoolers' event-based PM. Therefore, future research is required in order to more thoroughly examine the effect of a dual-task load on event-based PM. Finally, inconsistent with previous research, WM and IC (factor scores) did not independently predict PM performance after controlling for age and language ability. However, PM performance was related to one measure of IC, Simon Says, when age and language were not considered. Therefore, given the discrepancies across studies, further research is needed in order to clarify the relation between EF skills and PM performance in young children.

This study adds to the body of literature examining the relation between event-based PM and EF skills in preschoolers. Furthermore, it is valuable in that it is the first study examining this relation using a dual-task paradigm with preschoolers. However, given that the results revealed little support for the hypotheses, further research of this nature is warranted.

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Appendix A: Carleton University Research Ethics Board Certificate of Ethics Clearance

Carleton UNIVERSITY
Canada's Capital University

Research Compliance Office
511 Tory | 1125 Colonel By Drive
Ottawa, Ontario K1S 5B6
613-520-2600 Ext: 4085
ethics@carleton.ca

CERTIFICATION OF INSTITUTIONAL ETHICS CLEARANCE

The Carleton University Research Ethics Board-B (CUREB-B) has granted ethics clearance for the research project described below and research may now proceed.

CUREB-B is constituted and operates in compliance with the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS2).

Ethics Protocol Clearance ID: Project # 106062

Faculty Supervisor: Audrey Brown

Research Team: Sarah Gardiner (Other), Dr. Deepthi Kamawar (Research Supervisor)

Project Title: Event-Based Prospective Memory and Executive Functioning: The Effect of Inhibitory Control and Working Memory Load [Audrey Brown]

Effective: **December 14, 2016** Expires: **December 31, 2017**.

Restrictions:

This certification is subject to the following conditions:

1. Clearance is granted only for the research and purposes described in the application.
2. Any modification to the approved research must be submitted to CUREB-B via a Change to Protocol Form. All changes must be cleared prior to the continuance of the research.
3. An Annual Status Report for the renewal of ethics clearance must be submitted and cleared by the renewal date listed above. Failure to submit the Annual Status

Appendix B: Ethics Approval (School Board)

OTTAWA CATHOLIC SCHOOL BOARD

OTTAWA-CARLETON DISTRICT SCHOOL BOARD

Ottawa-Carleton Research and Evaluation Advisory Committee (OCREAC)

March 9, 2017

Audrey Brown
42 Renfrew Ave.
Ottawa, ON K1S 1Z5

Re: **Prospective memory and executive functioning: The effect of inhibitory control and working memory load**

Dear Ms. Brown,

The Ottawa-Carleton Research and Evaluation Advisory Committee has reviewed the submitted revisions to your application and is granting you formal **approval** to conduct your research in **this academic year**. This approval is for the Ottawa Catholic School Board and the Ottawa-Carleton District School Board. However, please note that final approval to participate in the study must come from the individual principal.

In order to facilitate access to the schools, please contact Dr. Tsala Mosimakoko, at the Ottawa-Carleton District School Board (tsala.mosimakoko@ocdsb.ca or 613-596-8211 ext. 8571) and Dr. Lauren Figueredo, at the Ottawa Catholic School Board (lauren.figueredo@ocsb.ca or 613-224-4455 ext. 2341).

When you are in the schools, please show your police clearance and a copy of this letter of approval to the school staff being approached to participate in your study. On behalf of the Ottawa-Carleton Research and Evaluation Advisory Committee, we thank you for approaching the Ottawa-Carleton area school boards as a venue for your study and we look forward to receiving a copy of your results.

Sincerely,

Lauren Figueredo, Ph.D.
Research Officer, Student Success – Leading & Learning
Ottawa Catholic School Board
613-224-4455 ext. 2341
lauren.figueredo@ocsb.ca

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

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

Ottawa-Carleton District School Board

Appendix C: Program Coordinator Informed Consent Form (Daycare)

Carleton UNIVERSITY
Canada's Capital University

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

Winter/Spring 2017

Dear Program Coordinator,

As part of a current project on children's cognitive development, we are talking to children to learn about their ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (clearance number: #106062; valid until 31/12/2017). In this letter, we will describe the project and request your permission for your centre's participation.

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

Children will be shown a series of cards, two at a time. Children will be asked to point to the cards with a picture of an animal. They will also be asked to watch for 'special' cards (a particular animal), and to not point to those cards and instead ring a quiet bell. We are interested in examining how dividing children's attention will effect their ability to remember to keep an eye open for the special cards. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child individually, for two sessions lasting approximately 20-30 minutes each. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the session without giving a reason and will still receive their stickers.

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Audrey Brown, Master's of Cognitive Science Candidate, and she can be reached by email at audreybrown@cmail.carleton.ca.

This study has been approved by Carleton University's Research Ethics Board-B (ethics clearance number: #106062) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. If you have any ethical concerns about this study, please contact: Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext. 4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

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

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD　　　　　Audrey Brown, M.Cog.Sc. Candidate

Carleton University Study –Prospective Memory

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

I have read the attached description of the study of *Prospective Memory* and I understand the conditions of my centre's participation.

I understand that the study will require two 20- to 30-minute testing sessions, with children of appropriate ages, whose parents/guardians have given written consent for their children's participation in the research project.

Name of Child Care Centre:

____

Address:

____

____

Signature: _____________________________ Date:____________________________

Name & Title: *(please print)*

____

Appendix D: Principal Informed Consent Form (School)

Carleton UNIVERSITY
Canada's Capital University

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

Winter/Spring 2017

Dear School Principal,

As part of a current project on children's cognitive development, we are talking to children to learn about their ability to remember to perform actions in the future (a skill known as *prospective memory*). The study has been approved by the Carleton University Research Ethics Board-B (approval number #106062; valid until 31/08/2017) and the Ottawa-Carleton Research and Evaluation Advisory Committee. In this letter, we will describe the project and request your permission for your school's participation.

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

Children will be shown a series of images, two at a time (e.g., a fish and a tree). Children will be asked to point to the picture of an animal (in this case, the fish). They will also be asked to watch for 'special' cards (a particular animal, such as a cat), and to not point to those cards, but and instead ring a quiet bell (it has been stuffed with felt so the ring is quite soft). We are interested in examining how dividing children's attention will affect their ability to remember to keep an eye open for the special cards. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child individually, for two sessions lasting approximately 20-25 minutes each. These sessions can take place wherever works best for you and your teachers either in a quiet corner of the classroom, in the hallway just outside of the classroom, or in a lunch room or library. To minimize interference with the children's daily routine, the sessions can also take place whenever works best for you and your teachers, either during classroom time or spare time, while ensuring that a teacher will be nearby at all times. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the session without giving a reason and will still receive their stickers. Children who choose not to participate, or whose parents did not provide written consent, will continue with their usual daily routine. No information will be collected from the files, records, or teachers of individual students. The study results will not appear in any school records.

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Audrey Brown, Master's of Cognitive Science Candidate, and she can be reached by email at audreybrown@cmail.carleton.ca, and by phone at (613) 520-2600 ext. 2885.

This study has been approved by Carleton University's Research Ethics Board-B (ethics protocol number: #106062) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with nearly 2000 children in the same age ranges over the past 13 years and found this reaction to be extremely rare. This study has also been approved by the Ottawa-Carleton Research and Evaluation Advisory Committee.

If you have any ethical concerns about this study, please contact: Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext.4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

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

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD

Audrey Brown, M.Cog.Sc. Candidate

Carleton University Study –Prospective Memory

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

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

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

Name of School: ____

Address:

____

____

______

Signature: _________________________ Date: ____________________________

Name & Title: *(please print)*

____

Appendix E: Informed Consent Form for Parents or Guardians (Daycare)

Carleton UNIVERSITY
Canada's Capital University

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

Winter/Spring 2017

Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (clearance number: #106062; valid until 31/12/2017). In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

Children will be shown a series of cards, two at a time. Children will be asked to point to the cards with a picture of an animal They will also be asked to keep an eye open for 'special' cards (a particular animal), and to not point to those cards and instead ring a quiet bell. We are interested in examining how dividing children's attention will effect children's ability to remember to keep an eye open for the special cards. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child twice, for approximately 20-30 minutes each time. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. The researchers all have current police record checks, and copies of these documents will be provided to the child care centre coordinator before we commence any interviews with your child. The researchers will also be sensitive to the children at all times. Children can stop playing at any time during the session and will still receive their stickers.

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

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

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Audrey Brown, Master's of Cognitive Science Candidate and she can be reached by email at audreybrown@cmail.carleton.ca.

This study has been approved by Carleton University's Research Ethics Board-B (ethics clearance number: #106062) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with children in the same age ranges over the past 13 years and found this reaction to be extremely rare. If you have any ethical concerns about this study, please contact: Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext.4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

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

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD — Audrey Brown, M.Cog.Sc. Candidate

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

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

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

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

Child's Name (please print):
____

Parent's/Guardian's Name (please print):
____

Signature: _________________________________ Date:
____

Participant Information

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

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

Child's Date of Birth: year _______ month ________ day ________

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

Appendix F: Informed Consent Form for Parents or Guardians (School)

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

Winter/Spring 2017

Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their ability to remember to perform actions in the future. The study has been approved by the Carleton University Research Ethics Board-B (approval number #106062; valid until 31/08/2017), the Ottawa-Carleton Research and Evaluation Advisory Committee and the Principal of your school. In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

Children will be shown a series of cards, two at a time. Children will be asked to point to the cards with a picture of an animal They will also be asked to keep an eye open for 'special' cards (a particular animal), and to not point to those cards and instead ring a quiet bell. We are interested in examining how dividing children's attention will affect their ability to remember to keep an eye open for the special cards. We will also play games that measure related skills, such as working memory and vocabulary. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they stop playing part-way through). We will also provide enough stickers for all children in the participating classrooms to the teacher, so that all children get some, even if their parents have not consented to their participation.

We will meet with each child twice individually, for approximately 20-25 minutes each time. These sessions will take place approximately one week apart. These sessions will occur at the school and take place wherever works best for your child's teacher – either in a quiet corner of the classroom, in the hallway just outside of the classroom, or in a lunch room or library. To minimize interference with the children's daily routine, the time of the sessions will be determined by your child's teacher, and will occur either during classroom time or spare time, while ensuring that a teacher will be nearby at all times.

Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. The researchers all have current police record checks, and copies of these documents will be provided to the school principal before we commence any interviews with your child. The researchers will also be sensitive to the children at all times. Children can stop playing at any time during the session and will still receive their stickers. Children who choose not to participate, or whose parents did not provide written consent, will continue with their usual daily routine. No information will be collected from the files, records, or teachers of individual students. The study results will not appear in any school records.

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017. Analyses presented in presentations or written publications will only contain group data, with no identification of individuals who participated in this study.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi.kamawar@carleton.ca. The primary researcher involved in this project is Audrey Brown, Master's of Cognitive Science Candidate and she can be reached by email at audreybrown@cmail.carleton.ca, or by phone at 613-520-2600, ext. 2885.

This study has been approved by Carleton University's Research Ethics Board-B (ethics clearance number: #106062) and has been deemed minimal risk. Some participants may find a particular task taxing, which could cause them to become upset. In those rare cases, children are dealt with in a very sensitive manner (told that we're all done, thanked for doing a great job) and taken back to their teachers. We have used similar tasks with nearly 2000 children in the same age range over the past 13 years and found this reaction to be extremely rare. This study has also been approved by the Ottawa-Carleton Research and Evaluation Advisory Committee.

If you have any ethical concerns about this study, please contact: Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext.4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca.

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

Thank you for your consideration.

Sincerely,

Deepthi Kamawar, PhD

Audrey Brown, M.Cog.Sc. Candidate

Informed Consent:

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

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

☐ I consent to my child's participation in the current study **[please fill out below]**

Child's Name (please print):

____

Parent's/Guardian's Name (please print):

____

Signature: _______________________________ Date: _________________________

Participant Information

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

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

Child's Date of Birth: year _______ month ________ day ________

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

Appendix G: Script for Obtaining Verbal Assent from Children

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

If child says, ‘No’, we say, “That’s okay. Can I ask you again another day if you want to play?”. If child says, ‘No’, the child is not asked again (this is noted). If the child says, ‘yes’, we note this and ask the child another day. If they decline to participate a second time, we do not ask again so as to not coerce the children into participating.

If a teacher tells a child that they have to go with us because a parent signed a consent form, we clearly (and cheerfully) make sure to let the teacher and the child know that it’s entirely up to the child and no one has to participate if they don’t want to.

Appendix H: Debriefing Letter for Parents or Guardians (Daycare)

Carleton UNIVERSITY
Canada's Capital University

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

Winter/Spring 2017

Dear Parent(s) or Guardian(s),

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

The purpose of our current research program was to gain a better understanding of children's growing ability to remember to complete some task in the future. Children were shown a series of cards, two at a time. They were then asked to point to the cards with a picture of an animal. They were asked to keep an eye open for 'special' cards (a particular animal), and to not point to those cards and instead ring a quiet bell. We are interested in examining how dividing children's attention will effect their ability to remember to keep an eye open for the special cards. We also played games that measure related skills, such as working memory and vocabulary. Your child's answers to these questions will help us to understand how children begin to remember to perform action in the future independently.

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

If you have any ethical concerns about this study, please contact: Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext.4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca. The ethics protocol number for this study is #106062.

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017.

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

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

Thank you,

Deepthi Kamawar, PhD | Audrey Brown, M.Cog.Sc. Candidate

Appendix I: Debriefing Letter for Parents or Guardians (School)

Carleton
UNIVERSITY
Canada's Capital University

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

Winter/Spring 2017

Dear Parent(s) or Guardian(s),

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

The purpose of our current research program was to gain a better understanding of children's growing ability to remember to complete some task in the future. Children were shown a series of images, two at a time. They were then asked to point to the picture of an animal, to keep an eye open for 'special' cards (a particular animal), and to not point to those cards and instead ring a quiet bell. We are interested in examining how dividing children's attention will affect their ability to remember to keep an eye open for the special cards. We predicted that children would do a better job at remembering the special cards when their attention was not divided between this task and another task. We also played games that measure related skills, such as working memory and vocabulary.

Your child's answers to these questions will help us to understand how children begin to remember to perform actions in the future independently. By gaining a better understanding of the skills involved in the successful execution of future actions, this research can be applied in circumstances requiring children to perform a particular action in the future, to help improve children's ability to successfully remember and execute the desired action.

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

This study has been approved by Carleton University's Research Ethics Board-B (ethics clearance number: #106062). This study has also been approved by the Ottawa-Carleton Research and Evaluation Advisory Committee and your school Principal.

If you have any ethical concerns about this study, please contact: Dr. Lauren Figueredo, Chair, Ottawa-Carleton Research and Evaluation Advisory Committee (Lauren.Figueredo@ocsb.ca or 613-224-4455, ext. 2341) or Dr. Andy Adler, Chair, Carleton University Research Ethics Board-B (Andy.Adler@carleton.ca or 613-520-2600 ext.4085). You may also contact the Carleton University Research Compliance Office at ethics@carleton.ca. The ethics protocol number for this study is #106062 (Carleton University Research Ethics Board-B).

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

As soon as we have finished talking with all of the children that will be participating in the study, we will destroy the file linking children's names to their identification numbers used in the datafile. In other words, it will no longer be possible to identify an individual child's responses (the data will be anonymized). As a result, participants will no longer be able to withdraw their data. We estimate that this will occur in June 2017.

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

Thank you,

Deepthi Kamawar, PhD　　　　Audrey Brown, M.Cog.Sc. Candidate

Appendix J: Verbal Debriefing for Children Interview

We say, “That was our last game. Thank you for playing with me – that was fun. I wanted to learn more about how kids think and remember things. Do you have any questions about any of the games we played today? Thanks again for your help and have a great day!”

Appendix K: Verbal Labelling task

Source: modified from Mahy et al. (2015)

We're going to play a word game! In this game you're going to hear lots of words. Some words are about boys, some are about girls and some are about things. I want you to listen and tell me if the words go with boys, girls of things.

The experimenter will show pictures of each word to familiarize children with the sound of each word.

Experimenter demo: Let's think about the word king. The word king is about boys, right. Let's think about queen. The word queen is about girls, right. Let's think about chair. The word chair isn't about boys or girls it's just a thing.

Let's try some!
Let's think of brother. Is the word brother about boys, about girls or about things.
Let's try another, what about sister. Is the word sister about boys, about girls, or about things.

The rest of the words you're going to listen to on hear. Some words will be said by boys and some will be said by girls. I don't want you to worry about who said the word. I just want you to tell me if the word is about boys, about girls, or about things.

Practice trials: Let's try a few! *Correct if necessary. Circle child's response. (G = Girl; Boy = Boy; T=Thing; O=Other)*

1	Uncle	G	**B**	T	O
2	Car	G	B	**T**	O
3	Mom	**G**	B	T	O
4	Ball	G	B	**T**	O
5	Dad	G	**B**	T	O
6	Aunt	**G**	B	T	O
7	Prince	G	**B**	T	O
8	Book	G	B	**T**	O
9	Mommy	**G**	B	T	O
10	Tree	G	B	**T**	O
11	Princess	**G**	B	T	O
12	Daddy	G	**B**	T	O

TESTING (NO FEEDBACK): Circle child's response. (G = Girl; Boy = Boy; T=Thing; O=Other)

1	Brother	G	**B**	T	O
2	Mom	**G**	B	T	O
3	Cup	G	B	**T**	O
4	Uncle	G	**B**	T	O
5	Sister	**G**	B	T	O
6	Car	G	B	**T**	O
7	Aunt	**G**	B	T	O
8	Crayon	G	B	**T**	O
9	Dad	G	**B**	T	O
10	Grandmother	**G**	B	T	O
11	Truck	G	B	**T**	O
12	Princess	**G**	B	T	O
13	Ball	G	B	**T**	O
14	Grandfather	G	**B**	T	O
15	Queen	**G**	B	T	O
16	Daughter	**G**	B	T	O
17	Scarf	G	B	**T**	O
18	Prince	G	**B**	T	O
19	Mother	**G**	B	T	O
20	Spoon	G	B	**T**	O
21	Man	G	**B**	T	O
22	Father	G	**B**	T	O
23	Book	G	B	**T**	O
24	Woman	**G**	B	T	O
25	Prince	G	**B**	T	O
26	Wife	**G**	B	T	O
27	Shoe	G	B	**T**	O
28	Son	G	**B**	T	O
28	Mommy	**G**	B	T	O
29	Bike	G	B	**T**	O
30	Uncle	G	**B**	T	O
31	Train	G	B	**T**	O
32	Chair	G	B	**T**	O
33	Mommy	**G**	B	T	O
34	Husband	G	**B**	T	O
35	Daddy	G	**B**	T	O
36	Sister	**G**	B	T	O
37	Hat	G	B	**T**	O
38	King	G	**B**	T	O
39	Plane	G	B	**T**	O
40	Princess	**G**	B	T	O
41	Bus	G	B	**T**	O
42	Brother	G	**B**	T	O

Appendix L: Auditory 1-back

Source: Modified from Voigt et al., 2014

Now we're going to play the colour game! In this game, you'll hear colour words. You're going to hear the colour word, yellow, blue, green and red.

Colour identification: *Show card with four colours*. Can you point to the yellow? Blue? Green? Red?
If you hear the same colour word two times in a row, I want you to say "yes". The rest of the time you don't have to say anything!

Training:

Let's try a few! *Correct if necessary.*

Listen "blue, green, green". Let's try another one "red, blue, yellow, yellow".
If both correct, proceed. Else give 2nd training.

Let's try another one "green, red, red". Let's try one more "yellow, green, blue, blue".
Proceed after 2nd training regardless.

Practice trials: Okay now you're going to listen to some colour words on here. You're going to hear a lot of colour words. Remember to say yes if you hear the same colour word two times in a row. But then I want you to keep listening for more colour words.

Let's try a few! *Correct if necessary. Circle child's response. (Y = Yes; NR = No Response)*

1	Yellow	Y	NR
2	Blue	Y	NR
3	Blue	Y	NR
4	Green	Y	NR
5	Yellow	Y	NR
6	Red	Y	NR
7	Red	Y	NR
8	Blue	Y	NR
9	Green	Y	NR
10	Yellow	Y	NR

Good! Now I have even more colour words for you, then we'll play a different game!

TESTING (NO FEEDBACK): Circle child's response. (Y = Yes; NR = No Response)

1	Blue	Y	NR
2	Green	Y	NR
3	Red	Y	NR
4	Yellow	Y	NR
5	Yellow	Y	NR
6	Green	Y	NR
7	Blue	Y	NR
8	Red	Y	NR
9	Green	Y	NR
10	Blue	Y	NR
11	Blue	Y	NR
12	Yellow	Y	NR
13	Red	Y	NR
14	Green	Y	NR
15	Red	Y	NR
16	Red	Y	NR
17	Yellow	Y	NR
18	Blue	Y	NR
19	Green	Y	NR
20	Yellow	Y	NR

21	Yellow	Y	NR
22	Red	Y	NR
23	Blue	Y	NR
24	Yellow	Y	NR
25	Green	Y	NR
26	Green	Y	NR
27	Blue	Y	NR
28	Yellow	Y	NR
29	Red	Y	NR
30	Red	Y	NR
31	Yellow	Y	NR
32	Blue	Y	NR
33	Red	Y	NR
34	Green	Y	NR
35	Green	Y	NR
36	Yellow	Y	NR
37	Red	Y	NR
38	Blue	Y	NR
39	Blue	Y	NR
40	Green	Y	NR

Appendix M: Prospective Memory Paradigm

Ongoing task instructions – We are going to play the animal game! I'm going to show you some cards with some pictures on them. I will show you two cards at a time. Some cards have a picture of an animal on them and some cards have a picture of something that is not an animal. I want you to point to the picture of the animal on each page.

Experimenter demo: So if I show you these cards, Show [book] and [dog], I want you to point to the dog, because it is an animal. We will only point to pictures of animals.

Practice Trial 1
Let's practice a few! *Show [fish] and [shoe].*
Which picture do we point to?
If hesitation: Remember, we point to pictures of animals and we don't point to pictures of things that are not animals. Which picture do we point to?
If correct: Good job, that's right!
If incorrect: That's a shoe. It's not an animal. Remember, we point to pictures of animals.

Practice Trial 2
Let's try another one. *Show [soccer ball] and [horse].*
Which picture do we point to?
If hesitation: Remember, we point to pictures of animals and we don't point to pictures of things that are not animals. Which picture do we point to?
If correct: Good job, that's right!
If incorrect: That's a soccer ball. It's not an animal. Remember, we point to pictures of animals.

TESTING (NO FEEDBACK; OT-1): Circle child's response. (A = Animal; NA = Non-Animal)

1	Mouse	**A**	NA
2	Dog	**A**	NA
3	Panda	**A**	NA
4	Turtle	**A**	NA
5	Squirrel	**A**	NA
6	Giraffe	**A**	NA
7	Monkey	**A**	NA
8	Elephant	**A**	NA
9	Pig	**A**	NA
10	Camel	**A**	NA
11	Duck	**A**	NA
12	Bunny	**A**	NA
13	Fish	**A**	NA
14	Sheep	**A**	NA
15	Owl	**A**	NA

Now we're going to play the animal game again.

TESTING (NO FEEDBACK; OT-2): Circle child's response. (A = Animal; NA = Non-Animal)

Control condition

1	Chick	**A**	NA
2	Cow	**A**	NA
3	Zebra	**A**	NA
4	Beaver	**A**	NA
5	Penguin	**A**	NA
6	Flamingo	**A**	NA
7	Deer	**A**	NA
8	Bear	**A**	NA
9	Fox	**A**	NA
10	Raccoon	**A**	NA
11	Dog	**A**	NA
12	Koala	**A**	NA
13	Polar Bear	**A**	NA
14	Frog	**A**	NA
15	Rooster	**A**	NA
16	Duck	**A**	NA
17	Walrus	**A**	NA
18	Kangaroo	**A**	NA
19	Goat	**A**	NA
20	Hamster	**A**	NA
21	Rhino	**A**	NA
22	Hedgehog	**A**	NA
23	Hippo	**A**	NA
24	Bluejay	**A**	NA
25	Fish	**A**	NA
26	Owl	**A**	NA
27	Goose	**A**	NA
28	Horse	**A**	NA
29	Moose	**A**	NA
30	Budgie	**A**	NA

Now we're going to play the animal game again. But this time;
[*WM condition*] you are going to play the colour game at the same time. Remember I want you to say "yes" when you hear a colour two times in a row,

TESTING (NO FEEDBACK; OT-2): Circle child's response. (A = Animal; NA = Non-Animal; Y= Yes; NR = No Response)

WM condition

1	Chick	**A**	NA
2	Cow	**A**	NA
3	Zebra	**A**	NA
4	Beaver	**A**	NA
5	Penguin	**A**	NA
6	Flamingo	**A**	NA
7	Deer	**A**	NA
8	Bear	**A**	NA
9	Fox	**A**	NA
10	Raccoon	**A**	NA
11	Dog	**A**	NA
12	Koala	**A**	NA
13	Polar Bear	**A**	NA
14	Frog	**A**	NA
15	Rooster	**A**	NA
16	Duck	**A**	NA
17	Walrus	**A**	NA
18	Kangaroo	**A**	NA
19	Goat	**A**	NA
20	Hamster	**A**	NA
21	Rhino	**A**	NA
22	Hedgehog	**A**	NA
23	Hippo	**A**	NA
24	Bluejay	**A**	NA
25	Fish	**A**	NA
26	Ostrich	**A**	NA
27	Goose	**A**	NA
28	Horse	**A**	NA
29	Moose	**A**	NA
30	Budgie	**A**	NA

1	Yellow	Y	NR
2	Blue	Y	NR
3	Green	Y	NR
4	Green	Y	NR
5	Red	Y	NR
6	Yellow	Y	NR
7	Blue	Y	NR
8	Red	Y	NR
9	Red	Y	NR
10	Green	Y	NR
11	Yellow	Y	NR
12	Blue	Y	NR
13	Blue	Y	NR
14	Red	Y	NR
15	Green	Y	NR
16	Blue	Y	NR
17	Yellow	Y	NR
18	Yellow	Y	NR

19	Yellow	Y	NR
20	Blue	Y	NR
21	Green	Y	NR
22	Green	Y	NR
23	Red	Y	NR
24	Yellow	Y	NR
25	Blue	Y	NR
26	Red	Y	NR
27	Red	Y	NR
28	Green	Y	NR
29	Yellow	Y	NR
30	Blue	Y	NR
31	Blue	Y	NR
32	Red	Y	NR
33	Green	Y	NR
34	Blue	Y	NR
35	Yellow	Y	NR
36	Yellow	Y	NR

Now we're going to play the animal game again. But this time;
[*IC condition*] you are going to play the word game at the same time. Remember I want you to tell me if the word is about boys, about girls, or about things. Ready?

TESTING (NO FEEDBACK; OT-2): Circle child's response. (A = Animal; NA = Non-Animal; Y= Yes; NR = No Response)

IC condition

1	Chick	**A**	NA
2	Cow	**A**	NA
3	Zebra	**A**	NA
4	Beaver	**A**	NA
5	Penguin	**A**	NA
6	Flamingo	**A**	NA
7	Deer	**A**	NA
8	Bear	**A**	NA
9	Fox	**A**	NA
10	Raccoon	**A**	NA
11	Dog	**A**	NA
12	Koala	**A**	NA
13	Polar Bear	**A**	NA
14	Frog	**A**	NA
15	Rooster	**A**	NA
16	Duck	**A**	NA
17	Walrus	**A**	NA
18	Kangaroo	**A**	NA
19	Goat	**A**	NA
20	Hamster	**A**	NA
21	Rhino	**A**	NA
22	Hedgehog	**A**	NA
23	Hippo	**A**	NA
24	Bluejay	**A**	NA
25	Fish	**A**	NA
26	Ostrich	**A**	NA
27	Goose	**A**	NA
28	Horse	**A**	NA
29	Moose	**A**	NA
30	Budgie	**A**	NA

1	Sister	**G**	B	T	O
2	Prince	G	**B**	T	O
3	Bus	G	B	**T**	O
4	Aunt	**G**	B	T	O
5	Brother	G	**B**	T	O
6	King	G	**B**	T	O
7	Mommy	**G**	B	T	O
8	Ball	G	B	**T**	O
9	Queen	**G**	B	T	O
10	Shoe	G	B	**T**	O
11	Daddy	G	**B**	T	O
12	Crayon	G	B	**T**	O
13	Princess	**G**	B	T	O
14	Uncle	G	**B**	T	O
15	Chair	G	B	**T**	O

16	Sister	**G**	B	T	O
17	Prince	G	**B**	T	O
18	Bus	G	B	**T**	O
19	Aunt	**G**	B	T	O
20	Brother	G	**B**	T	O
21	King	G	**B**	T	O
22	Mommy	**G**	B	T	O
23	Ball	G	B	**T**	O
24	Queen	**G**	B	T	O
25	Shoe	G	B	**T**	O
26	Daddy	G	**B**	T	O
27	Crayon	G	B	**T**	O
28	Princess	**G**	B	T	O
29	Uncle	G	**B**	T	O
30	Chair	G	B	**T**	O

PM instructions – Oh, there is one more thing. I have a bell just for cats, see. *Bring out bell.* So, if you see a picture with any cats, I don't want you to point to it. Instead, ring the bell, *ring be*ll, *move bell behind them*, it's behind you. Ring the bell when you see any cats, *point*. . But the rest of the time point to animals.

So what do you do when you see a picture of a cat? **T1[ ] T2[ ] T3[ ]**

If correct: That's right. You ring the bell.
If incorrect: Actually, when you see a picture of a cat, you ring the bell.

Repeat up to three times, if necessary.

Okay good. I have some things to do before you can play, so you can draw something first. Here are some paper and crayons (*time 3 min on phone with no beeper*).

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

TESTING (NO FEEDBACK; OT-3): Circle child's response.

Control Condition *(A = Animal; NA = Non-Animal; C=Cat)*

Set 1

1	Squirrel	A	NA	C
2	Owl	A	NA	C
3	Cat	A	NA	C
4	Mouse	A	NA	C
5	Penguin	A	NA	C
6	Dog	A	NA	C
7	Elephant	A	NA	C
8	Cat	A	NA	C
9	Giraffe	A	NA	C
10	Monkey	A	NA	C
11	Duck	A	NA	C
12	Bunny	A	NA	C
13	Panda	A	NA	C
14	Rhino	A	NA	C
15	Goat	A	NA	C

Set 2

1	Pig	A	NA	C
2	Cow	A	NA	C
3	Sheep	A	NA	C
4	Fish	A	NA	C
5	Flamingo	A	NA	C
6	Cat	A	NA	C
7	Zebra	A	NA	C
8	Dog	A	NA	C
9	Bear	A	NA	C
10	Hamster	A	NA	C
11	Cat	A	NA	C
12	Camel	A	NA	C
13	Frog	A	NA	C
14	Deer	A	NA	C
15	Chick	A	NA	C

Set 3

1	Budgie	A	NA	C
2	Walrus	A	NA	C
3	Beaver	A	NA	C
4	Raccoon	A	NA	C
5	Kangaroo	A	NA	C
6	Duck	A	NA	C
7	Fox	A	NA	C
8	Hedgehog	A	NA	C
9	Cat	A	NA	C
10	Bluejay	A	NA	C
11	Hippo	A	NA	C
12	Fish	A	NA	C
13	Ostrich	A	NA	C
14	Cat	A	NA	C
15	Moose	A	NA	C

Oh, can you remind me what you were supposed to do when you saw a card with a picture of a cat on it? Great! That is the end of this game

TESTING (NO FEEDBACK; OT-3): Circle child's response.
WM Condition *(A = Animal; NA = Non-Animal; C=Cat; Y= Yes; NR= No Response)*

Set 1

1	Squirrel	A	NA	C
2	Owl	A	NA	C
3	Cat	A	NA	C
4	Mouse	A	NA	C
5	Penguin	A	NA	C
6	Dog	A	NA	C
7	Elephant	A	NA	C
8	Cat	A	NA	C
9	Giraffe	A	NA	C
10	Monkey	A	NA	C
11	Duck	A	NA	C
12	Bunny	A	NA	C
13	Panda	A	NA	C
14	Rhino	A	NA	C
15	Goat	A	NA	C

Set 3

31	Budgie	A	NA	C
32	Walrus	A	NA	C
33	Beaver	A	NA	C
34	Raccoon	A	NA	C
35	Kangaroo	A	NA	C
36	Duck	A	NA	C
37	Fox	A	NA	C
38	Hedgehog	A	NA	C
39	Cat	A	NA	C
40	Bluejay	A	NA	C
41	Hippo	A	NA	C
42	Fish	A	NA	C
43	Ostrich	A	NA	C
44	Cat	A	NA	C
45	Moose	A	NA	C

Set 2

16	Pig	A	NA	C
17	Cow	A	NA	C
18	Sheep	A	NA	C
19	Fish	A	NA	C
20	Flamingo	A	NA	C
21	Cat	A	NA	C
22	Zebra	A	NA	C
23	Dog	A	NA	C
24	Bear	A	NA	C
25	Hamster	A	NA	C
26	Cat	A	NA	C
27	Camel	A	NA	C
28	Frog	A	NA	C
29	Deer	A	NA	C
30	Chick	A	NA	C

1	Green	Y	NR
2	Blue	Y	NR
3	Red	Y	NR
4	Red	Y	NR
5	Yellow	Y	NR
6	Green	Y	NR
7	Blue	Y	NR
8	Blue	Y	NR
9	Red	Y	NR
10	Blue	Y	NR
11	Green	Y	NR
12	Yellow	Y	NR
13	Yellow	Y	NR
14	Blue	Y	NR
15	Red	Y	NR
16	Green	Y	NR
17	Green	Y	NR
18	Yellow	Y	NR
19	Red	Y	NR
20	Green	Y	NR
21	Yellow	Y	NR
22	Blue	Y	NR
23	Blue	Y	NR
24	Red	Y	NR
25	Green	Y	NR
26	Yellow	Y	NR
27	Blue	Y	NR

28	Green	Y	NR
29	Blue	Y	NR
30	Red	Y	NR
31	Red	Y	NR
32	Yellow	Y	NR
33	Green	Y	NR
34	Blue	Y	NR
35	Blue	Y	NR
36	Red	Y	NR
37	Blue	Y	NR
38	Green	Y	NR
39	Yellow	Y	NR
40	Yellow	Y	NR

Oh, can you remind me what you were supposed to do when you saw a picture of a cat?
Great! That is the end of this game

TESTING (NO FEEDBACK; OT-3): Circle child's response.
IC condition *(A = Animal; NA = Non-Animal; C=Cat; G= Girl; B= Boy; T=Thing; O=Other)*

Set 1

1	Squirrel	A	NA	C
2	Owl	A	NA	C
3	Cat	A	NA	C
4	Mouse	A	NA	C
5	Penguin	A	NA	C
6	Dog	A	NA	C
7	Elephant	A	NA	C
8	Cat	A	NA	C
9	Giraffe	A	NA	C
10	Monkey	A	NA	C
11	Duck	A	NA	C
12	Bunny	A	NA	C
13	Panda	A	NA	C
14	Rhino	A	NA	C
15	Goat	A	NA	C

Set 2

16	Pig	A	NA	C
17	Cow	A	NA	C
18	Sheep	A	NA	C
19	Fish	A	NA	C
20	Flamingo	A	NA	C
21	Cat	A	NA	C
22	Zebra	A	NA	C
23	Dog	A	NA	C
24	Bear	A	NA	C
25	Hamster	A	NA	C
26	Cat	A	NA	C
27	Camel	A	NA	C
28	Frog	A	NA	C
29	Deer	A	NA	C
30	Chick	A	NA	C

1	Train	G	B	**T**	O
2	Mother	**G**	B	T	O
3	Son	G	**B**	T	O
4	Book	G	B	**T**	O
5	Sister	**G**	B	T	O
6	Hat	G	B	**T**	O
7	Father	G	**B**	T	O
8	Daughter	**G**	B	T	O
9	Bus	G	B	**T**	O
10	Brother	G	**B**	T	O
11	Grandmother	**G**	B	T	O
12	Ball	G	B	**T**	O
13	King	G	**B**	T	O
14	Cup	G	B	**T**	O
15	Grandfather	G	**B**	T	O
16	Queen	**G**	B	T	O
17	Prince	G	**B**	T	O
18	Truck	G	B	**T**	O
19	Aunt	**G**	B	T	O
20	Princess	**G**	B	T	O
21	Spoon	G	B	**T**	O
22	Mommy	**G**	B	T	O
23	Uncle	G	**B**	T	O
24	Daddy	G	**B**	T	O

Set 3

31	Budgie	A	NA	C
32	Walrus	A	NA	C
33	Beaver	A	NA	C
34	Raccoon	A	NA	C
35	Kangaroo	A	NA	C
36	Duck	A	NA	C
37	Fox	A	NA	C
38	Hedgehog	A	NA	C
39	Cat	A	NA	C
40	Bluejay	A	NA	C
41	Hippo	A	NA	C
42	Fish	A	NA	C
43	Ostrich	A	NA	C
44	Cat	A	NA	C
45	Moose	A	NA	C

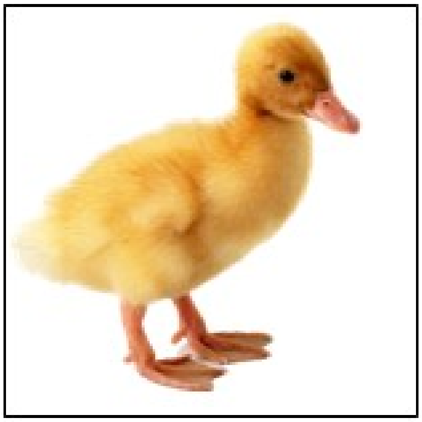
25	Train	G	B	**T**	O
26	Mother	**G**	B	T	O
27	Son	G	**B**	T	O
28	Book	G	B	**T**	O
29	Sister	**G**	B	T	O
30	Hat	G	B	**T**	O
31	Father	G	**B**	T	O
32	Daughter	**G**	B	T	O
33	Bus	G	B	**T**	O
34	Brother	G	**B**	T	O
35	Grandmother	**G**	B	T	O
36	Ball	G	B	**T**	O
37	King	G	**B**	T	O
38	Cup	G	B	**T**	O
39	Grandfather	G	**B**	T	O
40	Queen	**G**	B	T	O

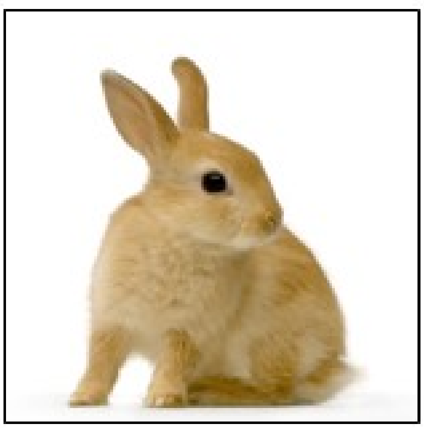
Oh, can you remind me what you were supposed to do when you saw a picture of a cat?

Great! That is the end of this game

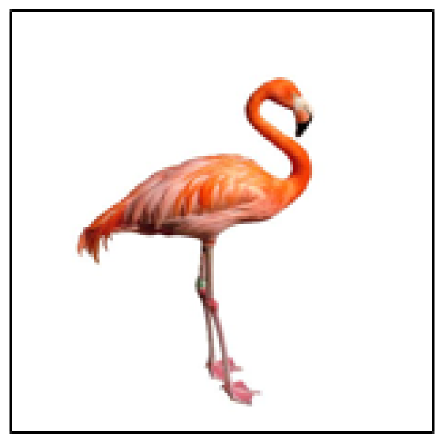
Appendix N: Prospective Memory Paradigm Stimuli

N1. Prospective Memory Non-Target Cards

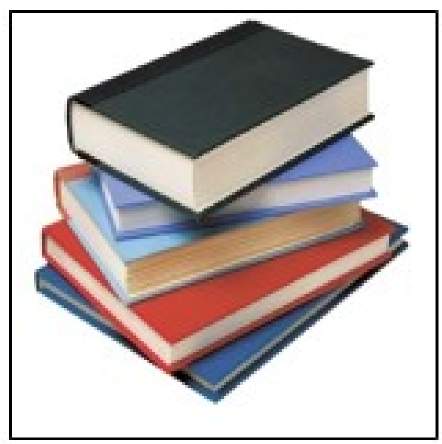


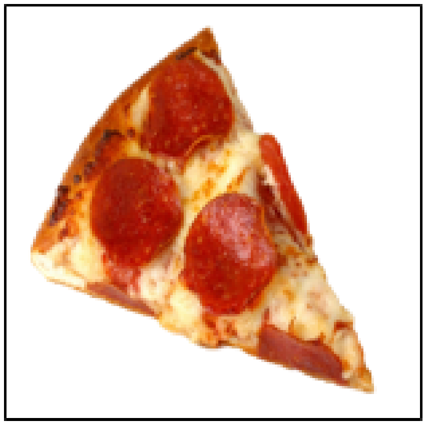



Crayola
CRAYONS
24



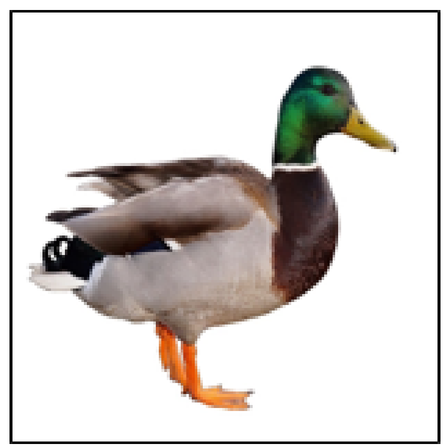

8
Crayola
MARKERS
CLASSIC COLORS



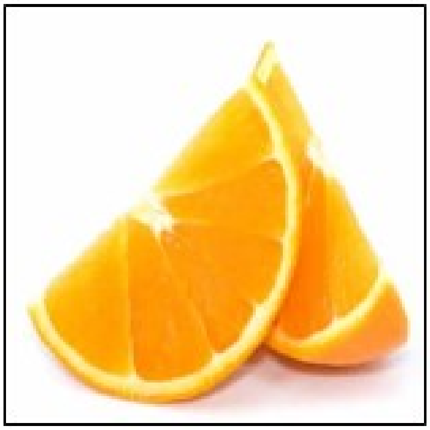


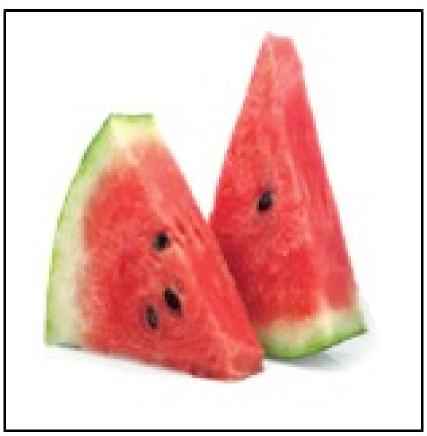

12
1
2
3
4
5
6
7
8
9
10
11


A
B
C

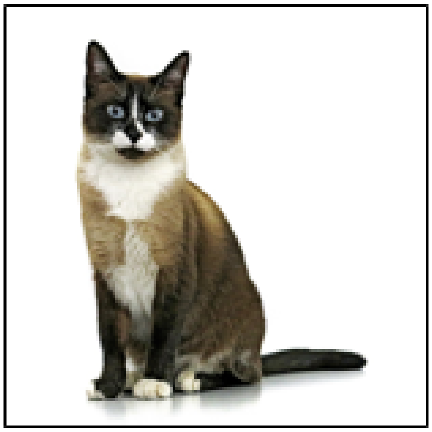



Minute
Maid.
100% JUICE
APPLE JUICE





N2. Prospective Memory Target Cards



Appendix O: Bell

Appendix P: Auditory Backward Digit Span

Source: Carlson et al. (2002)

"This is my friend, Willy. Whenever I say numbers, Willy says them backwards. Listen: **5 – 8**. (*Willy says*:) **8 – 5**. Now I want you to do the same as Willy and say my numbers backwards. Do you understand? Let's try one. Ready? Listen carefully. Remember to say the numbers backwards. **2 – 4**." *(score below)*

"Let's try another one. Remember to say the numbers backwards. **7 – 1**."

Digits Forward	Child's Response
i. **2 – 4** ("That's right!" or correct the mistake)	____ – ____ ; ____ – ____
ii. **7 – 1** ("That's right!" or correct the mistake)	____ – ____ ; ____ – ____

1.	**6 – 3**	_____ – _____
2.	**4 – 9**	_____ – _____
3.	**2 – 9 – 5**	_____ – _____ – _____
4.	**8 – 1 – 6**	_____ – _____ – _____
5.	8 – 5 – 2 – 6	_____ – _____ – _____ – _____
6.	4 – 9 – 3 – 7	_____ – _____ – _____ – _____
7.	**8 – 1 – 3 – 7 – 9**	_____–_____–_____–_____–____
8.	**4 – 2 – 5 – 8 –1**	_____–_____–_____–_____–____
9.	9 – 3 – 5 – 1 – 8 – 4	_____–_____–_____–_____–_____–_____
10.	6 – 5 – 8 – 4 – 2 – 7	_____ – _____ – _____ – _____ – _____ – _____

Appendix Q: Visual Backward Word Span

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

I'm going to show you some cards with some pictures on them. I will show you the picture on each card, one at a time, and say what it is, aloud. Then, I'll put them on the table, with the picture side down so we can't see it any more. Once you've looked at all of the pictures, I want you to tell me the names of them, but in backwards order.
So if I show you a cake *[show cake and then place face down]* **and a ball** *[show ball and place face down beside cake],* **I want you to tell me 'ball'** *[pointing to back of ball]* **and 'cake'** *[pointing to back of cake]***. Let's try one.**

PRACTICE TRIAL 1:

Show cat*. Name It:* **What's this? [cat] [other]**
Place card face down in a new row (below cake). Accept any reasonable answer.
Show grapes*. Name it:* **And what's this? [grapes] [other]**
Place card face down in a new row (below ball). Accept any reasonable answer.

Tell me the names of those pictures in backwards order: *Point as they name.* **[grapes– cat] ___** (√ or x)
If correct: **Good job, that's right!**
If incorrect: **Remember to tell me the pictures in backwards order.**
You saw "cat" then "grapes" so you need to tell me "grapes, cat".

PRACTICE TRIAL 2:

Let's try another one!
Show tree*. Name it:* **What's this? [tree] [other]**
Place card face down in a new row (below cat). Accept any reasonable answer.
Show pig*. Name it:* **And what's this? [pig] [other]**
Place card face down in a new row (below grapes). Accept any reasonable answer.

Tell me the names of those pictures in backwards order: *Point as they name.* **[pig – tree] ___** (√ or x)
If correct: **Good job, that's right!**
If incorrect: **Remember to tell me the pictures in backwards order.**
You saw "tree" then "pig" so you need to tell me "pig, tree".

Test Trials: DO NOT point to the back of pictures during test trials. For each new trial, place the cards in a row beneath the last trial – placing cards from left to right. Name each card for child before placing the card.

1. **Dog – Bus** _____ (√ or x)

2. **Hand – Snail** _____ (√ or x)

3. **Fox – Shoe – House** _____ (√ or x)

4. **Spoon – Book – Fish** _____ (√ or x)

5. **Bee – Sock – Kite – Leaf** _____ (√ or x)

6. **Cup – Bird – Drum – Plant** _____ (√ or x)

7. **Frog – Star – Barn – Chair – Corn** _____ (√ or x)

8. **Horse – Bed – Hat – Car – Heart** _____ (√ or x)

Appendix R: Happy/Sad

Source: Lagattuta, Sayfan & Monsour (2011)

Now we're going to play a different game!

Show happy.

This is happy, right? When you see this card, I don't want you to say 'happy'. No, I want you to say 'sad'.

Remove happy; show sad.

This is sad, right? When you see this card, I don't want you to say 'sad'. No, I want you to say 'happy'.

Training:

Show sad. If hesitation - **What do you say for this one?**

[S] [H] (Good.)

Show happy. If hesitation - **What do you say for this one?**

number of training trials

[S] (Good.) [H]

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

Testing - No feedback:
Circle or write in child's response, if not happy/sad:

1	**H**	S	________
2	H	**S**	________
3	**H**	S	________
4	H	**S**	________
5	H	**S**	________
6	**H**	S	________
7	**H**	S	________

8	H	**S**	________
9	**H**	S	________
10	H	**S**	________
11	H	**S**	________
12	**H**	S	________
13	H	**S**	________
14	**H**	S	________

15	H	**S**	________
16	**H**	S	________
17	H	**S**	________
18	H	**S**	________
19	**H**	S	________
20	H	**S**	________
21	**H**	S	________

Appendix S: Simon Says

Source: modified from Carlson (2005), as in Mahy et al. (2014)

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

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

If children fail, repeat them up to 3 times, but continue on the test trials.

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

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

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

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

Score only the non-Simon Says trials.
0 = commanded movement, 1 = partial movement,
2 = different movement, 3 = no movement

Score: ______/15

Appendix T: Peabody Picture Vocabulary Test-III

Source: Dunn & Dunn (1997)

Please refer to the PPVT manual. Testing pages are copyrighted.

Appendix U: Peabody Picture Vocabulary Test-4

Dunn & Dunn, 2007

Please refer to the PPVT manual. Testing pages are copyrighted.

Appendix V: Preliminary Analyses

Table V1.

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

	Mean (SD)			ANOVA		
	Control	WM-load	IC-load	*F*	*df*	*p*
Prospective Memory	4.17 (2.60)	4.33 (2.37)	3.05 (2.80)			
Ongoing Task (OT-3)	37.96 (1.43)	36.54 (4.88)	37.09 (4.02)	0.88	(2,67)	.42
Working Memory						
Auditory 1-back	94.90 (5.59)	93.33 (4.93)	96.70 (4.32)	2.62	(2,67)	.08
Visual Backward Word Span	1.92 (1.38)	1.38 (1.06)	2.26 (1.09)	4.00	(2,67)	.02
Auditory Backward Digit Span	0.87 (1.06)	1.21 (1.25)	1.36 (1.65)	0.81	(2,66)	.45
Inhibitory Control						
Verbal Labelling	76.98 (20.13)	81.57 (17.41)	84.31 (11.40)	1.12	(2,66)	.33
Happy/Sad	14.33 (5.42)	10.08 (5.37)	12.90 (6.38)	3.42	(2,67)	.04
Simon Says	7.25 (5.88)	8.54 (5.67)	8.90 (5.92)	0.52	(2,67)	.60
PPVT	81.71 (20.18)	75.67 (18.72)	82.50 (23.05)	0.77	(2,67)	.47
Age (in months)	57.88 (8.34)	59.92 (7.03)	60.64 (8.21)	0.77	(2,67)	.47

Note. Prospective Memory Total (0-6, n = 70), Ongoing Task (0-39; n = 70), Auditory 1-Back (0-100; n = 70), Visual Backward Word Span (0-8; n = 70), Auditory Backward Digit Span (0-10; n = 69), Verbal Labelling (0-100; n = 69) Happy/Sad (0-21; n = 70), Simon Says (0-15; n = 70), PPVT (20-160; n = 70).

Table V2.

Comparing Groups on Gender

	Control	WM-load	IC-load
Males	12	11	10
Females	12	13	12

-- *Note.* Gender did not differ by group, χ^2 (2) = 0.12, p = .942.

Table V3.

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

Measure	Skewness	Kurtosis
Total Prospective Memory	-0.65	-1.44
Working Memory		
Auditory 1-back	-0.74	-0.57
Visual Backward Word Span	0.20	-0.38
Auditory Backward Digit Span	0.80	-0.39
Inhibitory Control		
Verbal Labelling[5]	-1.74 (-0.90)	3.26 (0.35)
Happy/Sad	-0.39	-0.97
Simon Says	-0.21	-1.61
Vocabulary Test	-0.06	-0.19

Note. Scores within +/- 2.0 indicate normality.

[5] Square root transformation statistics presented in brackets

Appendix W: Principal Component Analysis

Table W1.

Component Loading for Working Memory Factor

	Component Loading
Auditory 1-back	0.79
Visual Backward Word Span	0.79
Auditory Backward Digit Span	0.76

Note. Extraction Method: Principal Component Analysis.

Table W2.

Component Loading for Inhibitory Control Factor

	Component Loading
Verbal Labelling (*transformed*)	0.81
Simon Says	0.80
Happy/Sad	0.71

Note. Extraction Method: Principal Component Analysis.