ABSTRACT


Preschool children are capable of displaying strategies in memory tasks and demonstrating an early understanding of memorization (e.g., Wellman, 1988; Baker-Ward, Ornstein, & Holden, 1984). Questions remain, however, about the origins of strategic behavior in early childhood. A great deal of recent attention has been devoted to the interrelations among working memory and measures of executive functioning/inhibitory control in elementary-school children (e.g., Schneider, Schumann-Hengsteler, & Sodian, 2005). The goal of this investigation was to extend this work to preschool children in order to examine possible influences on the emergence of deliberate remembering. Specifically, interrelations among working memory, inhibitory control, and deliberate task approaches were examined in 168 three-year-olds who participated in a large-scale, broadly-focused investigation of development, the Durham Child Health and Development Study. Although predicted relations among multiple domains of cognitive functioning were not observed, important findings did emerge. Previous results examining the use of deliberate task approaches were replicated in a more diverse and younger sample. Support for the presence of deliberate remembering in young preschoolers was found in a significant positive relation between language ability and the extent of deliberate task approaches. Finally, an unexpected relation between deliberate task approaches and subsequent recall performance was found; this result is discussed in relation to Utilization Deficiency. Implications for understanding some of the contributors to the emergence of deliberate remembering are presented, and directions for future research are discussed.
Deliberate Memory in Three-Year-Old Children: Interrelations Among Task Approaches, Working Memory, and Inhibitory Control

by
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BIOGRAPHY

Kimberly Turner was born in Merriam, Kansas to Howard and Mary Turner. In 2003, she graduated with Honors, receiving a Bachelors of Arts in Psychology and in Human Development from the University of Kansas. Kimberly’s research as a graduate student at North Carolina State University centers largely on understanding how different cognitive factors within a child may be associated with developmental changes in mnemonics and learning. Moreover, she is committed to learning how early mnemonic strategies and cognitive skills predict later academic abilities.
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Deliberate Memory in Three-Year-Old Children: Interrelations Among Task Approaches, Working Memory, and Inhibitory Control

In 1971, John Flavell, a patriarch of the study of child development, organized a symposium at the meeting of the Society for Research in Child Development entitled “What is memory development the development of?” Since it was first proposed, this pivotal question has helped define the study of children’s memory. More recently, this question was readdressed and expanded upon by Ornstein and Haden (2001). Ornstein and Haden argue that most research to date has examined “memory development,” which involves the description of the age differences in specific process through cross-sectional investigations. In contrast, Ornstein and Haden advocated a focus on the “development of memory,” which is driven by the characterization of development by examining the forces that propel memory processes into more complex and sophisticated processes. This principle of understanding how memory processes interrelate with more complex processes is a foundation of this proposal. Specifically, the current investigation was designed to provide a better understanding of how working memory and inhibitory control interact to predict performance of deliberate task approaches. Moreover, this examination has provided the initial time point for a future study that will longitudinally examine how cognitive capabilities propel the development of early mnemonics and strategies in hopes of beginning to address the key question of “What develops?”

Great strides have been made towards creating theories to explain the interrelations among cognitive processes through recent empirical studies examining the associations among theory of mind, working memory, effortful control, and executive functioning throughout childhood (e.g., Schneider, Lockl, & Fernandez, 2005). Nonetheless, there is still much work that
must be done, especially involving the emergence of these processes, in order to provide an integrated and multifaceted theoretical perspective on cognitive development. With regard to memory development, there is extensive programmatic research on remembering in infancy and toddlerhood (see Bauer, Wenner, Dropik, & Wewerka, 2000), and important longitudinal analyses of components of skilled remembering across the elementary school years (Schneider et al., 2005). Nonetheless, little is known about the emergence of deliberate remembering in development. In the present study, the influence of several components of cognitive functioning on early deliberate memory was examined. Specifically, the potential interrelations among task approaches, working memory, and inhibitory control in three-year-old children were investigated.

Strategic/Deliberate Memory

In order to understand the relevance and impact of research on strategic memory, it is important to discuss the historical context that has led to current perspectives on strategies. In the 1970s, research in developmental psychology was influenced by two major theoretical assumptions. The first was the notion that humans are cognitively active organisms; the second was the idea that the development of cognitive processes is interrelated or mutually inclusive. At the time that the active view of development was coming to fruition, Jean Piaget was conducting research that examined the development of general operations that he believed influenced intelligence and memory performance. Specifically, Piaget believed that these general operations underwent dramatic qualitative changes, which in turn produced qualitative shifts in memory (Piaget & Inhelder, 1973). This body of work by Piaget, in combination with the perspective that
humans are cognitively active organisms, motivated researchers to begin to study the qualitative development of memory.

In addition to the major theoretical shifts in the examination of memory development, a pioneering body of work by Flavell and his associates (e.g., Flavell, 1970; Flavell, Beach, & Chinsky, 1966) on mediators (such as rehearsal and organization) that could effectively promote recall was being established. Specifically, Flavell and his colleagues were interested in examining how children utilized verbal mediators in the intentional storage and recall of information in memory. Moreover, they studied in great detail two developmental limitations in children’s use of memory mediators. The first limitation was that children do not produce a particular strategy to enhance recall because they are incapable of doing so, a limitation described as a production deficiency (Flavell et al., 1966). On the other hand, the limitation might be that young children are capable of producing a behavior, but because that behavior will not “mediate” the relationship between the task stimulus and memory recall children do not exhibit the behavior. This limitation has been described as a mediation deficiency (Reese, 1962). The distinction between production and mediation deficiencies can be seen when children are trained to use a particular strategy. If teaching children to use the strategy increased recall, a productive deficiency was assumed to exist. However, if the child is taught the strategy and recall does not increase, a mediation deficiency was identified. Subsequent investigations (e.g., Bjorklund, Coyle, & Gaultney, 1992; Miller & Seier, 1994) identified an additional limitation in the development of memory strategies in which young children spontaneously produce a strategy without instruction, but do not experience mnemonic benefits from the application. This limitation has been labeled a utilization deficiency (Miller & Seier, 1994). These deficiencies are
not bound to a particular age; such that children do not overcome these limitations at a specific point in their life. These deficiencies need to be considered in relation to the development of a particular strategy. For example, the strategy of labeling appears earlier in life (in preschool) than categorization (in elementary school); yet, children could exhibit production, mediation, and/or utilization deficiencies when acquiring both strategies individually.

The work of Flavell and his associates led to the conclusion that memory development in children could be understood largely as the transition from nonstrategic to strategic behavior (see Schneider & Pressley, 1997, for review). Moreover, Flavell’s work inspired more than three decades of research examining the use and significance of strategies, including assessments of the relation between knowledge and strategies (e.g., Bjorklund & Buchanan, 1989; Schneider & Bjorklund, 1992) and the relation between strategies and metamemory (e.g., DeMarie & Ferron, 2003; Fabricius & Cavalier, 1989).

**Strategic/Deliberate Behaviors in Preschool Children**

In contrast to Flavell’s characterization of preschool children as having very limited strategic memory skills, many researchers have represented preschool-age children as possessing tactics for deliberate remembering, at least in some task settings. In a comprehensive review, Wellman (1988) argued that preschool children show evidence for strategies in memory tasks and demonstrate an early understanding of memorization. Specifically, Wellman described how three- and four-year-old children’s behavior during memory activities is deliberate, intentional, and purposeful. Supporting these characterizations, he provided evidence that preschoolers’ tactics for deliberate remembering can often be strategic and that preschool-age children vary their use of strategies across different problems in accordance with task demands.
Other investigators have concurred with Wellman’s depiction of preschoolers as demonstrating strategic memory in some contexts. Bray and his associates (Bray, Reilly, Villa, & Grupe, 1997) conducted a comprehensive review of strategy development in which they emphasized that children as young as 18 months use external orientations (e.g., pointing, visually examining, touching) in tasks that require the child to remember the location of objects. For example, work by DeLoache, Cassidy, and Brown (1985) found that during a hide-and-go-seek game, children 18 to 24 months of age looked at the hiding place, pointed to it, hovered near it, and even peeked at a hidden object. Moreover, Schneider and Pressley (1997) described a transition to the more active deployment of attention at about age four, when children develop the ability to actively scan their environments, rather than being passively drawn to an object’s novelty or salience. The views of Bray and the observations of Schneider and Pressley have been supported through research by Baker-Ward, Ornstein, and Holden (1984), in which the authors examined deliberate memory capabilities and limitations among preschool children during an Object Memory Task. Specifically, Baker-Ward et al. found that preschool children displayed different behaviors depending upon whether they were asked to either remember or play with a set of stimulus objects that they would subsequently remember. When given the instruction to try to remember the objects, children spent more time engaging in on-task or study-like behaviors with the objects, compared to the task approach of children instructed to play. However, the authors also reported that there were few links between the use of overt mnemonic behaviors and children’s subsequent recall of the objects among the groups of children younger than six years of age. Baker-Ward et al.’s original findings have been replicated more recently in investigations by Haden, Ornstein, Eckerman, and Didow (2001) and Rudek and Haden (2005). These
investigations have also supported the occurrence of a utilization deficiency in three-year-olds during this task, such that there is a developmental lag between spontaneous strategy production and strategy effectiveness (e.g., Coyle & Bjorklund, 1996; Lange & Pierce, 1992; Miller, Seier, Barron, & Probert, 1994).

In conclusion, research has shown that although young children may not engage in adult-like strategies, such as rehearsal, categorization, and elaboration, they do show deliberate and strategic behaviors in some memory tasks. Moreover, some researchers would argue that these strategic behavioral tendencies are important in understanding the development of memory strategies (Wellman, 1988). In other words, children’s very early strategy-like behaviors or “proto-strategic” behaviors, although not as well-organized and premeditated as adult-like strategies, may provide valuable insight into the development of strategic memory. For example, the use of proto-strategies could aid in understanding how children come to develop more sophisticated, adult-like strategies; specifically, because these early behaviors may predict children’s later use of mnemonics. This characterization is consistent with the extensive literature on the utilization deficiency (Bjorklund, Miller, Coyle, & Slawinski, 1997), which assumes that these early strategic behaviors have developmental significance even before they have mnemonic benefit. Therefore, examining preschool children’s use of strategic or deliberate memory behaviors is important and noteworthy, regardless of whether or not these strategies yield effective mnemonic outcomes.

**Possible Predictors of Deliberate/Strategic Memory**

Much research has shown that the acquisition of strategic memory behaviors is a developmental process (see Schneider & Pressley, 1997, for a review). Specifically, research on
strategy development has focused on age-related improvements in the acquisition of new strategies, refinement of existing ones, and the application of existing strategies to new situations. These changes in strategic memory behaviors have been conceptualized as a balance between the cost of mental effort and the benefit of remembering (Siegler & Alibali, 2005). When a child first applies a memory strategy in task performance, the costs in cognitive resources required to use that strategy are greater than they will be later on when the child has more experience and practice. Traditionally, costs to cognition have been described and examined as limitations in mental capacity, such that producing a highly effortful strategy demands a large amount of the capacity of a novice strategy producer (e.g., Bjorklund & Harnishferger, 1987; Woody-Dorning & Miller, 2001). However, at present there has been little research that has examined the potential contributions that other cognitive processes, such as working memory or inhibitory control, make toward children’s use of deliberate memory strategies. As described in more detail in following sections, the development of working memory and inhibitory control enables a richer interaction with our world and supports the opportunity to engage in goal-oriented behaviors (e.g., Reznick, Marrow, Goldman, & Snyder, 2004). Hence, it is reasonable to predict that developments in these domains might contribute to the emergence of memory strategies. In the following sections, the early development of working memory and inhibitory control is briefly reviewed.

Working Memory

The term *working memory* was first introduced to the psychological lexicon in 1974 in a classic article by Alan Baddeley and Graham Hitch. Before the publication of this work, cognitive psychologists only distinguished between short- and long-term memory. Information
processing was thought of as the interaction between the limited and rapidly decaying capacity of short-term memory and the more permanent and larger capacity of long-tem memory (Neisser, 1967). Baddeley and Hitch were dissatisfied with this model of memory because of its emphasis on the maintenance of information in short term memory through rehearsal. They believed that memory could not be described without understanding how information is manipulated and transformed while it is being maintained in the short-term storage. Therefore, working memory is defined both by the ability to maintain information in the short-term store and the capacity to simultaneously manipulate and transform the information (Schneider & Bjorklund, 1998).

Moreover, limitations in working memory may stem from factors other than restricted capacity. Working memory is also affected by the amount of information that can be processed (speed of processing) or attended to (executive monitoring) at a given movement in time (Miyake & Shah, 1999).

When examining working memory in young children, it is vital that measures assess the components of capacity and manipulation in a manner that is sensitive to the developmental status of the participants. Previous research by Reznick, Marrow, Goldman, and Snyder (2004) has provided a developmentally appropriate measure of working memory in the very young. These researchers assessed toddlers’ ability to retain information such as the identity or location of an event for seconds or minutes and then to use this information to develop a plan, perform a task, or solve a problem. Specifically, they used a delayed-response task previously administered to non-human primates (Hunter, 1913), in which a desired object is hidden in one of several possible locations, to assess working memory. In this task, a child is first presented with a target object that is placed in one of several possible locations, and then a delay involving distraction is
provided, following which the child attempts to locate the object. This task is performed across multiple trials that become progressively more difficult by increasing the number of possible locations and the length of the delay. The target locations are varied randomly across the multiple trials. The delayed-response task has been used by many authors with children as young as one year and as old as five years (e.g., Diamond, 1985; Pelphrey, Reznick, Goldman, Sasson, Morrow, Donahoe, & Hodgson, 2004) as a means to assess working memory. The delayed-response task has construct validity as a measurement of working memory because the information specifying the hidden object’s location must be maintained across a delay despite distraction and must be updated on each new trial.

Inhibitory Control

Inhibitory control is defined as the ability to regulate the deployment of attention and inhibitory processes (Baddeley, 1996). In addition, inhibitory control is conceptualized as a cognitive ability of the executive system, which is a theorized cognitive system that controls and manages other cognitive processes such as working memory. Inhibitory control is commonly assessed through children’s abilities to impede their prepotent response history (e.g., Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Carlson & Moses, 2001). For instance, in young children, it is often assessed by requiring a child to perform a behavior that is contrary to or the opposite of the normal behavioral response. In the Day/Night task (Gerstadt, Hong, & Diamond, 1994), for example, a child responds “day” to an image of a moon and stars and “night” to an image of the sun (e.g., Davidson, Alos, Anderson, & Diamond 2006; Kochanska et al., 1996).
Neurological Basis for Inhibitory Control

Present perceptions of inhibitory control have been developed on the basis of research involving the brain’s prefrontal cortex. The prefrontal cortex is located in a privileged part of the brain, such that there are intricate connections and feedback loops between it and virtually all other parts of the brain. The prefrontal cortex is a relatively late-appearing structure in the evolution of the brain, and as a consequence, it is noticeably large in humans relative to other mammals (Luciana, 2003). Another distinctive characteristic of the human frontal cortex is that it is the last brain region to reach full maturity (Diamond, 2002) and the first to deteriorate with age (Kemper, 1994). The development of the frontal lobes, which comprise the prefrontal cortex, increases sharply from birth to the third year of life, followed by a less pronounced growth spurt from about four years of age to about seven years of age. Thereafter, there is a slow increase in the size of the frontal lobes until young adulthood (Luria, 1973).

Research on inhibitory control has historical roots in neuropsychological studies of patients with prefrontal lobe damage. It has been known for a long time that individuals with damage to the prefrontal cortex exhibit severe problems in their ability to regulate and control their behavior. Moreover, despite the fact that these patients may perform well on various cognitive tasks and IQ tests, they show impairment on a host of executive tasks including tasks of inhibitory control (e.g., Damasio, 1994; Shallice & Burgess, 1991). Such tasks have included the Wisconsin Card Sorting Test (WCST) (Berg, 1948), which requires that participants shift from sorting based on one category to another, and the Stroop task, which targets inhibiting prepotent responses (Stroop, 1935). Specifically, in the WCST, most normal adults are able to learn the new sorting category after just a few trials, whereas patients with prefrontal lobe lesions
often make preservation errors (Milner, 1964) due to an inability to inhibit the original sorting category. Similar to the results obtained with the WCST, in the Stroop task patients with prefrontal lesions exhibit a higher degree of interference or are less able to inhibit prepotent responses compared to unimpaired adults. Specifically, patients with prefrontal lesions performed significantly more poorly and often failed to inhibit naming the word in a task in which they were instructed to disregard the name of the word but to name the color of ink in which the word was written (Benton, Stuss, Naesar, Weir, Kaplan, & Levine, 1981). Taken together, these investigations have shown that a prefrontal cortex deficit manifests itself as an inability to overcome or inhibit inappropriate responses.

Recent neuropsychology investigations by Diamond and her colleagues (e.g., Diamond, 2002; Davidson, Amso, Anderson, & Diamond, 2006) have helped shed light on the relation between the prefrontal cortex maturation and inhibitory control. Using neuroimaging (fMRI), these investigators found that three and four-year-olds who were not successful at inhibiting their dominant or prepotent response during a Simon-says task demonstrated more activation in their temporal lobes than in their prefrontal cortex, whereas those who succeeded demonstrated the opposite pattern. These findings are important because they illustrate that young children who cannot successfully inhibit prepotent responses are not activating the region of the brain which is associated with inhibitory control. Therefore, these results are consistent with a potential relation between prefrontal cortex maturation and inhibitory control at approximately three years of age.

**Inventory of Inhibitory Control**

All measures of inhibitory control reviewed thus far have concentrated on task orientated performance. Attempts have been made, however, to quantify inhibitory control in children
through a standardized behavioral inventory. The Behavior Rating Inventory of Executive Function – Preschool version (BRIEF-P; Gioia, Espy, & Isquith, 2002) was developed to try to overcome problems with behavioral assessments of executive functioning and inhibitory control arising from motor and verbal proficiency limitations. Specifically, the BRIEF-P is an inventory of questions completed by the caregiver (parent, teacher, or day care provider) to rate the child's executive functioning within the context of his or her everyday environments (e.g., home and preschool). The BRIEF-P was developed to assess executive functioning through targeting the processes of inhibition, shifting of attention, emotional control, working memory, and planning/organization. The Brief-P has been validated through high convergent and discriminate validity with the ADHD Rating Scale-IV- Preschool Version (DuPaul, Power, Anastopoulous, & Reid 1998), the Child Behavior Checklist (Achenbach, 1991) and the Behavior Assessment System for Children-Parent Rating Scale (Reynolds & Kamphaus, 1992). Concisely, the BRIEF-P provides a unique approach to assessing and understanding children’s inhibitory control that is ecologically valid and efficient; as such it seems advantageous to consider such inventory measures when examining inhibitory control.

*Relationships between Working Memory and Inhibitory Control*

To provide an accurate and complete understanding of inhibitory control, it is important to understand the relationship between inhibitory control and working memory. The concept of inhibitory control first originated in Baddeley and Hitch’s (1974) model of working memory with the component of the central executive. As mentioned earlier, an essential component of working memory is the ability to regulate one’s attention to a specific stimulus at a given moment in time. It is this component of working memory that Baddeley and Hitch posited as
controlled by the central executive. Specifically, Baddeley and Hitch postulate that it is the responsibility of the central executive to control and regulate the three major slave systems of working memory: the phonological loop, the visuospatial sketch pad, and the episodic buffer, which operate in isolation of each other.

Baddeley (1996) further explained his concept of the central executive by defining its four main executive functions. First, it was hypothesized that it is the responsibility of the central executive to coordinate the processing of simultaneous tasks, a process defined as task switching. Secondly, Baddeley thought the central executive had the responsibility of controlling the encoding and retrieval strategies of temporarily stored information. In addition to just controlling information in short-term storage, it was also hypothesized that it was the central executive’s duty to control the retrieval and manipulation of long-term stored information. Finally, Baddeley theorized that it was a function of the central executive to regulate the selection of attention and inhibitory processes. The conceptualization of these executive functions, including inhibitory control, has found a recent resurgence based on the growing understanding of the neurological processes of the brain.

Even though there is much support for the idea of executive functioning, there have also been inconsistencies in the literature surrounding its exact role in relation to working memory. Theoretically, executive functioning and inhibitory control have different histories and meanings in the various disciplines of psychology. In the experimental tradition, executive functioning and inhibitory control are usually treated as part of the working memory system, vis-à-vis Baddeley and Hitch’s (1974) model of working memory. Conversely, in the neuropsychology tradition, working memory, similar to inhibitory control, tends to be a subcomponent of executive
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functioning. This conceptualization is illustrated by the work of Roberts and Pennington (1996), who came to the conclusion that working memory is a more specific cognitive ability than executive functioning.

Empirically, there is also mixed evidence from studies examining the relation between inhibitory control and working memory. Specifically, some correlation studies with young adults (Miyake & Shah, 1999) and elementary school children (Schneider, Lockl, & Fernandez, 2005) have found little correlation between measures of executive functioning and working memory. In contrast, research by Carlson and Moses with preschool children (2001; Carlson, Moses, & Breton, 2002) and by Davidson, et al. (2006) with children from 2 to 13 years of age, found that executive functioning, and namely inhibitory control, is positively correlated with working memory. Due to the ambiguity between working memory and inhibitory control, it seems beneficial to examine inhibitory control and working memory as separate constructs in order to investigate empirically the possible interdependency between these constructs. Moreover, by examining these constructs as distinct, it increases the possibility that a conceptually precise enough understanding of the construct of inhibitory control to allow for the ability to make predictions (e.g., Oberauer, 2005).

Existing Theoretical Models of the Development of Children’s Memory

As mentioned at the beginning of this proposal, within recent years there has been a growing interest in examining the development of memory of children in conjunction with examining the joint actions of cognitive processes. Notable examples of such research are the Würzburg Model (Schneider, Schlagmüller, & Visé, 1998) and the Utilization Deficiency Model (DeMarie, Miller, Ferron, & Cunningham 2004), which are theoretical models developed
through path analyses to attempt to explain relations among capacity, metamemory, strategy use, and recall. These models have specifically focused on development occurring between 5 and 11 years of age. The Würzburg Model, as illustrated in Figure 1, proposes a linear relation from cognitive resources (capacity and verbal IQ) to metamemory to strategy usage to recall performance. The Utilization Deficiency Model, as summarized in Figure 2, represents an expansion of the Würzburg Model to propose a more complex relation between these processes. Similar to the Würzburg Model, the Utilization Deficiency Model suggests that, with increasing age, capacity and metamemory increase, which in turn facilitates strategy production, which in turn enhances recall. The Utilization Deficiency Model takes the Würzburg Model a step further by incorporating an additional pathway that represents the link from strategy production to strategy effectiveness. However, unlike the Würzburg Model, the Utilization Deficiency Model does not contain a component of verbal ability, which was found to be a significant predictor of metamemory in the Würzburg Model.

Figure 1. Würzburg Model of Children’s Memory Performance (Schneider, Schlagmüller, & Visé, 1998)
DeMarie, Miller, Ferron, and Cunningham (2004) conducted path analyses of the Würzburg Model’s and the Utilization Deficiency Model’s ability to predict young children’s (kindergarten to fourth grade) ability to recall a list of 18 words. They found that the Würzburg Model accounted for approximately 42% of the variance in recall and the Utilization Deficiency Model has accounted for approximately 48% of the variance in recall. The success of these models in predicting recall performance illustrates the importance of examining the contributions of multiple cognitive processes. Neither model, however, is clearly applicable to the emergence of strategic memory in preschool children. The proposed research was designed to accomplish the initial steps in developing such a model by identifying influences on the early expression of strategic memory behaviors. Specifically, the interrelations among working memory, executive functioning, and early deliberate memory behavior will be examined. Moreover, similar to research with the Würzburg Model, this investigation examined whether or not these processes are interrelated when accounting for language abilities.
Proposed Research

Rationale

Despite the attention given to deliberate memory, working memory, and inhibitory control in isolation, research examining the interrelationships among these three processes in children is sparse. As mentioned earlier, the relationships among working memory and measures of executive functioning has received considerable examination. (e.g., Davidson, Amos, Anderson, & Diamond, 2006; Schneider, Schumann-Hengsteler, & Sodian, 2005). However, this research has yielded inconsistent findings, warranting the need for further investigations.

In addition to the work on executive functioning and working memory, there has been increased interest in examining joint cognitive processes to explain strategy development. The Würzburg Model (Schneider, Schlagmüller, & Visé, 1998) and the Utilization Deficiency Model (DeMarie, Miller, Ferron, & Cunningham, 2004) have enabled great strides in the understanding of the development of memory during the elementary school years. Nonetheless, the present literature does not extend this type of research to onset of strategic memory in preschool children. Applying such models to these children could provide insight into the current understanding of individual differences in young children’s use of strategies. Therefore, this investigation expanded on the work of Schneider and DeMarie by examining early strategic memory in three-year-olds. Moreover, this research provided the unique element of integrating research on executive functioning and working memory into these models. This integration is assumed to be due to the fact that strategic or deliberate memory requires children to maintain and manipulate information (working memory) and to focus attention and inhibit their prepotent responses (executive functioning).
In summary, the overarching goal of this research was to add to the existing knowledge of interrelations among deliberate memory, working memory, and inhibitory control by addressing inconsistencies in previous research and expanding upon the current models of the development of strategic memory.

Specific Aims and Hypotheses

Aim 1. To describe task approaches used by three-year-olds during a task of deliberate memory.

Previous research examining deliberate or strategic memory in preschool children’s memory has concluded that children as young as three show evidence of strategies for remembering during memory tasks (e.g., Wellman, 1988; Baker-Ward, Ornstein, & Holden, 1984; Bray, Reilly, Villa, & Grupe, 1997). Therefore, the first aim of this investigation was to describe the behaviors that the participants used during a task of deliberate remembering, (i.e., the Object Memory Task created by Baker-Ward et al. (1984)). Specifically, the current examination described and compared the use of deliberate remembering task approaches (e.g. manipulation, pointing) and non-deliberate remembering task approaches (e.g. playing, distraction), as defined Baker-Ward, et al. and used more recently by Haden, Ornstein, Eckerman, and Didow (2001) and Rudek and Haden (2005). As noted above, the present investigation concentrated on describing the occurrence of deliberate behaviors rather than their effects on recall because previous research (e.g. Baker-Ward et al., 1984) has documented a utilization deficiency in early strategy development. However, to replicate previous work, the relation between deliberate memory behaviors and recall in the Object Memory Task was also explored. It should be noted that the measures obtained through the completion of this aim will be utilized in future, longitudinal analyses.
Aim 2. To examine the relationship between measures of working memory and inhibitory control.

At present, there is inconsistent evidence about the relation between inhibitory control and working memory in children. As stated previously, some studies (e.g. Miyake & Shah, 1999; Schneider, Lockl, & Fernandez, 2005) have found little relation between measures of inhibitory control and working memory, whereas others (e.g. Carlson & Moses, 2001; Davidson, Amos, Anderson, & Diamond, 2006) have reported significant correlations between measures of inhibitory control and working memory. In addition, most of the research examining this potential relation has concentrated on kindergarten and elementary school children; a notable exception is the work by Carlson and Moses (2001; Carlson, Moses, & Breton, 2002). Therefore, the second aim of this research was to expand the current understanding of the potential linkage between inhibitory control and working memory by examining the relation between measures of inhibitory control and working memory in three-year-olds, when children first exhibit the ability to inhibit their prepotent responses (Carlson and Moses, 2001).

Hypothesis 1. It was hypothesized that the measure of working memory, as assessed by the Cups Working Memory Task (adapted from Reznick, Fueser, & Bosquet, 1998), would be positively associated with inhibitory control as indexed by performance on three age appropriate, Stroop-like tasks: the Unicorn/Dragon task (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996), the Day/Night task (Gerstadt, Hong, & Diamond, 1994), and the Grass/Snow task (Carlson & Moses, 2001). Preliminary analyses determined whether performance on these tasks should constitute a composite measure or whether they should be examined individually.

Aim 3. To examine the interrelationships among measures of working memory, inhibitory control, and deliberate memory.
At present, research examining associations among cognitive processes in three-year-olds have not specifically examined the potential interrelations among working memory, inhibitory control, and deliberate memory. However, as mentioned earlier, there are reasons to predict associations among these variables. In particular, research has shown that measures of working memory and inhibitory control in older children (e.g. Carlson & Moses, 2001; Davidson, Amso, Andrson, & Diamond, 2006) are positively correlated. Previous research has also shown that in elementary school children, measures of short-term memory capacity\(^1\) are positively correlated with strategy usage (e.g. Schneider, Schlagmüller, & Visé, 1998; DeMarie, Miller, Ferron, & Cunningham, 2004). Previous work by Schneider (e.g., Schneider et al., 1998, Schwenck, Bjorklund, & Schneider, 2007), as seen in the Würzburg Model of Children’s Memory Performance, has also shown that that verbal IQ (language ability) is positively correlated with strategy usage. Therefore, the third aim of this investigation was to examine potential interrelations among measures of working memory, inhibitory control, and deliberate memory in three-year-olds, controlling for the effects of language ability.

*Hypothesis 2:* It was hypothesized that performance on the inhibitory control tasks, as assessed by the Unicorn/Dragon task, the Day/Night task, and the Grass/Snow task, would positively predict the occurrence of deliberate memory behaviors as assessed by the Object Memory Task.

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\(^1\) It should be noted that short-term memory capacity and working memory are not the same cognitive process; nonetheless, the positive relation between measures of memory capacity and strategy usage provides evidence for the potential relationship association between working memory and deliberate memory.
Hypothesis 3: It was hypothesized that performance on the working memory task, as assessed by the Cups Working Memory Task would positively predict the occurrence of deliberate memory behaviors as assessed by the Object Memory Task.

Hypothesis 4: It was hypothesized that both performance on the working memory task and the three inhibitory control tasks would each positively predict a unique amount of the variance associated with the occurrences of deliberate task approaches.

Hypothesis 5: It was hypothesized that after controlling for language abilities, as assessed by the Preschool Language Scale – 4th Edition (PLS-4; Zimmerman, Steiner, & Pond, 2002), both performance on the working memory task and three inhibitory control tasks would have a significant positive relationship with the occurrences of deliberate task approaches.

Aim 4. To examine the relation between behavioral or task orientated measures of inhibitory control and standardized behavioral inventory of executive functioning.

As described earlier, the Behavior Rating Inventory of Executive Function – Preschool version (BRIEF-P; Gioia, Espy, & Isquith, 2002) is a standardized behavioral inventory of executive functioning. The measure has been validated with the clinical assessment such as ADHD Rating Scale-IV- Preschool Version (DuPaul, Power, Anastopoulous, & Reid 1998), the Child Behavior Checklist (Achenbach, 1991) and the Behavior Assessment System for Children-Parent Rating Scale (Reynolds & Kamphaus, 1992). Therefore, the fourth aim of this research was to examine the relation between the BRIEF-P and task oriented measures (i.e., laboratory task performance) of inhibitory control. Examining the potential association between the task oriented and parent report measures has implications for the conceptualization and validation of task oriented measures of inhibitory control.
Hypothesis 6. It was hypothesized that the scores on the BRIEF-P would be positively associated with behavioral measures of inhibitory control. Specifically, it is hypothesized that there would be a positive correlation between the inventory’s inhibition subscale and performance on the Unicorn/Dragon task, the Day/Night task, and the Grass/Snow task.

Method

Participants

All participants were recruited as part of the Durham Child Health and Development Longitudinal Study (DCHD). Recruitment began in August, 2002 and was completed in January, 2004. A total of 206 families with full-term, healthy three-month-old infants were enrolled during this time. Participants were selected in accordance with a stratified sampling plan designed to reflect the recruitment city’s demographic diversity (ethnicity and income). Attempts were to have approximately equal representation of below poverty African American (N=70) and Caucasians (N=36) and above poverty African American (N=47) and Caucasians (N=53). Even though the representation in the sample of the four participant groups was not equivalent ($\chi^2 (3, N = 206) = 7.6, p < .05$); there was equal representation of above-poverty African Americans and above poverty Caucasians ($\chi^2 (1, N = 100) = 0.36, p > .05$), and equal representation of above-poverty Caucasians and below poverty Caucasians ($\chi^2 (1, N = 89) = 3.25, p > .05$). Between the enrollment at 3 months and the 36 month visit, 38 families dropped out of the study, leaving a remaining sample of 168 families, which was a non-significant attrition ($\chi^2 (1, N = 370) = 3.12, p < .05$). The remaining sample consisted of 57 below poverty African American families, 25

\footnote{Written permission to acquire and utilize data from the DCHD study was obtained from the co-directors of the investigation, Drs. Martha Cox and Peter Ornstein.}
below poverty Caucasian families, 40 above poverty African American families, and 46 above poverty Caucasian families. Chi-square analyses were conducted to determine if attrition was associated with demographic groups. Results indicated that the attrition was not significant for below poverty African Americans ($\chi^2(1, N = 127) = 1.31, p > .05$), below poverty Caucasians ($\chi^2(1, N = 61) = 1.98, p > .05$), above poverty African Americans ($\chi^2(1, N = 87) = 0.56, p > .05$), and above poverty Caucasians ($\chi^2(1, N = 99) = 0.50, p > .05$). Moreover, there were no significant effects of attrition for either African Americans ($\chi^2(1, N = 214) = 1.87, p > .05$) and Caucasians ($\chi^2(1, N = 160) = 2.03, p > .05$) and for either below poverty families ($\chi^2(1, N = 188) = 3.06, p > .05$) and above poverty families ($\chi^2(1, N = 186) = 1.05, p > .05$).

The DCHD study was uniquely designed to describe interrelated patterns of qualitative and quantitative change in social, emotional, and cognitive functioning from birth to early schooling through a systems model of biological, psychological, interpersonal, and broader contextual processes. Every six months, the children and their parents participated in home or laboratory visits that included a wide range of measures designed to assess social, emotional, and cognitive functioning. Specific to the current investigation, all measures of interest were completed during two assessments conducted when the target child was between 36 and 40 months of age. Families received compensation of about $200 each year for their participation, for a total of $650 for the whole study. Families also receive payment for travel costs or taxi fare for visits to the project’s playroom.

**Materials**

In order to administer the Object Memory Task the following materials were required: wooden board, cloth to cover objects, objects to be remembered (lid, ring, frog, key, hat, truck,
cup, ball, sunglasses, bell, and block), and a stopwatch. To administer the working memory task a board with marked locations, a wooden screen, six cups, stickers, block, small bag, and stopwatch were required. A unicorn puppet and a dragon puppet were required to complete the unicorn/dragon task. To complete the day/night task, 4 inch by 6 inch day/night cards were needed. The day card had a white background and had a picture of a yellow sun. The night card had a black background and a picture of a white crescent moon and stars. To complete the grass/snow task, a placemat that has two child-sized felt hand shapes centered beneath a white card and a green card was required. Lastly, the Preschool Language Scale 4th Edition (PLS-4) book is needed to administer the PLS-4.

Procedures

Overview of 36-Month Visit. The 36-month assessment took place over two visits that each required approximately one and a half to two hours for completion. During the first visit, the target child completed the Preschool Language Scale-4 (PLS-4), while all other tasks (deliberate memory, working, memory, and inhibitory control) were completed during the second visit, which on average occurred 5.44 days after the first visit. An overview of the visit protocols can be found in Appendix A. All tasks with the target child were administered at the DCHD Study’s playroom, which was set up for inconspicuous videotaping and observations via one-way mirror. All tasks were administered by research assistants employed by the DCHD Study, who were thoroughly trained by faculty members at the Center for Developmental Science at the University of North Carolina – Chapel Hill, who had experience in administering the assessments. In addition, a series of questionnaires were mailed to the parents before their scheduled visits. Specific to the current investigation, mothers completed the Behavior Rating
Inventory of Executive Function - Preschool Version (BRIEF-P) at the second 36-month visit. A summary of all tasks utilized in this proposal can be located in Table 1 and are described in more detail below.

Table 1

<table>
<thead>
<tr>
<th>Task</th>
<th>Construct Assessed</th>
<th>Primary Reference</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Memory Task</td>
<td>Deliberate Memory</td>
<td>Baker-Ward, Ornstein &amp; Holden, 1984</td>
<td>0 - 24</td>
</tr>
<tr>
<td>Cups Working Memory Task</td>
<td>Working Memory</td>
<td>Reznick, Fueser, &amp; Bosquet, 1998</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Unicorn/Dragon Task</td>
<td>Inhibitory Control</td>
<td>Kochanska, Murray, Jacques, Koenig, &amp; Vandegeest, 1996</td>
<td>0 - 30</td>
</tr>
<tr>
<td>Day/Night Task</td>
<td>Inhibitory Control</td>
<td>Gerstadt, Hong, &amp; Diamond, 1994</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Grass/Snow Task</td>
<td>Inhibitory Control</td>
<td>Carlson &amp; Moses, 2001</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Behavior Rating Inventory of Executive Function</td>
<td>Executive Function/Inhibitory Control</td>
<td>Gioia, Espy, &amp; Isquith, 2002</td>
<td>$M=50$ $SD=10$</td>
</tr>
</tbody>
</table>

Deliberate Memory: Object Memory Task. Deliberate memory was examined using an Object Memory Task based on previous work by Baker-Ward, Ornstein and Holden (1984) and
used more recently by Haden, Ornstein, Eckerman, and Didow (2001) and Rudek and Haden (2005). The task assesses children’s behavioral task approaches during a 2-minute study period prior to recall performance. In the administration of this task, children were seated at a table upon which there were 11 small, relatively unrelated objects (e.g., ball, hat, cup). The children were told that they should try to do anything that they could to help them remember the objects. They were then given a 2-minute activity period after which a cloth was used to cover the objects and the children were asked to recall as many items as they could. All interactions with the stimuli were videotaped for subsequent analysis.

Coding of the Object Memory Task was conducted from video recordings of the task. The task performance was coded based on the work of Baker-Ward, Ornstein, and Holden (1984); Haden, Ornstein, Eckerman, and Didow (2001); and Rudek and Haden (2005). The scheme was designed to capture both physical interactions with the stimuli such as playing and manipulation; visual inspection of the array; and language used in the performance of the task, such as object naming and object descriptions. A complete list of codes and description of the codes is provided in Appendix B. Because the interest in the present research was on children’s task approaches rather than on the effects of varying types of interactions on the recall of specific stimuli (cf. Haden et al., 2001), time-sampling was chosen to capture the children’s behavior in performing the task. This approach was also previously used by Baker-Ward et al. (1984) and Haden et al. (2001). Specifically, the two-minute study period was divided into five-second blocks or intervals. Each of the five-second blocks was coded separately for the occurrence of verbal and non-verbal task approaches. Verbal task approaches used in each block were recorded as a raw count of the number of times the approach was used in a 5-second block; however, non-
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verbal task approaches used in each block were recorded just as either occurring or not occurring in that block. Each individual task approach, both verbal and non-verbal, was classified as either deliberate or non-deliberate in nature. This distinction was established based on previous work of Baker-Ward et al. (1984) and Haden, et al. (2001). Specifically, deliberate approaches included those that are expressions of memorization or deliberate remembering, such that they occurred significantly more when children were given instruction to “remember” rather than to “play” in the Object Memory Task. Deliberate task approaches included manipulation of objects, overt mnemonic activity, covert mnemonic activity, pointing, visual examination, grouped rehearsal, object talk, association, categorizing, and recall (see Appendix B for coding definitions). Non-deliberate task approaches include behaviors that are not representative of study-like behaviors. Non-deliberate task approaches include playing, engaging the examiner, distraction/being off-task, looking away, no behavior, relevant talk, and irrelevant talk.

After the occurrences of all task approaches exhibited in each 5-second block were recorded, the predominant verbal and nonverbal task approach exhibited during the block was classified. For example, in the case of a non-verbal task approach, if a child spent three seconds manipulating the task items and two seconds playing with the task items, the block was coded as manipulation. Based on the predominant verbal and nonverbal task approaches exhibited in the five-second block in question, the block was categorized as being deliberate or non-deliberate in nature. Specifically, both the nature (deliberate or non-deliberate) of the verbal and the nonverbal task approaches were used in the diagnosis of a block as being deliberate or not. If both the predominant verbal and non-verbal task approaches were deliberate in nature, then the block was coded as being deliberate. If both the predominant verbal and non-verbal task approaches were
non-deliberate in nature, then the block was coded as being non-deliberate. In order to be
conservative in the estimates of deliberate task approaches, however, if there was a “mismatch”
between the predominant verbal and non-verbal task approaches, such that one was deliberate
and the other non-deliberate in nature, the block was coded as being non-deliberate
(approximately 7% occurrence rate). Lastly, if a block in question lacked the occurrence of any
verbal task approaches, then that block was only coded as being deliberate or non-deliberate in
nature based on the predominant non-verbal task approach. Therefore, based on the coding
scheme, the major dependent measure was the number of 5-second intervals of the study period
(range 0-24) characterized by the presence of deliberate mnemonic activity.

Coders received extensive training on the Object Memory Task through the use of a
master subset of videos. Half of videos came from another study using the Object Memory Task
and the other half came from a randomly selected set from the present study. Only those
participants from the present study were included in subsequent data analyses. All coders
established high reliability with this set before coding the data. Previous work by Baker-Ward,
Ornstein, and Holden (1984) established reliability by calculating percentages of agreement.
Therefore, this proposal followed the same method by calculating percent of agreement by
dividing the number of agreements by the number of agreements and disagreements for each
possible task approach for each interval. Percent agreement on the overall indication of or raw
count of behaviors occurring during the task for the master set of videos was 97.4%, which was
comparable to previous work by Baker-Ward, Ornstein, and Holden (1984) that established
percent agreement to 95%. Moreover, the percent agreement on the predominant non-verbal task
approach exhibited in each interval was 94.3% and the percent agreement on the predominant
The percent agreement for the verbal task approach exhibited in each interval was 95.6%. The percent agreement for the classification of the interval as deliberate in nature was 95.6%.

**Working memory: Cups Working Memory Task.** Working memory was examined using the Cups Working Memory Task adapted from previous work by Reznick, Fueser, and Bosquet (1998). This task has been used extensively to examine working memory in infants. The task was altered from the original in order to increase the complexity to an age appropriate level for 3-year-olds. Specifically, the number of possible locations for items to be hidden increased and the length of the delay interval increased compared to the original task. In the administration of this task, a sticker was hidden under one of 2, 4, or 6 cups. The child's view of the cups was then obstructed for a delay interval of 1, 5, 10, or 15 seconds, after which the child was encouraged to find the hidden object. Trials proceeded systematically (Figure 3) until the child failed on two successive trials.

![Figure 3. Working memory task (total correct score for each step in the task is in parentheses)](image)

The Cups Working Memory Task was scored in two ways: the total number of correct retrievals (Total Correct) and the proportion of correct retrievals to total searches (Proportion Correct), as adapted from previous work by Reznick, Fueser, and Bosquet (1998). The Total Correct reflects the degree of task difficulty on a scale of 1 to 10, and corresponds to the
flowchart in Figure 3. Therefore, a total correct score of 5 represents accurately finding an object under one of four cups following a 5-second delay. Accuracy was measured by the Proportion Correct, which takes into account the number of correct retrievals the child makes out of the total number of correct and incorrect attempts.

Research assistants were required to receive training on the working memory task through the use of master set videos before administering the working memory task. Reliability was established with the research assistants because it was their responsibility to establish when a child failed on two successive trials and ended the task. All research assistants properly code the master set of videos to a level of greater than 90% correct (range of 92% to 97%).

Inhibitory Control: Unicorn/Dragon Task. The Unicorn/Dragon task (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996) requires a child to respond counter to a prepotent tendency of following the commands of both a unicorn and dragon puppet. The task is a simplified version of the childhood game of Simon Says, in which children need to selectively suppress commanded actions. A correct response would be to act out the command of the unicorn and ignore the command of the dragon. Specifically, in the administration of this task, the children were introduced to the two puppets and told that they are going to play a game such that they should do what the “nice” unicorn says and not to do what the “mean” dragon says. All commands involved simple, easy to evaluate tasks (e.g., touch your nose, touch your ears, clap your hands). Practice trials were administered until the child correctly responded to one unicorn request and failed to respond to one dragon request. During the practice phase, corrective prompts were offered as needed. If a child was unable to demonstrate success for each animal after 5 trials each, the task was stopped. If the child was successful with the practice trials, 10
“unicorn” and 10 “dragon” statements were made. All interactions with the stimuli were videotaped for subsequent analysis.

Coding of the Dragon/Unicorn task was conducted from video recordings of the task. The task was coded based upon Kochanska, Murray, Jacques, Koenig, and Vandegeest’s (1996) coding scheme that was specifically developed for the task. Separate scores were calculated for unicorn and dragon statements using the scoring system (codes) provided in Appendix C. Each prompt was scored using a 4 point rating (0-3) resulting in dragon and unicorn scores that range from 0 to 30.

Based on the observations of the research assistants who administered the Dragon/Unicorn task, there was concern that performance on this task would be at floor levels. Therefore, before coding of the task began, a randomly select subsample equal to 20% of the whole sample (N = 29) was coded by the master coder to determine if there were floor effects. Examination of this subsample revealed that 48% (N = 14) did not learn the initial rules and hence did not qualify for the administration of the task and 10% (N = 3) did not respond to all of the 20 trials that comprised the task proper. Moreover, of the 42% of children who were administered the task proper, ten children (35% of the entire sample) performed the task at random, and only two children (7% of the entire sample) actually were able to successfully perform the task. Because of the difficulty imposed by this measure and the resulting absence of data, the task performance was not considered further.

Inhibitory Control: Day/Night Task. The Day/Night task (Gerstadt, Hong, & Diamond, 1994) requires a child to respond counter to the prepotent tendency of saying “day” when a picture of a sun is presented and saying “night” when a picture of a moon is presented.
Therefore, a correct response is marked as correct when the child says the opposite of what the picture shows. To verify that the children associated the sun with daytime and the moon with nighttime, the children were engaged in a conversation about when the sun comes up (in the day) and when the moon and stars come out (in the night). The children were then presented with a white card with a yellow sun drawing on it and a black card with a white moon and stars on it. The children were then told that they are going to play a silly game such that when they are presented with a white card with the yellow sun they should say “night” and when they are presented with a black card with moon and stars they should say “day.” Practice trials were administered until the child successfully labeled each card correctly once. During the practice phase, corrective prompts were offered as needed and children are prompted to respond if they did not respond. If a child was unable to demonstrate success after 5 trials each for day/night cards, the task was stopped. If the child was successful with the practice trials, 10 “day” and 10 “night” cards were shown to the child in a predetermined random order (same for each child), for a total of 20 trials. No feedback was given after the practice round concluded.

Scoring of the Day/Night task was conducted from video recordings of the task. Children were awarded 1 point for every correct response (i.e., saying “night” when presented with a white card with the yellow sun and saying “day” when presented with a black card with moon and stars). Based on the coding scheme, the major dependent measure was the number of trials, out of a possible 20, on which the children correctly responded to the prompt.

Coders received training on the Day/Night task using a designated master set of videos from randomly selected participants in the present study. These participants were used in subsequent data analyses. Reliability on the master set of videos was equal to 98% agreement,
which was comparable to the 95% agreement established in previous research by Carlson and Moses (2001). Reliability was then monitored throughout the coding of participant’s data. Interrater reliability was calculated on a randomly selected 20% of the participants ($N = 29$) by two independent coders. Coders were unaware of which participants were being used for reliability. Final reliability on the 20% overlap was 94.6% agreement.

**Inhibitory Control: Grass/Snow Task.** The Grass/Snow task (Carlson & Moses, 2001) requires children to respond counter to a prepotent tendency of pointing to green for “grass” and point to white for “snow.” Therefore, a correct response was for the children to point to the color that was opposite to its associate. To verify that the children associated green with grass and white with snow, the children were engaged in a conversation about the color of the ground during summer, when grass is growing (green), and during the winter, when it is covered with snow (white). The children were then told that they are going to play a silly game in which they will place their hands on top of two child-size felt hand shapes centered beneath a white card and a green card on the table. The experimenter then asked the child to point to the white card when the experimenter said “grass” and point to the green card when she said “snow.” Practice trials were administered until the child successfully pointed to each swatch correctly once. During the practice phase, corrective prompts were offered as needed and children were prompted to respond if they fail to do so. If a child was unable to demonstrate success after 5 trials each for grass/snow commands, the task was stopped. If the child was successful with the practice trials, 10 “grass” and 10 “snow” statements were issued in a predetermined random order (same for each child), for a total of 20 trials. No feedback was given after the practice round concluded.
Scoring of the Grass/Snow task was conducted from video recordings of the task. Scoring was conducted by awarding children 1 point for every correct response (i.e., pointing to the white card when the experimenter said “grass” and pointing to the green card when she said “snow”). Based on the coding scheme, the major dependent measure was the number of trials, out of a possible 20, in which the children correctly responded to the prompt.

Coders received training on the Grass/Snow task using a designated master set of videos from randomly selected participants in the present study. These participants were used in subsequent data analyses. Reliability on the master set of videos was equal to 100% agreement, which was comparable to the 95% agreement established in previous research by Carlson and Moses (2001). Reliability was then monitored throughout the coding of the data. Inter-rater reliability was calculated on a randomly selected 20% of the participants ($N = 29$) by two independent coders. Coders were unaware of which participants were being used for reliability. Final reliability on the 20% overlap was 99.7% agreement.

*Preschool Language Scale - 4th Edition (PLS-4).* The PLS-4 (Zimmerman, Steiner, & Pond, 2002) is a measure of both expressive and receptive language for children from birth to 6 years, 11 months. Cognitive domains assessed by the PLS-4 include: vocabulary, grammar, morphology, and language reasoning. The task takes approximately 20-45 minutes to administer. The PLS-4 is composed of two subscales: Auditory Comprehension and Expressive Communication. Auditory Comprehension is used to evaluate what children “know” or understand, but may not “say.” The tasks on this subscale tap skills that are considered important precursors for language development (e.g., attention to speakers, appropriate object play). The Expressive Communication is used to determine what children actually say or produce. Tasks on
this subscale are designed to tap vocal development and social communication. The PLS-4 provides age-based standard scores, percentile ranks, and age equivalents for the Auditory Comprehension, Expressive Communication, and Total Language scores. The PLS-4 can be used as a proxy for intelligence and is highly correlated with the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). The PLS-4 standard scores have a mean of 100 and a standard deviation of 15. The present investigation used the PLS-4 Total Language percentile rankings (combination of the Auditory Comprehension and Expressive Communication) for subsequent analyses.

Research assistants were required to receive extensive training on the PLS-4 before administering the PLS-4 to participants. Training required that research assistants be both reliable at the administration of the PLS-4 tasks and reliable at correctly scoring children’s responses to the tasks. Based on inter-rater reliability established by Zimmerman, Steiner, and Pond (2002), research assistants were required to correctly code a master set videos to a level of greater than 95% percent agreement (range of 95% to 98%).

Scoring of the PLS-4 followed the guidelines set forth by Zimmerman, Steiner, and Pond, (2002). Items were scored “1” for each question if the pass criterion is met or if the child self-corrects a response. A score of “0” was given for each item if the pass criterion was not met or for partially correct or incomplete responses. Raw scores were computed for each subscale by subtracting the number of “0” scores after the “true” basal from the number of the last subscale task administered (i.e. the “true” ceiling).

Behavior Rating Inventory of Executive Function - Preschool Version (BRIEF-P). The BRIEF-P (Gioia, Espy, & Isquith, 2002) is a 63-item measure of executive functioning in
preschoolers (Ages 2.0-5.11 years), which can be completed by parents or teachers. In the present study, the BRIEF-P items were rated by parents and assessed the child’s executive functioning within the context of his or her everyday home environment. The BRIEF-P is based on the original Behavior Rating Inventory of Executive FunctionTM (BRIEFTM). The BRIEF-P has been found to be an ecologically valid and efficient means for assessing and monitoring children’s executive functioning and development (Isquith, Crawford, Espy, & Gioia, 2005). Items on the BRIEF-P target a number of aspects of executive functioning: Inhibition, Shifting of Attention, Emotional Control, Working Memory, and Planning/Organization. The clinical scales form 3 broad indexes (Inhibitory Self-Control, Flexibility, and Emergent Metacognition) and one composite score (Global Executive Composite). The BRIEF-P also provides two validity scales (Inconsistency and Negativity). The BRIEF-P has high internal reliability with a range of .80 to .95 for parental respondents and has convergent and discriminate validity with the ADHD Rating Scale-IV- Preschool Version, the Child Behavior Checklist and the Behavior Assessment System for Children-Parent Rating Scale.

The BRIEF-P asks parents to think about their child and indicate how much different behaviors have been a problem during the past six months. The participant’s parent marked each behavior as being “never a problem,” “sometimes a problem,” or “often a problem.” Example items are provided in Appendix D. The BRIEF-P required approximately 10-15 minutes to complete and was completed at the second 36-month visit.

Scoring of the Brief-P followed the guidelines set forth by Gioia, Espy, and Isquith (2002). The Brief-P is scored on a scale of 1 to 3, where 1 corresponds to responses of “never,” 2 corresponds to responses of “sometimes,” and 3 corresponds to responses of “often.”
individual scores are matched to a normative conversion table to obtain t-scores and percentiles for each participant based on gender and age. Each of the 63 questions corresponds to one of five subscales: inhibition, shifting of attention, emotional control, working memory, and planning/organization. These five categories in turn make up three broad indexes: Inhibitory Self-Control, Flexibility, and Emergent Metacognition. The Inhibitory Self-Control Index (ISCI) is calculated by summing the scores from the questions corresponding to the inhibition and emotional control subscales. The Flexibility Index (FI) is calculated by summing the scores from the question corresponding to the shifting of attention and emotional control subscales. The Emerging Metacognition Index (EMI) is calculated by summing the scores from the questions corresponding to the working memory and planning/organization subscales. The score on the three indexes are matched to a normative conversion table to obtain t-scores and percentiles for each participant based on gender and age. To obtain the Global Executive Composite (GEC) score for the Brief-P the sum of the five sub-scales was calculated. The present investigation used the T-Scores on the BRIEF-P’s Global Executive Composite and Inhibition Subscale for subsequent analyses. Larger T-Scores on the BRIEF-P were associated with lower executive functioning.

Results

Preliminary Analyses

Variability in task performance. The Day/Night and Grass/Snow tasks used to assess inhibitory control presented unexpected difficulties for many participants. Although more children qualified for the administration of these tasks on the basis of their completion of the practice trials than was the case with the Dragon/Unicorn task; 32% and 47% of the participants
failed to complete the Day/Night task and Grass/Snow task, respectively. Among these children, about 15% were unable to meet the criterion for the administration of the measure, and the remainder did not respond to all of the 20 trials that comprised the task proper. Given the extent to which the children were unable to perform the task, it was concluded that the planned dependent variable, the number of trials on which inhibitory control was observed, would fail to describe the performance of the sample. Hence, categories depicting alternative patterns of performance were created, and participants were assigned to post-hoc groups on the basis of these categories. This approach enabled the inclusion of the children who failed to learn the instructions for the task. A summary of the criteria for each category is provided in Table 2, which also presents the frequency of participants in each category. These categories reflected very different approaches to the task. In addition to a group consisting of children who failed to comprehend the instructions, another subset of children perseverated on a preferred response throughout the task (e.g., always responding “day,”) suggesting that the task presented overwhelming demands to the young participants. Other groups were defined on the basis of deviations from chance levels of performance, determined on the basis of the binomial probabilities of outcomes (i.e., “matches” to targets) more extreme ($p < .05$, operationalized as .058 given that the number of trials variable was an integer) than would be expected on the basis of chance alone. Examination of the distribution of participants across the categorical groups indicated that post-hoc groups were unbalanced for both the Day/Night task ($\chi^2 (4, N = 125) = 22.00, p < .05$) and the Grass/Snow task ($\chi^2 (4, N = 103) = 11.61, p < .05$). Even though the assumption of balanced data was violated, examinations involving children’s categorical
inhibitory control performance were still conducted due to the robustness of the design and analyses of the present study.

The separate categorization of performance on the Day/Night and Grass/Snow tasks revealed an inconsistent pattern of performance across the measures, $\phi_c (N=98) = .25, p > .05$. Notably, as can be seen in Table 2, more children completed the Day/Night task than did the Grass/Snow task. The greater success of the Day/Night task may have occurred because the Grass/Snow task was the last task children performed in their hour and a half visit (note that the administration of the inhibitory control tasks was not counterbalanced), and hence fatigue effects may have affected performance to a greater extent on this measure. Given this limitation, all subsequent analyses examining inhibitory control were conducted using the post-hoc groups created by categorizing performance on the Day/Night.
Table 2

*Criterion for Categorizing the Day/Night and Grass/Snow Tasks*

<table>
<thead>
<tr>
<th>Group</th>
<th>Criterion</th>
<th>Day/Night</th>
<th>Grass/Snow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Child did not meet criterion for completion of practice trials, hence task was not administered</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>Child performed correctly at a level significantly below chance (i.e., on 6 or fewer of the 20 trials), reflecting failure to inhibit prepotent response</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>Child perseverated throughout the measure (e.g., said “day” to every prompt; pointed to the green swatch every prompt)</td>
<td>46</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Child performed correctly at chance levels (i.e., on 7 to 13 of the 20 trials)</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Child perform correctly at a level significantly greater than chance (i.e., on 14 or more of the 20 trials), reflecting the ability to inhibit the prepotent response</td>
<td>21</td>
<td>16</td>
</tr>
</tbody>
</table>

**Gender Effects.** Preliminary analyses were conducted to determine if there were any unexpected effects of gender on performance. Specifically, independent samples t-tests were conducted to examine differences between male and female participants’ task performances on the Object Memory Task, the Cups Working Memory Task, the PLS-4, and the BRIEF-P. Due to the fact that the Day/Night task was a categorical variable, gender effects were examined using
Pearson’s Chi-Square. As seen in Table 3, female participants had significantly more deliberate intervals ($M = 14.19$) than did their male counterparts ($M = 12.71$). Therefore, in subsequent analyses involving the total number of deliberate intervals, gender was included as a covariate.

Table 3

**Summary of Gender Effects**

<table>
<thead>
<tr>
<th>Task</th>
<th>$t$</th>
<th>$df$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object Memory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Deliberate Intervals</td>
<td>-2.16*</td>
<td>150</td>
</tr>
<tr>
<td>Total Number of Items Recalled</td>
<td>-1.23</td>
<td>150</td>
</tr>
<tr>
<td><strong>Cups Working Memory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Correct Responses</td>
<td>-1.02</td>
<td>162</td>
</tr>
<tr>
<td><strong>Day/Night</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences across Inhibitory Control Categories</td>
<td>2.48$^1$</td>
<td>4</td>
</tr>
<tr>
<td><strong>PLS – 4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Language Percentile Rank</td>
<td>-1.70</td>
<td>166</td>
</tr>
<tr>
<td><strong>BRIEF-P</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibit Scale T-Score</td>
<td>-2.25</td>
<td>175</td>
</tr>
<tr>
<td>Global Executive Composite T-Score</td>
<td>-1.64</td>
<td>175</td>
</tr>
</tbody>
</table>

* $p < .05$

$^1$ Due to the fact that the Day/Night task was categorical, Pearson’s Chi-Square was used to examine gender effects. The statistic provided is $\chi^2$
Age Effects. Preliminary analyses were conducted to examine if there were any effects of age at testing. Specifically, correlation analyses were conducted to examine if there was a significant relation between participants’ age in months at task administration and task performance for the Object Memory Task, the Cups Working Memory Task, the PLS-4, and the BRIEF-P. Analyses of Variance (ANOVAs) were conducted to examine if there were age effects related to the Day/Night task. As seen in Table 4 and as expected on the basis of the limited variability in months of age in this sample, there were no significant age effects.
Table 4

Summary of Age Effects

<table>
<thead>
<tr>
<th>Task</th>
<th>( r )</th>
<th>( df )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Deliberate Intervals</td>
<td>-.04</td>
<td>148</td>
</tr>
<tr>
<td>Total Number of Items Recalled</td>
<td>.09</td>
<td>148</td>
</tr>
<tr>
<td>Cups Working Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Correct Responses</td>
<td>.13</td>
<td>162</td>
</tr>
<tr>
<td>Day/Night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences across Inhibitory Control Categories</td>
<td>.43(^1)</td>
<td>4, 119</td>
</tr>
<tr>
<td>PLS – 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Language Percentile Rank</td>
<td>-.04</td>
<td>164</td>
</tr>
<tr>
<td>BRIEF-P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibit Scale T-Score</td>
<td>-.03</td>
<td>161</td>
</tr>
<tr>
<td>Global Executive Composite T-Score</td>
<td>-.03</td>
<td>161</td>
</tr>
</tbody>
</table>

\(^1\) Due to the fact that the Day/Night and Grass/Snow tasks are categorical variables, ANOVAs were conducted to examine age effects. The statistic provided, is \( F \) (not \( r \)).

**PLS-4.** In order to determine if subsequent regression analyses including language ability (as assessed by the PLS-4) were warranted, correlation analyses were conducted to examine if participants’ total language scores (defined in terms of scores) were associated with the Object Memory Task and the Cups Working Memory Task. As seen in Table 5, participants’ total
language scores were significantly related to performance on the Object Memory Task, the Cups Working Memory Task, and the BRIEF-P. Specifically, higher total language scores were associated with higher frequencies of intervals characterized as deliberate and with larger item recall. In this task, language ability accounted for 22% of the variance in deliberate task approaches and 10% of the variance in recall performance. Higher total language scores were also associated with better working memory performance, although the language measure explained only 3% of the variance. Higher total language scores were also associated with lower T-Scores on the BRIEF-P’s Inhibit Scale and Global Executive Composite (i.e., more inhibitory control and more global executive functioning), explaining approximately 3% and 5% of the variance on the BRIEF-P’s Inhibit Scale and Global Executive Composite, respectively.
In order to reveal any significant differences in language ability among the post-hoc group categorizations in the Day/Night task, an ANOVA was conducted. Analysis indicated that there were significant group differences in language ability on the Day/Night, $F(4,119) = 5.48, p < .05, \eta^2 = .16$. Preplanned contrasts were conducted in order to identify where the group difference occurred on the Day/Night tasks. Mean language scores across tasks and groups, on which the post-hoc tests are based, are provided Table 6. As expected, children who did not successfully perform the task (Groups 0 and 2) demonstrated lower levels of language ability than children who did perform in an interpretable manner (i.e., those whose performance indicated task engagement; Groups 1, 3, and 4), $F(1, 119) = 20.08, p < .05$. Further, children
who perseverated (Group 2) did not differ from those who failed to master instructions (Group 0), $F (1, 119) = 2.72, p > .05$. In addition, the groups of children who did perform in an interpretable manner did not differ on language ability, $F (1, 119) = 2.36, p > .05$. Hence, in contrast to expectations, children who consistently demonstrated inhibitory control (Group 4) did not differ with regard to language ability to the group from participants (Group 1) whose performance did not evidence the capacity to suppress the prepotent response.

<table>
<thead>
<tr>
<th>Group</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>51.65</td>
<td>27.54</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>89.07</td>
<td>16.24</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>62.91</td>
<td>26.98</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>74.14</td>
<td>25.89</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>75.15</td>
<td>29.96</td>
<td>22</td>
</tr>
</tbody>
</table>

Aim 1: Description of Task Approaches

The first aim of this study was to describe the task approaches used by three-year-olds during the deliberate memory task. In order to address this aim, performance during the 2-minute study period included in the Object Memory Task was analyzed. Specifically, each 5-second interval’s predominant non-verbal and predominant verbal task approaches were examined. The
mean number of intervals that were characterized by the various non-verbal task approaches (i.e., manipulation, pointing, visual examination, play, engaging examiner, and distraction) and their corresponding standard errors are seen in Figure 4. This figure also differentiates between whether a task approach was considered to be deliberate or non-deliberate in nature, as based on previous research. Approaches that did not occur within the task are not represented. Paired samples t-tests compared an aggregate deliberate score (i.e., total number of intervals characterized by manipulation, pointing, and visual examination) with an aggregate non-deliberate score (i.e., total number of intervals characterized by play, engaged examiner, and distraction) to determine if there were significant differences in the occurrences of the non-verbal task approaches. Results indicated that deliberate task approaches occurred significantly more often than non-deliberate task approaches, \( t(152) = 4.77, p < .05 \).
Figure 4. Mean number of 5-second intervals characterized by the various non-verbal task approaches. Approaches that did not occur within the task are not included.

Figure 5 presents the mean number of intervals that were characterized by the various verbal task approaches (i.e., associations, naming, object talk, relevant talk, onomatopoeia, irrelevant talk) and their corresponding standard errors. This figure also differentiates between task approaches that were considered deliberate versus non-deliberate in nature. Approaches that did not occur within the task are not represented. Paired samples t-tests compared an aggregate deliberate score (i.e., total number of intervals characterized by associations, naming, object talk, and relevant talk) with an aggregate non-deliberate score (i.e., total number of intervals characterized by onomatopoeia, irrelevant talk) to examine if there were significant differences.
in the occurrences of the non-verbal task approaches. Results indicated that deliberate task approaches occurred significantly more often than non-deliberate task approaches, $t(152) = 12.15, p < .05$.

Figure 5. Mean number of 5-second intervals characterized by the various verbal task approaches. Approaches that did not occur within the task are not included.

A sub-goal of Aim 1 was to examine the relation between children’s deliberate task approaches and their subsequent recall ($M = 2.93, SD = 2.03$) during the Object Memory Task. To address this goal, a regression analysis was conducted. Results indicated that there was a significant relation between the number of deliberate intervals and the number of items recalled ($\beta = .28, t(149) = 3.49, p < .01$), even when controlling for gender effects. Specifically, higher occurrences of deliberate task approaches were associated with more items recalled. Moreover,
as indicated by $R^2$, the number of deliberate intervals accounted for 9% of the variance in items recalled. In order to test if this relation was dependent on the fact that both variables were significantly related to language ability; a hierarchical regression was conducted with participants’ PLS-4 total language scores entered in as the second step. Results indicated that the significance of the relation between the number of deliberate interval and subsequent recall decreased with the inclusion of the measure of language ability, although it remained significant ($\beta = .15, t(146) = 1.96, p = .05$).

**Aim 2: Relation between Working Memory and Inhibitory Control**

The second aim of this study was to examine the relations among measures of working memory and inhibitory control by testing the hypothesis that performance on the measure of working memory, the Cups Working Memory Task, would be positively associated with inhibitory control as indexed by performance on the Day/Night task (Hypothesis 1 on p. 19). Due to the fact that performance on the Day/Night task was operationalized in terms of categories of performance, an ANOVA was conducted to examine if there were significant Day/Night group differences in working memory performance. Results indicated that there were no group differences in performance on the Cups Working Memory task, $F(4,118) = .31, p > .05, \eta^2 = .01$. The use of language ability as a covariate did not change this effect, $F(4,117) = .21, p > .05, \eta^2 = .01$. The mean number of correct responses to the Cups Working Memory Task for each of the Day/Night categorical groups (see Table 2) is provided in Table 7.
Table 7

Mean Correct Response to the Cups Working Memory Task for the Day/Night Categorical Groups

<table>
<thead>
<tr>
<th>Day/Night Group</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.65</td>
<td>2.41</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>6.21</td>
<td>3.17</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>6.25</td>
<td>2.95</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>6.55</td>
<td>3.07</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>6.14</td>
<td>1.96</td>
<td>22</td>
</tr>
</tbody>
</table>

Aim 3: Interrelations Among Measures of Working Memory, Inhibitory Control, and Deliberate Memory

The third aim of this study was to examine the interrelations among measures of working memory, inhibitory control, and deliberate memory. In order to address this aim, four hypotheses were tested. Originally, it was hypothesized (Hypothesis 2 as presented on page 20) that performance on the Day/Night task would positively predict the occurrence of deliberate memory task approaches (as assessed by the Object Memory Task). Due to the fact that the Day/Night task was categorized, an ANCOVA was conducted to examine if there were Day/Night group differences in the number of deliberate intervals participants exhibited during the Object Memory Task, when controlling for gender. Results indicated that there was a trend towards significant differences in the occurrence of deliberate memory task approaches for the
Day/Night groups, $F(4,119) = 2.24$, $p = .07$, $\eta^2 = .07$; as seen in Table 8. However, this effect disappeared when language was included as a covariate, $F(1,117) = 2.37$, $p < .10$.

Table 8

Mean Number of Deliberate Intervals for the Day/Night Categorical Groups

<table>
<thead>
<tr>
<th>Day/Night Group</th>
<th>M</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.30</td>
<td>4.45</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>14.50</td>
<td>4.07</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>12.66</td>
<td>3.85</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>15.24</td>
<td>3.70</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>14.23</td>
<td>4.22</td>
<td>22</td>
</tr>
</tbody>
</table>

To test the hypothesis that performance on the working memory task would positively predict the occurrence of deliberate memory behaviors as assessed by the Object Memory Task (Hypothesis 3 on page 21), a regression analysis was conducted. As summarized above, preliminary analyses indicated that gender was significantly related to the total number of deliberate intervals and that language ability was significantly related to both the total number of deliberate intervals and the number of correct responses to the working memory task; therefore, in order to control for these effects, a hierarchical regression was conducted. Specifically, the total number of deliberate intervals was entered as the dependent measure and language and gender as the Step 1 independent measure and the total number of correct responses on the
working memory task as the Step 2 independent measure. As seen in Table 9, the results indicated that performance on the Cups Working Memory task did not significantly predict the total number of deliberate intervals, above and beyond the effects of gender and language.

It was hypothesized that performance on the Cups Working Memory task and the Day/Night task would each positively predict a unique amount of the variance associated with the occurrence of deliberate memory task approaches (Hypothesis 4 on page 21). Although the absence of a relation between these measures and the criterion was inconsistent with expectation, suppression effects were possible. Hence, performance on the Day/Night task was dummy coded and a hierarchical regression analysis was conducted. Specifically, the total number of deliberate intervals was entered as the dependent measure, gender as the Step 1 independent measure, working memory task as the Step 2 independent measure, the dummy coded Day/Night task as the Step 3 independent measures. As seen in Table 10, neither performance on the working memory task nor performance on the Day/Night task significantly predicted the total number of deliberate intervals on the Object Memory Task.
Table 9

*Summary of Hierarchical Regression for Working Memory Predicting Deliberate Task Approaches*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>Language Ability</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Gender</td>
<td>1.15</td>
<td>0.67</td>
</tr>
<tr>
<td>Working Memory Performance</td>
<td>-0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>R²</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05
Table 10

Summary of Hierarchical Regression for Working Memory and Inhibitory Control Predicting Deliberate Task Approaches

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>Gender</td>
<td>1.43</td>
<td>.76</td>
<td>0.17</td>
</tr>
<tr>
<td>Working Memory Performance</td>
<td>-0.10</td>
<td>0.14</td>
<td>-0.07</td>
</tr>
<tr>
<td>Day/Night: 0 Rating</td>
<td>-1.90</td>
<td>1.23</td>
<td>-0.18</td>
</tr>
<tr>
<td>Day/Night: 1 Rating</td>
<td>0.07</td>
<td>1.42</td>
<td>0.01</td>
</tr>
<tr>
<td>Day/Night: 2 Rating</td>
<td>-1.46</td>
<td>1.09</td>
<td>-0.17</td>
</tr>
<tr>
<td>Day/Night: 3 Rating</td>
<td>1.03</td>
<td>1.28</td>
<td>0.09</td>
</tr>
<tr>
<td>Intercept: Day/Night 4 Rating</td>
<td>14.29</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.03</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.00</td>
<td>0.06</td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05
An additional hypothesis posited significant interrelations among measures of working memory, inhibitory control, and deliberate memory after controlling for language abilities (via the PLS-4), both performance on the working memory task and the Day/Night tasks would have a significant positive relationship with the occurrence of deliberate memory behaviors (Hypothesis 5 on p. 21). To test this hypothesis a hierarchical regression was conducted on the dependent measure of the total number of deliberate intervals on the Object Memory Task. Independent measures were participants’ total language percentile ranking (i.e., language ability) and gender entered in Step 1, the number of correct responses to the Cups Working Memory task entered in Step 2, and the dummy coded Day/Night task entered in Step 3. As seen in Table 11, results indicated that language ability was the only significant predictor of the occurrence of deliberate task approaches, such that higher scores were associated with a higher occurrence intervals being characterized by deliberate task approaches.
Table 11

*Summary of Hierarchical Regression for Predicting Deliberate Task Approaches Controlling for Language*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Block 1</th>
<th></th>
<th></th>
<th>Block 2</th>
<th></th>
<th></th>
<th>Block 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>β</td>
<td>B</td>
<td>SE</td>
<td>β</td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>Language Ability</td>
<td>0.05</td>
<td>0.01</td>
<td>0.32*</td>
<td>0.05</td>
<td>0.01</td>
<td>0.33*</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Gender</td>
<td>1.11</td>
<td>0.72</td>
<td>0.13</td>
<td>1.18</td>
<td>0.73</td>
<td>0.14</td>
<td>1.13</td>
<td>0.74</td>
</tr>
<tr>
<td>Working Memory</td>
<td></td>
<td></td>
<td></td>
<td>-0.15</td>
<td>0.14</td>
<td>-0.10</td>
<td>-0.16</td>
<td>0.14</td>
</tr>
<tr>
<td>Day/Night: 0 Group</td>
<td></td>
<td></td>
<td></td>
<td>-0.87</td>
<td>1.23</td>
<td>-0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day/Night: 1 Group</td>
<td></td>
<td></td>
<td></td>
<td>-0.53</td>
<td>1.37</td>
<td>-0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day/Night: 2 Group</td>
<td></td>
<td></td>
<td></td>
<td>-0.93</td>
<td>1.06</td>
<td>-0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day/Night: 3 Group</td>
<td></td>
<td></td>
<td></td>
<td>1.14</td>
<td>1.23</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept: Day/Night 4 Rating</td>
<td>11.21</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>∆R²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note. *p < .05
Aim 4: Correspondence between Performance on the Inhibitory Control Task and Parental Ratings

The fourth aim of this study was to examine the relation between behavioral or task orientated measures of inhibitory control and standardized behavioral inventory of executive functioning. To address this aim, it was hypothesized that the scores on the BRIEF-P would be positively associated with behavioral measures of inhibitory control (Hypothesis 6 on p. 22). Originally, it was hypothesized that there would be a positive relationship between the inventory’s inhibition subscale and performance on the Day/Night task. However, due to the fact that the Day/Night task was categorized, an ANOVA was conducted to examine if there were Day/Night group differences in BRIEF-P T-Scores. First, to test for possible group differences in the BRIEP-P’s Global Executive Composite T-Scores an ANOVA was conducted. Results indicated that there were not significant differences between participants’ Global Executive Composite T-Scores for the Day/Night groups, $F(4,116) = .86, p > .05, \eta^2 = .03$. Moreover, when language was entered as a covariate, group difference remained non-significant, $F(4,115) = .78, p > .05, \eta^2 = .03$. The mean Global Executive Composite percentile ranking for each of the Day/Night groups are provided in Table 13.

To test for possible Day/Night group differences in the BRIEP-P’s Inhibition Scale T-Scores, an ANOVA was conducted. Results indicated there were not significant differences between participants’ Inhibition Scale T-Scores for the Day/Night groups, $F(4,116) = .77, p > .05, \eta^2 = .03$. When language was entered as a covariate, group difference remained non-significant, $F(4,115) = .84, p > .05, \eta^2 = .03$. The mean Inhibition Scale T-Scores for each of the Day/Night groups are provided in Table 12.
Table 12

*Mean BRIEF-P T-Scores for the Day/Night Categorical Groups*

<table>
<thead>
<tr>
<th>Day/Night Group</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Executive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>50.59</td>
<td>9.57</td>
<td>22</td>
</tr>
<tr>
<td>1</td>
<td>51.29</td>
<td>11.97</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>50.07</td>
<td>13.74</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>45.86</td>
<td>10.36</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>47.36</td>
<td>7.87</td>
<td>22</td>
</tr>
<tr>
<td>Inhibition Scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>49.23</td>
<td>8.55</td>
<td>22</td>
</tr>
<tr>
<td>1</td>
<td>52.00</td>
<td>13.45</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>48.74</td>
<td>12.34</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>45.86</td>
<td>8.83</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>47.59</td>
<td>8.74</td>
<td>22</td>
</tr>
</tbody>
</table>

Discussion

Research in the field of memory development across childhood has focused on age-related improvements in the occurrence, quality, and effectiveness of memory strategies. Indeed, some researchers have argued that children’s memory development can be understood largely as the transition from nonstrategic to strategic behavior (see Schneider & Pressley, 1997, for review). Much of this work has concentrated on elementary and middle school children, resulting
in a relative paucity of information about deliberate remembering in preschool-aged children. Notable exceptions have indicated that preschool children are capable of displaying strategies in memory tasks and demonstrating an early understanding of memorization (e.g., Wellman, 1988; Baker-Ward, Ornstein, & Holden, 1984). Questions remain, however, about the origins of strategic behavior in early childhood. Recent investigations that use modeling techniques to examine the linkages among cognitive processes and strategy development in elementary school children could provide great insights into the emergence of deliberate memory in preschool children (e.g., Schneider et al., 1998; DeMarie et al., 2004).

A great deal of recent attention has been devoted to the interrelations among working memory and measures of executive functioning/inhibitory control (e.g., Davidson, Amso, Anderson, & Diamond, 2006; Schneider, Schumann-Hengsteler, & Sodian, 2005). Much of the work, however, has yielded inconsistent findings and has yet to examine these relations in the context of strategic memory in preschoolers. The goal of the present study was to add to the existing knowledge of interrelations of cognitive processes and the existing knowledge of strategic remembering in preschool children by examining the linkages among working memory, inhibitory control, and deliberate task approaches in three-year-olds. As will be discussed, the results have implications for understanding some of the contributors to the emergence of deliberate remembering, despite the inability to test some of the hypotheses. Following an examination of the measurement issues that necessitated a change in the proposed operationalization of inhibitory control, each aim of the research will be revisited and the relevant findings will be reviewed. Limitations of the present approach are examined within the
context of the individual objectives of the investigation, and the section concludes with recommendations for future research efforts.

*Conceptualizing Inhibitory Control Performance*

The data obtained from the Durham Child Health and Development Longitudinal Study provided the resource of multiple measures of cognitive development from approximately 160 families. The use of preexisting data, however, yielded some limitations beyond the control of the current investigation. In particular, coding the inhibitory measures revealed that the children had unexpected difficulties in completing the associated tasks. In contrast, previous research had established that the Day/Night, Grass/Snow, and Dragon/Unicorn tasks were all within the capacity of three-year-olds (see Gerstadt, Hong, & Diamond, 1994; Carlson & Moses, 2001; Kochanska et al., 1996). One possible explanation for the surprising difficulty of these tasks arises from the fact that the inhibitory control measures all occurred at the end of an hour and a half assessment battery. It is likely that many of the young participants were quite fatigued by the time the tasks were administered, and hence were unable to perform as well as had been anticipated. Baumeister’s work on ego depletion in adults (see Baumesiter, Vohs, & Tice, 2007) supports this possibility. Baumeister and his colleagues provide evidence that the supply of self-control needed to marshal cognitive resources (e.g., to exercise inhibitory control) can be exhausted through the performance of previous cognitively-demanding tasks. He suggests that glucose depletion contributes to the phenomenon. If adults’ executive functioning can be disrupted through effortful performance, it seems reasonable that children should be even more susceptible to this effect. If so, the children’s difficulty in the present research was not simply
boredom, and hence even the best efforts of trained research assistants would be insufficient to elicit compliance with the instructions.

In the absence of a reasonable distribution of performance on the anticipated measure of successful trials, categories depicting alternative patterns of performance on the Day/Night and Grass Snow tasks were created, and children were assigned to corresponding post-hoc groups. These categories reflected very different approaches to the task. One group consisted of children who failed to comprehend the instructions, whereas another subset of children succeeded on the practice trials but perseverated on the actual trials. Other groups were defined on the basis of deviations from chance levels of performance, determined on the basis of the binomial probabilities of outcomes more extreme than would be expected on the basis of chance alone. Unfortunately, individual patterns of performance were inconsistent across the different inhibitory control tasks. In the absence of counterbalancing, only performance on the first measure, the Day/Night task, was examined.

Despite the limitations inherent in defining performance in terms of differences in the performance of post-hoc groups, including the violation of the assumption that there were balanced distributions of participants across the post-hoc groups, there is support for this approach. First, the groupings have clear face validity. The group of children who performed at levels below chance, for example, consistently failed to inhibit the prepotent response, despite their mastery of the instructions as indicated by their success on the practice trials. This group’s task approach contrasts with those of the children who performed at levels significantly above chance and hence reliably demonstrated inhibitory control. Second, group differences in language ability corroborate the rationale for the group assignments. The children that did not
perform the task in an interpretable manner, either by failing to meet the criterion for administration or by perseverating in the performance of the task, demonstrated lower levels of language ability than children who engaged in the task with a coherent strategy. Further, no differences in performance were observed between the two groups who appeared to be overwhelmed by the task demands. Similarly, no differences were found among the groups who engaged in the task.

**Occurrences of Task Approaches**

The first aim of the research was to describe preschool children’s approaches to the memorization task, essentially to replicate previous results with this more diverse sample. Exploratory analyses of task behaviors during the two minute study period in the Object Memory Task demonstrated that the most frequent were manipulation (occurring in 43% of intervals), playing (39%), naming (20%), and visual examination (13%). This pattern of results is generally comparable to that found by Haden and her colleagues (Haden et al., 2001) in 42-month-old children. Specifically, Haden also found that manipulation (occurring in 52% of intervals), naming (28%), visual examination (24%), and playing (22%) were the most frequently used task approaches. It is notable that, as would be expected, Haden’s older children in comparison to the present younger participants showed greater use of deliberate task approaches (manipulation, visual examination, and naming) and less play. In addition, the levels of deliberate memory behavior observed among the current investigation’s three-year-olds were similar to the patterns of behaviors found by the four-year olds assessed by Baker-Ward, Ornstein and Holden (1984). In their work, Baker-Ward and colleagues found that children who were instructed to remember the items presented to them had higher occurrences of manipulation compared to play, 42% and
25%, respectively. The authors, however, reported lower occurrence levels of naming (8%) compared to the present investigation. A variation in the procedures may explain these discrepancies. The earlier investigation did not reinstate the instructions at the midpoint of the instruction period, whereas the more recent studies did so. Despite some variations in the levels of performance, the pattern of results across the investigations establishes that preschool children deliberately engage in attempts to remember when instructed to do so. It is notable that this outcome is robust across investigations that use different units of analysis in coding performance.

The present investigation provided additional support for the presence of deliberate remembering in young preschoolers by identifying a significant positive relation between language ability and the extent of deliberate task approaches. A similar result was found in the research that generated the Würzburg Model of Children’s Memory Performance (Schneider, Schlagmüller, & Visé, 1998) for elementary school children. Specifically, the authors found that verbal IQ significantly predicted metamemory, which in turn predicted strategy usage. It is quite possible that metamemorial knowledge also mediates the relation between language ability and deliberate task approaches in this investigation, although further research is necessary to establish such an effect. Children must understand remembering as an active process mediated by the deployment of intentional behavior (see Wellman, 1988) before they can acquire the specific mediators that function effectively in the task.

A final finding emerging from the analyses of task approaches was the unexpected relation between deliberate task approaches and subsequent recall performance. The children’s level of recall was consistent with past research. The three year old participants in this study recalled 29% of the to-be-remembered objects, in comparison to the 37% and 40% reported by...
Haden and her colleagues (Haden et al., 2001) and Baker-Ward et al. (1984), respectively, in their investigations of somewhat older preschoolers. However, a utilization deficiency was expected to characterize the relation between tasks approaches and recall, in that no mnemonic benefits from the children’s use of deliberate study behaviors was expected (see Miller & Seier, 1994).

Previous research suggests that this finding is not simply a Type I error. Haden et al. (2001) found that children who engaged in greater amounts of play remembered fewer objects than did those who played less during the study period. It should not be assumed, however, that this result contradicts the findings of utilization deficiency research. The present investigation did not explore the direct relations between the object(s) at which the task approaches was directed (i.e., the object being manipulated or played with) and the recall of that object; therefore, no clear conclusion can be made about a linkage between a specific task approach and subsequent recall. The association between deliberate activity and subsequent recall could result from incidental learning. Children who used manipulation, pointing, and other deliberate approaches tended to interact with a number of the to-be-remembered objects, whereas children who primarily played during the study period often directed their attention to a smaller subset of the stimuli as some objects afforded more play than others. Hence, among the children who used deliberate approaches, greater recall could have results from the mere exposure to more items. Future research should be conducted to determine when a deliberate task approach is actually an effective mnemonic mediator.
Working Memory and Inhibitory Control

One of the aims of the present investigation was to examine the relation between inhibitory control and working memory in hopes of better understanding these cognitive processes in three-year-olds. As discussed in the introduction, there is at present inconsistent evidence about the relation between inhibitory control and working memory in children. Some studies with kindergarten and elementary school children have found little association between measures of inhibitory control and working memory (e.g., Miyake & Shah, 1999; Schneider, Lockl, & Fernandez, 2005), whereas others have reported significant relations between measures of inhibitory control and working memory (e.g., Carlson & Moses, 2001; Davidson, Amso, Anderson, & Diamond, 2006). It was hypothesized that the latter of these two bodies of results would be supported by the present research (i.e., working memory and inhibitory control would be related); however, this was not the case. Results indicated that the post-hoc inhibitory control groups did not differ in working memory performance. This result must be interpreted with caution, due to the limitations in the measures of inhibitory control, including questions regarding the sensitivity of the categorical approach and the circumstances under which the inhibitory control tasks were administered (as discussed above). Future research should be conducted in order to better examine the relation between working memory and inhibitory control. In particular, research minimizing the current investigation’s fatigue effects through the counterbalancing of tasks and the reduction of effort required for children to complete all desired tasks should be conducted.

Relations with Deliberate Memory

An extension of the aim of better understanding the relations between working memory
and inhibitory control was to examine the alternative contributions of these cognitive processes to the onset of deliberate or strategic memory in three-year-olds. Unexpectedly, there was no significant relation between working memory and deliberate memory task approaches, even when language ability was included as a covariate. Previous research involving the Würzburg (Schneider, Schlagmüller, & Visé, 1998) and the Utilization Deficiency (DeMarie, Miller, Ferron, & Cunningham 2004) models of children’s memory performance revealed a significant relation between cognitive capacity and strategy usage in kindergarten and elementary school children. Hence, more research on the relation between working memory and deliberate memory is justified. Particularly, the relations among working memory, deliberate tasks approaches, and subsequent recall should be examined. Working memory could possibly influence the finding that the use of deliberate task approaches was associated with subsequent recall, as reflected in the Utilization Deficiency Model. It could also be the case that the relation between deliberate task approaches and recall could be moderated by working memory performance, such that children with better working memory are more likely to have recall benefits associated with deliberate task approaches.

More evidence was found for the hypothesized relation between inhibitory control and the occurrence of deliberate task approaches than was the case regarding the association between working memory and task approaches. Results of analyses of post-hoc inhibitory control group differences on the extent of deliberate tasks approaches revealed trends in the expected direction. Specifically, it was found that children who performed in an interpretable manner in the inhibitory control task generated more deliberate tasks approaches than children whose inhibitory control task performance was uninterpretable. It should be noted, however, that this
planned comparison became non-significant when language was entered as a covariate. These results, taken together with the limitations inherent in the measures of inhibitory control, indicate that further research is needed. Specifically, research that minimizes the current investigation’s fatigue effects might provide the sensitive assessment necessary to avoid a Type II error. In the absence of such information, the contributions of language ability as identified in this investigation are difficult to interpret. Language could serve a key role in the self-regulation of cognition. Alternatively, it could simply be that a threshold of language competence is necessary to comprehend the instructions necessary to perform the inhibitory control task.

**BRIEF-P**

A final aim of the current investigation was to examine the relations between the BRIEF-P, a standardized behavioral inventory of executive functioning, and task oriented measures of inhibitory control. The examination of this potential association had implications for the establishment of concurrent validity of the task oriented measures of inhibitory control. Discriminate validity for the BRIEF-P has been established, in that it has been shown to successfully differentiate children with and without clinical diagnoses. Therefore, the BRIEF-P has the potential of providing validation for task oriented measures of inhibitory control. The present results, however, did not support the hypotheses that the task orientated measures of inhibitory control would be associated with the BRIEF-P’s inhibitory scale and global composite scale scores, in that no differences were observed between the post-hoc inhibitory control groups. The previously-discussed limitations in the measure of inhibitory control are certainly relevant in interpreting the absence of an effect in the present investigation. Therefore, future examinations of the associations between these measures are warranted. In addition, it would be
advantageous to examine how performance on measures of working memory, measures of executive functioning (e.g., Wisconsin Card Sort Task, a measure of task switching), and measures of emotion regulation (e.g., Kochanska, Murray & Harlam’s [2000] gift wrap task) are associated with the BRIEF-P’s subscales, broad indexes, and global composite score.

**Future Directions**

As mentioned throughout this discussion, future research directions should involve examining the contribution of inhibitory control to measures of working memory and deliberate memory, while minimizing the fatigue effects that compromised the present data. Specifically, the tasks should be counterbalanced and the effort required for children to complete all desired tasks should be reduced. Such research can provide clarity to the current investigation’s findings involving inhibitory control.

Future investigations should also attempt to better understand the relations between the occurrences of deliberate task approaches and subsequent recall. A limitation of the current research was the lack of examination of the recall of specific items, which prevented a true test of the utilization deficiency. Another short-coming was the absence of an examination of the way in which working memory might moderate the relation between deliberate task approaches and recall, as supported by the Utilization Deficiency Model. Studies that move beyond these restrictions could help bring clarity to the understanding of deliberate or strategic memory performance in three-year-olds.

Finally, as mentioned at the beginning of this paper, the understanding of the development of memory (as defined by Ornstein & Haden, 2001) requires the examination of the processes that underlie age related changes in memory and strategy usage. Specifically, research
needs to address the forces that propel early memory into more complex and sophisticated processes. In order to understand the development of memory, longitudinal examinations must be conducted. A key strength of the current study is that it is a subset of a larger longitudinal investigation. Therefore, future investigations will explore how cognitive processes (working memory and inhibitory control) develop over early childhood. Moreover, forthcoming research will attempt to determine how these processes drive the development of strategic memory and school readiness.
References


Deliberate Memory in Three-Year-Old Children


APPENDICES
Appendix A
36-month Visit Protocols

<table>
<thead>
<tr>
<th>Time Elapsed</th>
<th>Episode Time</th>
<th>Episode Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>0</td>
<td>5 Acclimation</td>
<td>Greeting, Consent in playroom</td>
</tr>
<tr>
<td>II.</td>
<td>5</td>
<td>5 Cortisol #1</td>
<td>Obtain baseline cortisol from mom and child with cotton ropes. Extract sample into vials.</td>
</tr>
<tr>
<td>III.</td>
<td>10</td>
<td>30 PLS-4 (Auditory Comp. Subscale-Book)*</td>
<td>Auditory Comprehension subscale book items are to be completed first.</td>
</tr>
<tr>
<td>IV.</td>
<td>40</td>
<td>5 Snack (if necessary)</td>
<td>If the child needs a break, bring in a couple of cookies and water for them to have. NO JUICE</td>
</tr>
<tr>
<td>V.</td>
<td>45</td>
<td>15 PLS-4 (Expressive Comp. Subscale-Book)*</td>
<td>Elicit all Expressive items and then any items requiring the toys from the Auditory and Expressive Subscales</td>
</tr>
<tr>
<td>VI.</td>
<td>60</td>
<td>10 Baseline Heart Rate</td>
<td>Four minutes of baseline for each mom and child. Ask mom to sit calmly with her child during baseline sampling.</td>
</tr>
<tr>
<td>VII.</td>
<td>70</td>
<td>10 Parent-Child Challenge/</td>
<td>Puzzle (Easy, Medium, and Difficult) Task</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teaching Task</td>
<td></td>
</tr>
<tr>
<td>VIII.</td>
<td>80</td>
<td>3 Cortisol #2</td>
<td>Second saliva sample taken and extracted.</td>
</tr>
<tr>
<td>IX.</td>
<td>83</td>
<td>6 Gift-Wrap Task</td>
<td>Child waits at table while RA “wraps” the present behind them and then leaves to get the bow.</td>
</tr>
<tr>
<td>X.</td>
<td>89</td>
<td>3 Temperature/Physical Measurements</td>
<td>Obtain temperature from Mom and Child. Then get physical measurements from the child.</td>
</tr>
<tr>
<td>XI.</td>
<td>92</td>
<td>10 Questionnaires/Medical Questions</td>
<td>Ask mom all oral questionnaires</td>
</tr>
<tr>
<td>XII.</td>
<td>102</td>
<td>3 Cortisol #3</td>
<td>Final saliva sample taken</td>
</tr>
<tr>
<td>XIII.</td>
<td>105</td>
<td>3 Payment</td>
<td>Pay the Mom and thank them for coming.</td>
</tr>
</tbody>
</table>

* Task utilized in current proposal
### Visit B

<table>
<thead>
<tr>
<th>Time Elapsed</th>
<th>Episode Time</th>
<th>Episode Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| I. 0         | 5            | Acclimation  | Greeting in playroom  
|              |              |              | Event Selection for Reminiscing Task |
| II. 5        | 15           | Braken Basics Concept Scale | Complete the first six subscales of this cognitive development and achievement test |
| III. 20      | 7            | Memory Task #1 (Cups)* | Working Memory for Locations Task |
| IV. 27       | 3            | Memory Task #2 (Prospective Memory) | Deliberate Memory Task |
| V. 30        | 6            | Memory Task #3 (Object Memory)* | Deliberate Memory Task |
| VI. 36       | 10           | Memory Task #4 (Reminiscing) | Event Memory Task |
| VII. 46      | 10           | Baseline Heart Rate | Four minutes of baseline for each mom and child. Ask mom to sit calmly with her child during baseline sampling. |
| VIII. 56     | 5            | Inhibitory Control Task: Unicorn/Dragon* | Executive Function Task with Unicorn and Dragon Puppets |
| IX. 61       | 5            | Inhibitory Control Task: Day/Night* | Executive Function Task with Day/Night Cards |
| X. 66        | 5            | Inhibitory Control Task: Grass/Snow* | Executive Function Task with placemat with child’s hands |
| XI. 71       | 3            | Prospective Memory Part Two | Prompt the child as needed to see if they remember the toy |
| XII. 74      | 7            | Additional Consents/Payment | Ask the Mom to sign the additional consents. Pay her and thank them for coming |

* Task utilized in current proposal
Appendix B
Object Memory Task Coding

Overview

This Object Memory Task assesses children’s behavioral and linguistic strategies during the study period as well as their actual recall. The task procedure is based on previous work by Baker-Ward, Ornstein and Holden (1984). Children were seated at a table upon which there were 15 small, relatively unrelated objects (e.g. block, crayon, feather). Children were told that they should try to do anything that they could to help them remember the objects. They were then given a 2-minute activity period after which a cloth was used to cover the objects and children were asked to recall as many items as they could. All interactions with the stimuli were videotaped for subsequent analysis.

Non-Verbal Codes

Deliberate Non-Verbal Codes

Manipulation: Child makes any type of manual contact with the objects that does not involve the unique properties of the object (e.g. lifting the objects or touching the objects). Coded if child touches object with any part of hand intentionally- look for touching with fingers or palm preferably. If touch appears unintentional- for example shoving several objects out of the way or brushing or bumping objects on the way to interact with a different object, these only needs to be coded if the touch occurs with the fingers or palm.

Overt Mnemonic Activity: Child displays overt mnemonic activity: (hides eyes while naming objects, self-tests, or rehearses aloud).

Covert Mnemonic Activity: Child displays covert mnemonic activity (closes eyes or looks at objects and looks away as if studying , moves lips as if rehearsing, scans in an obvious repeated pattern). The idea is that the child is potentially studying- Rehearsing - child’s mouth moves without speaking understandable words and they could possibly be saying words. This should at least include naming 3 objects, preferably while scanning the objects with their eyes.

Pointing: Child points to a particular object without touching or moving it. A child may also receive Point for generally pointing at the array of toys or pointing vaguely at unidentifiable toys.

Visual Examination: Child scans the objects for at least 1.5 seconds without touching any of the objects.
Non-Deliberate Non-Verbal Codes

Playing: Child manipulates the object by engaging with its unique basic properties (e.g. rolling a vehicle, stretching the slinky, taking a picture with the camera, wearing sunglasses, bouncing a ball, opening a container, placing things inside of a container).

Engages Examiner: Child makes eye contact with the examiner for at least 2 seconds. Child must be actively attempting to evoke examiner’s response. These attempts may include verbalizations (e.g., “I’m done,” “How do I do this?”) Begin when the eyes are not on the objects and are turning towards examiner. End when the eyes turn back towards the objects, sometimes seen as eyelids covering the eyes.

Distraction/Off-task: Child focuses on objects or events outside the context of the experiment for at least 2 seconds due to some stimulus (e.g. looks at another child entering or leaving the room). If the child’s behavior is a subtle look away- the stimulus should be fairly obvious to the coder (a noise in the room or an interruption). Other examples of this behavior could include: child turns around in their seat or plays with an object not a part of the task.

Verbal Codes

Deliberate Verbal Codes

Naming: Child labels an object without further description (e.g. “flower”). Children can have their own labels for objects.

Object Talk: Child discusses properties of the object (e.g. “These glasses are green”). These physical traits are visually or audibly available to the child during the study period. Do not double code object talk and naming for one utterance (e.g., “Blue mask” receives only one code- Object talk) “Only give both Naming and Object talk codes when there are two different utterances, ex: “Mask. It’s blue.” Each new idea should receive a code. Examples: Child says, “Big(1), purple paperclip(2)”- They would receive two codes of Object talk.

Association: Child verbalizes an association with or elaboration about an object. Children must bring information from outside of the task to bear. (e.g., “This butterfly can fly.” “I have a necklace like this.” “My mom talks on a cell phone.” “Apple has an A”, “Pretend paper clip” or “This is a toy”) If during study a child names an object something that could include an association, for example “electric guitar”, the child’s label should be checked by the coder when the objects are put away after the task. If the child labels the object “guitar” instead at clean-up, then when they label it “electric guitar” during study this is Association. If the child still labels the object “electric guitar” at clean up, this is Naming and not Association.
Object Talk or Association referring to multiple objects: When a category is being used by a child and he refers to all the objects in the category through either object talk (i.e. “these things are round”) or association (“these are garden things”), the appropriate code (object talk/association) should be given to all objects in the category. The child must signify that he is referring to all the objects in the category by using a clear reference word that includes all the objects (these, them, those, etc).

Categorizing: Child groups two or more items verbally or physically. The presence of the category- either physical or semantic- must be either obvious to the observer or identified verbally by the child. The category need not have an obvious semantic nature, but if the reason for the category is not obvious to the coder and the child does not say that they made categories, then the objects must be in physically distinct piles or rows easily definable by the coder. If the child makes groups, divides up the groups, and then regroups, they should be given credit each time they make each group.

Relevant Talk: Child asks or comments about the task or the objects (e.g. “How do I do this?” “This is a hard game” “I’m done.” “What’s this called?”, “Let’s play with different rules”, or “I remember them all”).

Non-Deliberate Verbal Codes

Irrelevant Talk: Child talks about objects or events completely outside of the task setting (e.g., child talks about color of her shirt or child asks to use the restroom).

Onomatopoeia: A child reproduces an imitation of sounds in words associated with objects or activities (e.g., the child says “vroom” while interacting with a car)
Appendix C
Unicorn/Dragon Coding Scheme (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996)

Unicorn Trials:

0  =  Failure to move (The child just sits there)

1  =  A wrong movement (If Unicorn says, "Touch your nose" and the child touches tummy) or just a flinch

2  =  A partial correct movement (If Unicorn says, "Touch your nose" and the child starts to bring finger up to nose, but then stops short of actually touching)

3  =  A full correct movement (If Unicorn says, "Touch your nose" and the child touches nose)

Dragon Trials:

0  =  A full commanded movement (If Dragon says, "Touch your nose" and the child touches nose)

1  =  A partial commanded movement (If Dragon says, "Touch your nose" and the child starts to bring finger up to nose, but then stops short of actually touching)

2  =  A wrong movement (If Dragon says, "Touch your nose" and the child touches tummy) or a flinch

3  =  No movement (If Dragon says, "Touch your nose" and the child sits still and does not touch)
Appendix D
Example Items from the Behavior Rating Inventory of Executive Functioning – Preschool Version (Gioia, Espy, & Isquith, 2002)

During the past 6 months, how often has each of the following behaviors been a problem?  

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overreacts to small problems</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>2. When given two things to do, remembers only the first or last.</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>3. Is unaware of how his/her behavior affects or bothers others</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>4. When instructed to clean up, puts things away in a disorganized, random way</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>5. Becomes upset with new situations</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>6. Has explosive, angry outbursts</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>7. Has trouble carrying out the actions needed to complete task (such as trying one puzzle piece at a time, cleaning up to earn a reward)</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>8. Does not stop laughing at funny things or events when others stop</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>9. Needs to be told to begin a task even when willing to do it</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
<tr>
<td>10. Has trouble adjusting to new people (such as babysitter, friend, or day care worker)</td>
<td>N</td>
<td>S</td>
<td>O</td>
</tr>
</tbody>
</table>