



2013

Relations Among Endogenous Attention, Executive Functioning, and Global Assessment Measures in Toddlers and Preschoolers Born Full-Term and Preterm

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LOYOLA UNIVERSITY CHICAGO

RELATIONS AMONG ENDOGENOUS ATTENTION, EXECUTIVE
FUNCTIONING, AND GLOBAL ASSESSMENT MEASURES

IN TODDLERS AND PRESCHOOLERS

BORN FULL-TERM AND PRETERM

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE GRADUATE SCHOOL
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

PROGRAM IN DEVELOPMENTAL PSYCHOLOGY

BY

NANCY MILLER WYSS

CHICAGO, IL

DECEMBER 2013

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ACKNOWLEDGEMENTS

I have many people to thank for their assistance and support in this project and throughout my graduate education. I first would like to thank the delightful children and their parents for their participation in the project. Without their interest in the field, I could not have completed the study. Second, I would like to thank the undergraduate research assistants, specifically my research mentee Plamena Daskalova, for all of their hard work and dedication in assisting me with my coding. Third, Kathryn Joyce O'Toole, you made the lab, coding, and data entry fun, and for that I will always be grateful. To my parents, who taught me the importance of graduate school and always supported my educational and professional endeavors, you're the best! Who knew I would add two more degrees from Loyola to the family? In addition, I would like to thank Andy for building stimuli for the project without knowing what it was for and my siblings for their unwavering support and the enrollment of their children in my study. My nieces and nephews were always my favorite and the cutest participants. A big thank you to Joe (Joeface), who supported, encouraged, and, no matter how much I disliked it, pushed me to finish my degree. Finally, I would like to thank my advisor, Kathleen N. Kannass, for the dedication, support, and care she has shown and given me since the day we met. To everyone, I cannot thank you enough.

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ABSTRACT

Infants born prematurely now represent about 12% of all live births in the United States and are at risk for numerous developmental issues. For example, children born preterm are at an increased risk, two to three times greater, for later attentional problems. With the high rate of attentional issues in later childhood, it is crucial to assess young children born preterm with a valid measure. Currently, global assessments are commonly utilized in neonatal follow-up programs as a broad-based assessment of children born preterm. However, they are often poor predictors of later functioning. There are many different components of attention, and experimental tasks eliciting specific abilities may be more useful in detecting differences between term and preterm children.

Participants were 81 toddlers and preschoolers born full-term and preterm. Children completed a battery of attentional measures as well as a standardized/global assessment. Preschoolers demonstrated more mature attention patterns than did the toddlers. When examining birth status, differences were found in some areas (distractibility), but not all (e.g., executive functioning). The study has important implications for the optimal way to examine the development of attention in children at-risk for attentional delays and demonstrates that experimental measures may be more fruitful in detecting attentional differences in children born preterm than the commonly used global assessments.

CHAPTER ONE

INTRODUCTION

The number of preterm births (< 37 weeks gestation) has risen in most industrialized countries and is currently at a rate of 11.7% of births in the USA (Hamilton, Martin, & Ventura, 2012). That is, one in every nine infants is born too early. These preterm infants are more likely to survive today than they once were due to medical advancements in obstetrics and neonatal intensive care (Doyle, 2004; Hack & Fanaroff, 1999). However, this positive trend in survival has not been matched with a reduction in the rate and severity of long-term impairments, with neurobehavioral impairments observed in approximately half of surviving children born very early or very small (Anderson, Doyle, & Victorian Infant Collaborative Study Group, 2003). Preterm survivors have high rates of dysfunction in numerous cognitive areas, such as visual processing, academic processing, executive function, and attention (Saigal & Doyle, 2008). Children born preterm are especially susceptible to difficulties related to inattention and hyperactivity (Anderson et al., 2003). Indeed, it is estimated that 50 to 70% of infants born preterm develop behavior problems, including internalizing and externalizing problems and symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) (Aylward, 2005; Bhutta, Cleves, Casey, Craddock, & Anand, 2002; Pinto-Martin et al., 2004; Taylor, Klein, & Hack, 2000). In addition, the rate of ADHD in the preterm population is estimated to be 2-3 times greater (16%) than that of term-born

children (6-9%) (Bhutta et al., 2002), and it has been estimated that 14% of all ADHD cases are attributed to prematurity (Mick, Biederman, Prince, Fischer, & Faraone, 2002). Interestingly, these issues have been identified even in children without any neurological developmental impairment and seem to be universal despite crosscultural differences (Bhutta et al., 2002; Elgen, Sommerfelt, & Markestad, 2002; Hille, den Ouden, & Saigal, et al., 2001). Even healthy premature infants (i.e., those with no neurological or somatic disorders shortly after birth or at a very young age) demonstrate early differences in attention patterns (Butcher, Kalverboer, Geuze, & Stremmelaar, 2002).

With the high rate of attentional issues in later childhood, it is crucial to assess young children born preterm with a valid measure. Early detection of any possible attention problems is extremely important so that the children may be given the proper therapies and possibly avoid attentional issues in childhood. Currently, global assessments are commonly utilized in neonatal follow-up programs as a broad-based assessment of children born preterm (Howard, Anderson, & Taylor, 2008). However, a major problem with interpreting results from such global measures is that they are often poor predictors of later functioning (Cheatham, Colombo, & Carlson, 2006; Hack, Youngstrom, Cartar, Schluchter, Taylor, Flannery, et al., 2004). One issue is that these measures usually tap into various underlying processes and provide information about general cognitive functioning. Specific underlying differences may exist between groups but may not be found with global measures. Using paradigms that tap or assess specific cognitive processes (e.g., attention, memory, inhibition) may be more fruitful in detecting differences (Cheatham et al., 2006). Thus, because there are many different components

of attention, tasks eliciting specific abilities may be more useful in detecting early attention issues.

In fact, past research has examined and found differences in distinct aspects of attention such as orienting and disengagement between infants born preterm and infants born at term (Butcher et al., 2002; Rose, Feldman, McCarton, & Wolfson, 1988; Stroganova, Posikera, & Pisarevskii, 2005; Thanh Tu, Grunau, Petrie-Thomas, Haley, Weinberg, & Whitfield, 2007). However, there has been little study of term and preterm differences in endogenous (voluntary) attention. Endogenous attention encompasses colloquial constructs of attention such as attention span, distractibility, and persistence. Distractibility tasks are used extensively in the research on the development of endogenous attention because they measure how infants and children allocate their attention in the midst of competition for attentional focus (Kannass & Colombo, 2007; Lansink & Richards, 1997; Oakes, Kannass, & Shaddy, 2002; Ruff & Capozzoli, 2003; Ruff & Rothbart, 1996). In the typical distractibility paradigm, infants or children focus on a target object or toy, and there is a distractor in the periphery. By examining the latency to turn to the distractor as well as other measures (proportion of turns, looking to the distractor), researchers are able to assess distractibility and examine how distractible infants are in different states of attention. Another well-known endogenous attention paradigm, multiple object free play, examines how children allocate their attention to multiple objects. Because the task involves the presentation of several items simultaneously, this paradigm also presents competition for attentional focus (Power, Chapieski, & McGrath, 1985). The task yields additional measures of attention and

inattention, such as how children hold and switch their attention among multiple stimuli. These measures of attention (i.e., looking to toys) and attentional switches are similar to measures used in the study of how children with attentional problems and typically developing children maintain their attention to multiple toys (e.g., Alessandri, 1992; DeWolfe, Byrne & Bawden, 2000; Roberts, 1990).

The current study examined differences in endogenous attention between (a) toddlers and preschoolers and (b) toddlers born preterm and toddlers born at term using both a distractibility task as well as a multiple object free play task. Executive functioning was also examined using two different paradigms, an A-not-B task as well as a reverse categorization task. In addition, performance in the attention tasks was compared to attention scores on a global assessment to examine if there is a relationship between the well documented paradigms and a commonly used assessment. Finally, questionnaires regarding the health and behaviors of the children and the home environment were completed by a parent or guardian.

CHAPTER TWO

LITERATURE REVIEW

The Importance of Attention Research

For infants and children, attention and attentional abilities play extremely imperative roles in cognitive development. Therefore, the study of attention is important for at least three reasons. First, attention enables children to explore and learn about specific information about their environment. Considering the extremely large amounts of information present in an infant's environment (e.g., all colors, noises, and textures), the ability to attend to and focus on a certain stimulus allows the infant to obtain and process data about his environment without becoming overwhelmed with the copious amounts of data in his surroundings. In order to attend to a specific stimuli or event, infants must learn to selectively focus on the stimulus and block (inhibit) all other aspects of their environment competing for their attention (Ruff & Rothbart, 1996). Second, attention is necessary for memory and memory formations in order to encode information about objects (Colombo & Cheatham, 2006). That is, if infants cannot process and attend to information long enough to manipulate the information in a meaningful way, they will not be able to create a memory of the situation or object. Retaining information in working memory is imperative to learning about objects for later recall and recognition (Cowan, 1997). Third, with increases in the rates of attention issues such as ADHD, studying the development in typically and atypically developing children can assist in the

detection and treatment of children with attentional disorders. Early detection of attentional differences in children at-risk for later issues (e.g., ADHD) could assist in early intervention for attention and other areas of cognition. Through the study of attention, researchers in the field may have the ability to understand how and why attentional problems develop in children born preterm. Thus, studying the development of early attention is important and results from such research may have important implications for how parents, teachers, and daycare providers may facilitate attention and construct environments in early childhood conducive to learning.

The goal of the following section is to review why researchers study attention. First, attention is important in the development of other cognitive processes. Second, attention predicts later cognitive functions. Third, attention is stable, demonstrating that certain cognitive tasks elicit specific processes at different ages.

Attention and the development of other cognitive processes. Because visual attention is the means by which infants learn, it affects numerous other areas of development such as motor skills and language, and is essential to cognitive development. Thus, infants born preterm with immature attention systems may be at-risk for delays in numerous areas of development. For example, attention is needed in the development of learning, motor skills, and language. In discrimination learning, an infant learns to discriminate between two targets and choose the one that consistently leads to reinforcement. Ruff and Rothbart (1996) argue that attention is needed in order to perform this task. The infant must inhibit attention to irrelevant cues and attend to the relevant stimuli. In addition to discriminate learning, the development of other abilities

elicits attention processes. At first, infants require much attention in their motor skills until they become efficient reachers (Ruff & Rothbart, 1996). Similar to motor skills, communication develops as the allocation of attention changes. Bloom and Beckwith (1989) propose that, in the beginning, attention is needed to produce a word. However, after more practice, producing language requires less cognitive effort. Because the development of attention is an important process in itself as well as in the development of other cognitive abilities, immature attentional abilities may affect numerous areas of the overall development of premature infants. In addition to attention during infancy, attentional skills are thought to form the building blocks from which other cognitive abilities develop, and inefficient attention can compromise a child's capacity to learn new skills and knowledge and greatly affect academic achievement (Anderson, Northam, Hendy, & Wrennall, 2001; Spira & Fischel, 2005). The early detection of any possible attention differences and subsequent treatment can possibly lessen later attentional issues and other cognitive delays.

Attention as a predictor of cognitive functions. Attention is not only essential to the development of other cognitive abilities, it has been shown to be predictive of cognitive functions. For example, researchers have found that when assessing infant learning (as in a habituation task) shorter looking durations at the visual stimulus correspond with higher IQ and vocabulary scores later in childhood (Colombo, Shaddy, Richman, Maikranz, & Blaga, 2004; Rose & Feldman, 1997). Researchers propose that durations of looking in these experimental tasks are tapping into specific underlying cognitive processes. In this case, shorter looking durations are attributed to faster speed

of processing and better memory abilities (Colombo & Mitchell, 1990; Colombo & Janowsky, 1998; Frick, Colombo, & Saxon, 1999). However, studies focusing on the relationship between attention span during object exploration and later outcome measures demonstrate that longer looking durations actually relate to later positive cognitive abilities (e.g., Kopp & Vaughn, 1982; Ruff 1990). Although these results appear to contradict each other, the two tasks may be tapping different abilities. These data could be attributed to different processes guiding infant looking in habituation paradigms and attention span in object exploration.

Because both short and long looking durations as measured in different tasks predict more optimal cognitive performance, the meaning of these looks must be understood. As attention develops during infancy, the underlying processes of attention also change. Therefore, the same measure (e.g., durations of looks to a stimulus) may reflect different processes at different ages (Colombo & Janowsky, 1998). For example, in early infancy, duration of looking in a single object task may reflect the infant's speed of processing of the stimulus. However, at older ages, this same paradigm could be examining attention span. It is also plausible that a single measure at any age can reflect multiple processes. For example, looking in a habituation task taps memory processes such as recognition memory (i.e., determining if the object is novel or familiar) and speed of processing information about the object. Various attention tasks may tap into different underlying processes at a given age (Ruff, Capozzoli, & Weissberg, 1998).

Stability of attention. Attention not only is a predictor of later cognitive functioning, but research has also demonstrated that there is some stability in attention

across age and task, indicating that similar cognitive processes are elicited as infants develop and mature. For example, Rose, Feldman, and Jankowski (2001) found stability in performance in a continuous familiarization task across ages. In the continuous familiarization task, infants were presented with a series of paired stimuli, with one remaining the same from trial to trial and the other changing. Trials terminated when the infant reached a specified criterion of consistent preference for novel stimuli. Because this allowed the same procedure to be used with different age groups, developmental differences in trials to criterion could be assessed using a constant metric. The results revealed that individual differences in attention measures (e.g., looking duration and shift rate) were modestly stable between 5 and 7 months and between 7 and 12 months of age (Rose et al., 2001). That is, infant performance on the same task is related to performance on the same task at older ages. The same was found for individual differences in the frequency of anticipatory eye movements from 5 to 7 months, and from 7 to 12 months of age in the continuous familiarization task (Rose, Feldman, & Jankowski, 2002).

In addition, Kannass, Oakes, and Shaddy (2006) investigated the consistency of attention across tasks at different ages and the stability of attention over time. Using multiple object free-play tasks at 7, 9, and 31 months of age, the researchers examined the duration of individual looks to the toys. Additionally, the infants participated in a distractibility paradigm at each age. Results demonstrated that at 7 and 9 months, there was no consistency in attention allocation between the multiple object free play session and the distractibility task. That is, infants' attention in the multiple object tasks was not

correlated with their attention in the distractibility task. The researchers pose that these tasks tap different underlying abilities in infancy. However, at 31 months, there was consistency in attention allocation across different tasks. Those who were more attentive in the free-play session were also less distractible. By 31 months of age, similar processes are elicited in the different tasks. In addition, the researchers found that infant distractibility at 9 months was related to distractibility at 31 months. For example, infants who exhibited longer latencies during focused attention at 9 months also exhibited longer latencies to turn to the distractor during focused attention at 31 months.

Other research has also demonstrated relationships between early attention differences and attention measures into early childhood. For example, Ruff and colleagues used free-play sessions to examine how measures of attention and inattention are predictive of later attentiveness in early childhood (Lawson & Ruff, 2004; Ruff, Lawson, Parrinello, and Weissberg; 1990). The researchers found that focused attention during free play in 7-month-old infants born preterm was predictive of focused attention at 2 years, but not 3 years (Lawson & Ruff, 2004). In addition, the research found that there is individual stability in full-term children from their 2 to 3.5-year-old measures. For preterm children, the results showed an association between the measures of activity and inattention at 1 year and activity and inattention measures at 3.5 years. In sum, the Rose et al. (2001), Kannass et al. (2006), Lawson and Ruff (2004) and Ruff et al. (1990) work all demonstrates the stability of attention in infancy and from infancy into toddlerhood and into the preschool years.

Because of the relationship between early attention patterns and later attention, early differences in attention can indicate possible issues in the future. Research has demonstrated that early attention issues (inattention, impulsiveness) are related to attention problems later in life (Snyder, Prichard, Schrepferman, Patrick, & Stoolmiller, 2004). If infants born prematurely are more distractible at a younger age, this immaturity in the attentional system may continue well into toddlerhood, resulting in delayed attention abilities.

Early attention performance is not only related to later attention but also to other behaviors and cognitive abilities (Colombo et al., 2004; Rose & Feldman, 1997). For example, the predictive value of early orienting of attention for later global cognitive functioning was demonstrated in a study by Sigman and Cohen and colleagues. They demonstrated that infants born preterm who displayed longer looks in a visual fixation task (measured by recording infant eye movements at a checkerboard pattern) at 40 weeks gestational age (i.e. the expected due date; children's ages ranged from 3 to 14 weeks of age depending on how early they were born) received lower developmental scores at 18 and 25 months of age (Sigman & Beckwith, 1980) and lower intelligence scores at 5 years (Cohen & Parmelee, 1983) and at 8 years (Sigman, Cohen, Beckwith, & Parmelee, 1986). These results suggest that longer looking at the expected due date can be considered a risk factor for subsequent developmental delay. More recently, Lawson and Ruff (2004) found focused attention at 7-months in a free play task to be predictive of behavioral problems (i.e. hyperactivity and impulsivity) at 4 to 5 years using a parental

report hyperactivity index and global cognitive abilities at 2, 3 and 4 to 5 years (measured using a standardized global assessment).

In sum, the findings from attention research reveal that attention is stable in individuals in infancy and early childhood (Kannass et al., 2006; Rose et al., 2001, Rose et al., 2002a; Ruff et al., 1990). Additionally, these differences in attention are related to outcome measures such as lower intelligence scores and increased behavioral problems later in childhood (Cohen & Parmelee, 1983; Lawson & Ruff, 2004; Sigman & Beckwith, 1980). Early detection of these differences could provide infants and children with the therapies needed to prevent the negative outcomes associated with immature attention patterns.

Development of Attention in Full-Term and Premature Infants and Children

The goal of this section is to discuss the development of the four systems of attention in full-term, typically developing infants and compare their development with that of infants born prematurely. Although attention develops quickly in the first year of life, it is a complex construct with many different components. In fact, Colombo has proposed that there are four different systems of attention: Alertness, spatial orienting, attention to object features, and endogenous attention (Colombo 2001; Colombo 2002; Colombo & Cheatham, 2006). Changes in looking durations to a stimulus as infants develop are thought to demonstrate changes in the attentional systems. For example, in typically developing infants, there is an increase in looking time from birth to around 8 weeks of age which researchers propose is due to the development of alertness and ability to orient (Colombo, 2001, 2002). There is then a linear decrease in looking duration to 6

months, which is attributed to increased speed of processing and disengagement (Colombo, 2001, 2002). Finally, there is another increase in look durations from 26 weeks into toddlerhood and beyond, which is thought to reflect the development of endogenous (voluntary) attention (Colombo, 2001, 2002). The developmental pattern of looking in preterm infants, however, is unknown at this time. In other words, the developmental trajectory of looking in premature infants is not well studied.

Alertness. The first component in the development of attention is alertness. The ability to attain an alert state is not possible until late in gestation and is not common in early infancy, even in infants born at term (Colombo, 2001). Research has demonstrated that infants spend less than 20% of their days in an alert state (Colombo & Horowitz, 1987). The emergence of well-defined behavioral states is a distinguishing characteristic of gestational age. From 30 weeks gestational age to term, the sleep and wake states become clearly differentiated, and the waking states themselves become reliably distinguishable (Aylward 1981; Berg & Berg, 1979; Wolff 1965). From birth to 8 or 10 weeks, infants cannot attend to stimuli for significant periods of time because they do not have the basic alertness required for attention (Colombo, 2001). By 3 months of age, infants have more time in alert stages and can attend to stimuli because of changes in their ability to attain and maintain an alert stage (Berg & Berg, 1979; Colombo, 2001).

Neurologically, researchers have suggested that the primary brainstem locus for the system of alertness is the locus coeruleus (Aston-Jones, Rajkowski, Kubiak, & Alexinsky 1994; Rajkowski, Kubiak, & Aston-Jones, 1994; Usher, Cohen, Servan-Schreiber, Rajkowski, & Aston-Jones, 1999). During episodes of alertness, this area is

highly active and is correlated with increases in norepinephrine in the cortex (Aston-Jones, Chiang, & Alexinsky, 1991). In addition, the cholinergic pathway is associated with sustained attention tasks (Robbins, Everitt, Marston, Wilkinson, Jones, & Page, 1989). Differences in the development of these areas could greatly affect attention behaviors and abilities. To date, specific information about the differences in these pathways between preterm and fullterm infants is unknown.

When comparing alertness in full-term and preterm infants, research has found that infants born preterm look longer than infants born at term at the expected due date and into the first months of life (Sigman, Kopp, Littman, & Parmelee, 1977). In this study, full term infants were tested 2-7 days after birth, while the premature infants were given time to catch up to 40 weeks so they ranged in age from 3- to 14-weeks old. Premature infants were more attentive in all trials and showed higher levels of arousal (Sigman et al., 1977). To examine this effect further, the authors retested the full-term infants again, after 2 weeks, to test if their visual fixation patterns would change. Interestingly, there was no change in the attentiveness of full-term infants after giving them more time to acclimate to the world. That is, differences in the visual attention patterns between premature and full-term infants cannot simply be attributed to their increased time in the world. The longer looking in preterms may be an indicator of slower speed of processing or perhaps a difference in the developmental course of their looking patterns with respect to fullterm infants. In sum, different attention patterns are already apparent in the first few weeks of life between full-term and premature infants.

Spatial orienting. Another component of attention is spatial orienting. Orienting to a stimulus is not a simple process. In fact, spatial orienting can be separated into three different steps: the engagement of visual attention at a stimulus, the disengagement of visual attention from the stimulus and the shifting of visual attention from the stimulus to another (Colombo, 2001). A posterior attention system (e.g., Posner & Petersen 1990) has been identified as the neural substrate that mediates these functions. Colombo (2001) explains that this system is composed of three structures, each of which has been identified with one of the functions necessary in orienting: (1) the pulvinar (a nucleus of cells in the thalamus) has been hypothesized to mediate engagement of visual attention to stimuli in particular spatial locations, (2) the posterior parietal lobe mediates disengagement of visual attention from stimuli in such locations, and (3) the superior colliculus mediates the shifting of visual attention from one locus to another.

As infants' visual systems mature, these separate processes also develop. Disengagement of attention can only occur if the infants can inhibit attention to one object and then use their eye muscles to move toward the new object. Infants who are immature and do not have the ability to disengage appear to have finished processing the stimulus but are unable to inhibit fixation to the object and look at another (Blaga & Colombo, 2006; Greenberg & Weizmann, 1971), a phenomenon known as obligatory attention (Stechler & Latz, 1966) or sticky fixation (Hood, 1996). As infants develop, their abilities to disengage from the current focus, shift attention, and reengage rapidly emerge in the period from 2 to 6 months of age. By 4 months of age infants are rarely captured by stimuli they are fixating and shift gaze rapidly from one stimulus to another

(Atkinson, Hood, Wattam-Bell, & Braddick, 1992; Johnson, Posner, & Rothbart, 1991).

By midway through their first year, full term infants can easily orient to stimuli, demonstrating another attentional ability.

Research has revealed conflicting results when comparing the speed of fixating and attention disengagement between infants born preterm and those born fullterm using visual orienting tasks (Butcher et al., 2002; Stroganova et al., 2005; Stroganova, Posikera, Pisarevskii, & Tsetlin, 2006a, 2006b). Hunnius, Geuze, Zweekers, and Bos (2008) examined shifts of attention in a longitudinal study with preterm [mean Gestational Age (GA): 29.6 weeks] and full-term infants. The infants were tested in a gaze shifting task with two different kinds of trials: competition and non-competition trials. All trials started with the appearance of a stimulus in the center of the monitor, the fixation stimulus. After the infant had been fixating the central stimulus for 1-2 seconds, a second stimulus was displayed in the periphery. In the non-competition trials the central stimulus disappeared when the peripheral target came up; in competition trials it persisted after the peripheral target had appeared. Thus, competition trials demanded disengagement of attention and gaze from the fixated central stimulus before an eye movement to the peripheral target could be generated. Preterm infants of 10 and 14 weeks of age (corrected age for all infants, calculated from the due date) were faster than the full-term infants when shifting their gaze to the newly appeared stimulus in the periphery. For the age period between 16 and 26 weeks, the effect of preterm infants exhibiting shorter latencies disappeared as infants grew older. That is, until about 16 weeks post term, preterm infants were faster in disengaging and shifting their attention

and gaze from a stimulus in their central visual field to the periphery than were full-term infants.

In contrast, in another longitudinal study, Butcher et al. (2002) tested full-term and preterm infants (all born less than 32 weeks gestation, range not given by authors) six times with a disengagement task between 6 and 26 weeks of age (adjusted age was used for the preterm groups). Again, similar to the Hunnius et al. (2008) work, competition and noncompetition trials were included. All trials began with the appearance of the fixation stimulus on the center monitor, accompanied by a brief melody. On competition trials, a peripheral target was added to the display when the infant had been fixating the stimulus for 1-2 seconds. After 5 seconds, the peripheral target and the fixation stimulus disappeared simultaneously. Following an inter-trial-interval with blank screens, the fixation stimulus reappeared and the following trial began. Competition trials thus required disengagement of gaze and attention from the fixation stimulus before an eye movement could be made to the peripheral target. These trials measured the attentional processing required for disengagement in addition to the sensory-motor processing involved in detecting and moving the eyes to the peripheral target. The frequency and latency of correct refixations on competition trials in each session provided an index of the efficiency with which infants disengaged. On noncompetition trials, the fixation stimulus disappeared when the peripheral target appeared. Noncompetition trials thus required only the generation and execution of an eye movement. Thus, the tasks were very similar to the Hunnius et al. study. Both groups of infants born preterm (low risk and high risk) disengaged less efficiently than the full-term group. The infants born

preterm continued to display a less mature form of errors with increasing age, by persistently staring at the fixation stimulus. In contrast, infants born at term increasingly made errors away from the target at older ages. In addition, infants born preterm showed fewer errors than infants born at term. Although this second finding seems to indicate superior performance, the authors argue that the type of errors the full-term group did make are indicative of a *more* mature inhibition of attention to the fixation stimulus and the inhibition of a response to a highly salient peripheral target in order to look toward another, apparently more attractive location.

Other research has demonstrated that preterm infants do not orient as well as full-term infants later in the first year. Landry (1985), for example, found that 7-month-old (corrected age), high-risk infants born preterm (gestational age not provided by authors) had more trouble turning from a blinking light to the habituation stimulus compared to low-risk infants born preterm and infants born at term, suggesting less efficient disengagement and shifting of attention. Poorer shifting skills in infants born preterm were also demonstrated in a longitudinal study by Rose and colleagues (Rose et al., 1988; Rose, Feldman, Wallace, & McCarton, 1991), who found that infants born preterm showed fewer changes in attentional focus (i.e., did not change attention between stimuli) than infants born at term at 7 months (Rose et al., 1988), but not at 12 months (Rose et al., 1991). Similar differences in attention behaviors were found in another longitudinal study by Rose et al. (2001), who demonstrated that infants born preterm not only looked longer, but also shifted slower between targets than infants born at term at 5, 7 and 12 months of age in a paired comparison task (Rose et al., 2001), and at 12 months in a new

continuous familiarization technique (Rose et al., 2002). In addition, at each age, full term infants were significantly faster at processing the stimuli than were the preterm infants. That is, in addition to differences in shifting attention, there are also differences in processing speeds between infants born full term and infants born preterm.

In sum, with the exception of the Hunnius et al. (2008), results from tasks of visual orienting suggest that, infants born preterm show less efficient orienting of attention than infants born at term during the first year of life, characterized by a tendency to be captured by stimuli, less efficient disengagement and shifting of attention and problems with maintaining anticipatory attention (Butcher et al., 2002; Landry, 1985; Rose et al., 2001, 2002; Sigman et al., 1977).

Object attention. While the “where” system of spatial attention provides information regarding the spatial coordinates of an object, the “what” pathway of object attention processes information about the object features of the stimulus (e.g., shape, color). This separate system involves attentional mechanisms that are involved in the analysis of foveal input and the processing of visual properties that eventually lead to the identification of patterns and objects (Webster & Ungerleider, 1998). This pathway extends from the occipital cortex through higher visual areas in the posterior inferior temporal cortex and into the inferior temporal cortex (Colombo & Cheatham, 2005). Along this pathway, the visual properties of the object are processed independently of one another (Livingstone & Hubel, 1987). At some point, these characteristics of the objects are then integrated together. Thus, this pathway mediates stimulus discrimination and recognition (Ungerleider & Mishkin, 1982).

As infants mature, their abilities to discriminate and recognize develop. For example, it has been found that younger infants do not scan stimuli as extensively as infants older than 2 months (Leahy, 1976). They also encode a design's form much faster than color, implying they are not combining the information. Research has shown that infant looking increases from the newborn period to about 8 or 10 weeks of age (Hood, et al., 1996) before dropping between 10 and 20 weeks of age (Colombo, 2002; Colombo et al., 2004) when substantial changes in object attention occur between 2 and 6 months of age (Colombo, 2001). Researchers have examined the developmental changes in object attention by examining looking measures (e.g., peak look, duration of first fixation, total looking) using visual habituation tasks (Colombo, Mitchell, O'Brien, Horowitz, 1987; Colombo & Mitchell, 1990). Colombo and colleagues examined developmental changes by testing infants monthly from 3 to 9 months of age (Colombo et al., 2004). Infants were habituated to stimuli (color slides of children's faces) using an infant-controlled sequence. The habituation criterion was met when the infant had two consecutive looking durations that were 50% of the longest look duration. Results revealed a significant decline in the longest look durations from 3 to 9 months of age. The decrease in look durations during this period is likely a result of changes in spatial and object attention as well as increased speed of information processing (Colombo, 2001). However, another measure, total looking duration to the stimuli, yields a different pattern of results. In this measure, infant looking begins another increase from 6 months of age onward (Colombo, 2001, 2002), attributed to the fourth system of attention, endogenous attention (discussed below).

Past research has found differences in habituation patterns between infants born preterm and infants born full-term (Rose, 1980; Rose, et al., 1988; Sigman & Parmelee, 1974). For example, Sigman & Parmelee (1974) used a paired comparison task on 4 month olds (corrected age for preterms, average gestational age 33.6 weeks) with checkerboard patterns and then faces (normal and scrambled). No difference was found between groups in terms of the total attention to the stimuli. In addition, both preterm and fullterm infants looked longer at the complex than the simple stimuli. However, differences were found in novelty preference. Infants born fullterm showed a novelty preference. That is, they looked longer at novel stimuli. When a novelty preference is evident, it is because the infant has finished processing the information from the familiar stimulus. Infants born preterm did not exhibit a novelty preference. When infants do not demonstrate a novelty preference, it indicates a slower information processing speed. The infants have not finished processing the stimulus during familiarization and encoded the information to recognize the familiar stimulus as something they have seen before. Thus, although the infants born preterm looked for the same amount of time as did the infants born fullterm, they are processing the stimuli in a different way because there were differences found in novelty preference.

Differences between infants born preterm and infants born fullterm are also evident at older ages. At 6 months of age (corrected age, average GA: 34.7), differences in novelty preferences can be seen (Rose, 1980). Infants were shown different stimuli (multi-dimensional (MD) and faces) until their total looking at the stimuli reached the criterion (5 seconds for MD and 20 seconds for faces). In the test phase, infants born full

term showed a novelty preference. Infants born preterm did not differentiate between novel and familiar in either the MD or the faces. In a second study, preterm infants were given longer times of familiarization. With the increased familiarization times, infants born preterm demonstrated significant novelty percentages. The findings of the second study by Rose imply that the preterms who failed to show significant novelty scores with shorter times were not necessarily unable to recognize the stimuli. On the contrary, they were able to discriminate between the paired test stimuli, store the initial information, and retrieve it from storage (Rose, 1980). They do, however, appear to process the visual information more slowly than infants born full term.

Differences in processing are also evident in other looking measures. Rose et al. (1988) examined how infants examined stimuli during familiarization. Using the same procedures and criterion as Rose (1980), the researchers calculated the exposure time score in 7-month-olds (corrected age for infants born preterm, mean GA: 31.3). This score is the amount of time that the stimuli needed to be on the screen in the familiarization phase before the infant accumulated the amount of looking (5 seconds for abstract patterns, 20 seconds for faces). Infants born preterm required a longer exposure time to the stimuli than did the infants born full-term in order to accrue the preset amount of looking time. In addition, the researchers computed the average duration of fixations for each infant and assessed the tendency of infants to shift their gaze between the two displays. A shift was defined as a change in fixation from one target to another. Infants born preterm exhibited less shifting than did infants born fullterm on abstract patterns and faces. In addition, in infants born preterm, longer fixations were accompanied by less

shifting of gaze between the 2 target stimuli, possibly indicating less active comparison (Rose et al., 1988). Shifts in gaze between stimuli are an integral component in the process of visual comparison (Ruff, 1975). Thus, the infants born preterm may be using an inefficient or nonoptimal strategy for gathering information.

Research has found that differences in habituation patterns occur throughout the first year of life (Rose et al., 2001, 2002). In a longitudinal study, infants were tested with a paired comparison task at 5, 7, and 12 months of age (corrected age for infants born preterm, mean GA: 29.6 weeks). Using faces of infant Caucasians the trials began when the first look to either of the paired targets and ended when the infant had accumulated 4 seconds of looking to the display. One was a familiar picture; 18 others were novel. Testing continued until the criterion was met (4 out of 5 consecutive trials having a novelty score >55%, but less than 100%). That is, for a trial to be included in the criterion run, there had to be some looking directed toward both targets, thus ensuring active comparison between them. The authors had a variety of measures including a) processing speed: the number of trials taken to reach criterion, b) the total amount of time spent looking at the familiar before achieving criterion, c) mean look (mean duration of looks on each trial averaged over trials) and d) shift rate (the number of shifts in gaze from one target to another, expressed as the number of shifts per second). At each age infants born full-term were significantly faster at processing the stimuli than were the infants born preterm. They took about 20% fewer trials to reach criterion and did so with 24-33% less time looking to the familiar target. For the attention measures (mean look and shift rate), there were differences at 12 months. Infants born fullterm had shorter

looks and faster shift rates (i.e., more shifts of gaze between the paired targets).

Differences between infants born preterm and infants born fullterm were similar at all three ages. Thus, there was no evidence that the gap in performance narrowed with age or that the preterms “caught up”. In sum, research using habituation tasks has revealed differences between infants born fullterm and infants born preterm in their attention, looking patterns, and novelty preference.

Endogenous attention. Recall that looking times increase from birth to 8 weeks of age, decrease from 8 to 24 weeks of age, and then begin to increase after 6 months of age. This second trend of increased looking patterns has been attributed to the development of the fourth system of attention, endogenous attention. This is the everyday definition of attention (attention span, distractibility, persistence) and concerns the ability to internally control what one does and does not focus on. Because infants are preverbal, the development of their attention is studied through behavioral means, in particular through looking time. From 9 months through early childhood, the duration of looking to a stimulus increases (Colombo, 2001; Colombo & Cheatham, 2005; Courage, Reynolds & Richards, 2006). However, the increase in durations of looking cannot be attributed to the development of speed of processing. Using only that reasoning, the data would suggest that infants actually become slower at processing information during the later part of the first year. Researchers have suggested that this is unlikely, and therefore, a different underlying cognitive process, endogenous attention, is the explanation for the increase in looking time (Colombo, 2001; Colombo & Cheatham, 2005; Courage et al., 2006; Ruff & Rothbart, 1996).

Previous research suggests that these voluntary attention functions are controlled by frontal areas such as the anterior cingulate (Posner & Petersen, 1990), the frontal eye fields, and the dorsolateral prefrontal cortex (Funahashi, Bruce, Goldman-Rakic, 1989; Guitton, Buchtel, & Douglas, 1985). Voluntary eye movements have been associated with the cingulate cortex in the medial frontal areas (Posner & Petersen, 1990), and the maintenance of attention and the inhibition of shifting have also been associated with frontal areas such as the frontal eye fields (Parasuraman 1998). In addition, these frontal areas are anatomically linked with the mechanisms that mediate both spatial orienting and object recognition (Webster & Ungerleider, 1998). Thus, Colombo (2001) argues that the frontal areas of the brain exert influence on the functions of these “what” and “where” systems explained above. Finally, it also appears that the frontal systems project back to certain brainstem structures (Watson, Valenstein, & Heilman, 1981) and may thus initiate or maintain states of arousal that are endemic to vigilant or sustained attentional states.

The beginning of the development of endogenous attention starts with the control of eye movements (Frick et al., 1999; Hood & Atkinson, 1993). It is often assumed that very young infants’ eye movements are mostly involuntary and reflexive (Richards, 2001). Research has demonstrated that there is a change from these primarily reflexive eye movements at 2 months of age to voluntary (attentive, cortically influenced) saccadic eye movements over the first 6 months (Richards & Holley, 1999). The development of voluntary eye movements towards a stimulus coincides with the beginnings of endogenous attention. The results from visual expectation paradigms (VExP) indicate that infants born preterm show similar abilities to make an anticipatory eye movement on

the basis of a regular pattern of events, compared to infants born at term (Rose, Feldman, Jankowski, & Caro, 2002b), but have more problems maintaining their anticipatory attention than infants born at term (Stroganova et al., 2005, 2006a, 2006b). In this paradigm, the latency and frequency of eye movements are recorded as the infant watches a series of pictures appearing on a video. As pictures move across the screen, researchers can examine the infants' abilities for both exogenous attention (following the stimuli) and endogenous attention (anticipating where the stimuli will appear). Rose et al. (2002a) found similar frequencies in anticipatory eye movements in 5-, 7-, and 12-month-old infants born preterm and infants born at term in their continuous familiarization task mentioned above. A more recent study by Stroganova et al. (2005) confirmed these findings in 5-month-old infants born preterm, but also found that infants born preterm had more trouble maintaining anticipatory attention (i.e., maintaining gaze fixation after anticipatory eye movement) than infants born at term. That is, although some studies have demonstrated comparable performance between preterm and full-term infants in visual expectation tasks, further analyses demonstrate that there are, in fact, differences in attention present early in the first year. After the endogenous control of eye movements has developed, the development of higher-level attentional control can be seen later in the first year of life (Colombo, 2001, 2002). To date little is known about term and preterm differences in attention span and distractibility. However, using various paradigms (e.g., single object and multiple object tasks), researchers have examined the development of endogenous attention through the preschool years in children born at term (Kannass &

Colombo, 2007; Kannass & Oakes, 2008; Oakes, et al., 2002; Ruff & Capozzoli, 2003).

This will be discussed in the following section.

Developmental changes in endogenous attention. The goal of the following section is to describe changes in endogenous attention over the first few years of life. Research on endogenous attention with toddlers and preschoolers has revealed developmental changes in attention span. For example, Kannass and Oakes (2008) tested children at 9 and 31 months of age with both single object and multiple object tasks. The toddlers had higher amounts of looking to the toys than did the infants. They also had longer averages of individual looks and fewer episodes of inattention. The authors argue that these differences are due to developmental changes in the ability to hold and sustain attention between infancy and toddlerhood. In addition, Kannass, Colombo, and Carlson (2009) found that children at 18 months of age displayed more total looking to the toys, longer average look lengths to the toys, and fewer shifts in attention between toys compared to the same task at 12 months of age. That is, the children were more attentive as 18-month-olds than they were as 12-month-olds.

In addition to examining attention span, researchers have used the same tasks, single-object and multiple object, to measure attentional focus and have found developmental differences. In a longitudinal study, Ruff and Lawson (1990) investigated the differences in focused attention between 1, 2, and 3.5-year-old children using both single-object and multiple object tasks. Researchers have found that the degree of attentional engagement (or degree of concentration) varies in a look. During focused attention, an infant is actively acquiring information about an object and encoding. In

casual attention, the infant is looking at the object, but is not actively engaged in processing information about the stimulus (Ruff, 1986; Ruff, Saltarelli, Capozzoli, & Dubiner, 1992; Oakes, Madole, & Cohen, 1991; Oakes & Tellinghuisen, 1994). At the first timepoint in the Ruff and Lawson (1990) study, the 1-year-olds were given 2 minutes to play with a single object (the single-object task) and then another 2 minutes with six different toys presented simultaneously (the multiple object task). The 2-year-olds had five minutes of free-play with multiple objects and the 3.5-year-olds had 7 minutes with multiple objects. The duration of focused attention on the toys was coded at each age. Ruff and Lawson (1990) found that the children maintained focused attention longer as they grew older. Additionally, the 1-year-olds showed a steady decrease in their focused attention as the session went on, suggesting limitations in their attention span. However, this was not observed in the older ages. The authors propose that because the 1-year-olds had a decline in focused attention in both the single and multiple-object conditions, this may be due to habituation. However, at the older ages, the increase in focused attention was attributed to complexity of play and increases in endogenously controlled attention. The older children were not focused on the physical characteristics of the toys. Instead, the children were goal-oriented with tasks (e.g., construction of a tower). Overall, this study demonstrates that focused attention increases with age, coinciding with increases in complexity of play and the development of endogenous attention (Ruff & Lawson, 1990).

Developmental changes are also apparent in distractibility, another aspect of endogenous attention. Distractibility research has shown that infants, in a rudimentary

way, begin to prioritize their attention at the end of the first year. Oakes et al. (2002) examined infants at 6.5 and 9 or 10 months of age. The infants explored an object while a distractor was presented in the periphery with auditory and visual components. The distractor was presented until the infant fixated on the screen, and latencies to turn to the distractor were recorded. The researchers varied the characteristics of the stimuli by testing the infants with both familiar and novel objects. The researchers found that the 6.5-month-old infants were equally distractible no matter the novelty of the object. In contrast, the 9 month olds exhibited longer latencies while examining novel toys than when exploring familiar toys. The authors pose that the older infants were able to allocate their attention to the novel toy and inhibit responding to the distractor because of the development of endogenous attention. This study demonstrates that infants begin to allocate attention later in the first year as endogenous attention develops.

Research has also demonstrated developmental changes in distractibility in older children. For example, Ruff and Capozzoli (2003) found that 10-month-olds were more distractible than 42-month olds when comparing the amount of turns to the distractor and the amount of time looking at the distractor. Another study demonstrated that 3.5-year-olds are distracted by different levels of distractions (continuous and intermittent), but by 4 years of age, preschoolers' attention spans have matured, and they are able to ignore an intermittent distractor (Kannass & Colombo, 2007). These studies demonstrate that endogenous attention increases from late infancy into early childhood. Although little is known about differences in attention span and distractibility between children born at

term and children born preterm, research on sustained attention has yielded some interesting results.

Differences in sustained attention between children born term and preterm. Van de Weijer-Bergsma, Wijnroks, and Jongmans (2008) reviewed differences between infants born full-term and infants born preterm. In their review, they identify important research areas in the literature. For example, they discuss how research on sustained attention during free play in infants born preterm shows some contradictory results. Whereas some researchers found infants born preterm show less looking and more attention shifting behaviors than infants born at term (Rose et al., 2001, 1988; Thanh Tu et al., 2007), others found no differences (Pridham, Becker, & Brown, 2000), or even found longer periods of focused attention in infants born preterm than infants born at term during free play (Ruff et al., 1990). Van de Weijer-Bergsma et al. (2008) also identify that, when infants become preschoolers, researchers report more consistent results, finding that children born preterm were less attentive than children born at term. These points are reviewed in the following section.

Researchers have used different measures to assess sustained attention. Some studies used looking measures (e.g., mean look length) to assess sustained attention (Rose et al., 1988; Rose et al., 2001), and others examined the type of attention (degree of attentional focus) when the infant or child is looking at the toy (Ruff et al., 1990; Thanh Tu et al., 2007). The different measures may account for differences in results. For example, Thanh Tu et al. examined focused attention in 8-month-olds with measures used in previous research. They found lower quantity of focused attention in infants born

preterm. Infants were rated as significantly lower in focused attention using a 5-point scale on all four trials. Unlike Thanh Tu et al. (2007), Pridham et al. (2000), found no differences in focused exploration between 8-month-old infants born preterm and infants born at term during free play. In this study, the measure used to assess attentional focus was the percentage of time in the first 2 minutes of the toys session during which focused exploration was observed. The researchers developed their own measure for focused exploration (attention) of the toys. Research examining attentional focus typically uses facial cues (e.g. intent expression, pursed lips, furrowed brow) in addition to object manipulation to assess degrees of attentional focus (Oakes & Tellinghuisen, 1994; Ruff, 1986; Ruff & Capozzoli, 2003). In the Pridham et al. (2000) study, infants were coded as engaging in focused exploration of a toy when they looked at and held the toy in at least one hand or manipulated the toy. Manipulation included using fingers and/or hands to feel, poke, prod, rotate the toy, transfer it from hand to hand, shake or bang it against the high chair tray or table while looking at the toy. Facial expression was not used to assess attentional focus. Thus, comparing focused attention measurements from the Pridham et al. (2000) work with the studies using different focused attention measures (Ruff et al., 1990; Thanh Tu et al, 2007) may not be accurate. Due to differences in how sustained attention was measured, the variations may explain why results differ.

In addition to various measures, researchers have also used different age groups. Both the Ruff et al. (1990) and the Thanh Tu et al. (2007) studies used measures of focused attention to assess sustained attention. Differences in the findings between these studies (Ruff et al. (1990) found higher focused attention in preterms; Thanh Tu et al.

(2007) found lower amounts of focused attention) may be explained because the researchers examined different age groups. While Ruff and colleagues measured focused attention in toddlers (2- and 3.5-year-olds), Thanh Tu and colleagues assessed focused attention in infancy (8-month-olds). There may be a change from infancy into toddlerhood in differences of focused attention between preterm and fullterm children. In sum, studies investigating attention in infants and children born full-term and those born preterm have revealed differing results. However, differences in measures (how focused attention was assessed) and age groups (toddlers versus infants) may explain these discrepancies.

When infants become preschoolers, researchers report more consistent results, finding that children born preterm were less attentive than children born at term (Caravale, Tozzi, Albino, & Vicari, 2005; McGrath, Sullivan, Devin, Fontes-Murphy, Barcelos, DePalma, & Faraone, 2005; Vicari, Caravale, Carlesimo, Casadei, & Allemand, 2004). For example, McGrath et al. (2005) demonstrated that high-risk children born preterm were less attentive than children born at term during a problem solving task at 4 years of age (not corrected for prematurity). Children came to a hospital where a videotaped problem-solving task assessed attention (Seifer & McGrath, 1993). The mother and child were instructed to use pieces of “Pipeworks” toys and given a model that they were to reproduce. They worked to build first a table and next a wagon. The tasks were designed to be graded in difficulty, with the second task being more difficult. Videotapes then were rated by independent coders using a scale of 1 (low attention) to 5 (high attention). Preschoolers born preterm were rated as less attentive than children

born fullterm. This finding is consistent with that of Vicari et al. (2004) and Caravale et al. (2005), who found that even low-risk children born preterm showed shorter periods of attention than did children born at term at 3 to 4 years (not corrected for prematurity) using the Leiter International Performance Scale-Revised (LIPS-R; Leiter, 1997). This is a barrage task with a time limit (30 seconds). Four sheets of paper with a target picture (a puppet) at the top and two different pictures (puppets and balls) at the bottom are presented to the child one at a time. For each sheet, the child has 30 seconds to cross out the pictures that are identical to the target. The score is the total number of correctly crossed out images, ranging from 0 to 64. In sum, the few studies investigating attention during the preschool years are more similar than those studying attention in infancy, suggesting that problems with attention become more visible in children born preterm with increasing age, regardless of their risk status.

Executive Functioning

Differences in attention can affect top down, metacognitive processes that involve the use of attentional abilities. Executive functions are higher-order cognitive processes that serve the purpose of maintaining future goals (Wahlstedt, Thorell, & Bohlin, 2008), involving a higher level management of the mechanisms of attention (Ruff & Rothbart, 1996). The behaviors and processes referred to as executive functioning are associated with higher-order cognitive abilities, that require attention, holding plans or programs in mind until executed (working memory), inhibiting irrelevant action (inhibition), and planning a sequence of actions (planning) (Sun, Mohay, & O'Callaghan, 2009). To successfully complete an executive functioning task (e.g., delayed response), a child must

not only orient to the task (a lower-level process of attention), he must also plan correct behaviors and inhibit incorrect behaviors. Consider a problem-solving task. In order for a child to complete the task, he must (a) develop a strategy to solve the problem, (b) keep the plan in mind long enough to guide his thought and behavior, and (c) after the action, evaluate his own behavior including both error detection and error correction (Zelazo & Müller, 2002). To accomplish the task, the child must maintain attention but also regulate and control other processes. That is, executive functioning requires attention, but also encompasses other cognitive abilities such as working memory, and planning in order to attain the goal.

Evidence of the relationship between attention and executive functioning can be seen early in life. Executive functioning is thought to emerge later in the first year for full-term infants (Zelazo & Müller, 2002). Infants' ability to inhibit behaviors changes around 9 to 12 months, at the very beginning of a higher level system of attention or endogenous attention (Ruff & Rothbart, 1996), and developmental changes in inhibitory control are observed in late infancy through early childhood (Clohessy, Posner, Rothbart, & Vecera, 1991). In addition, numerous studies have found relations between executive function deficits and ADHD from infancy through childhood (for review see Wilcutt, Doyle, Nigg, Farone, & Pennington, 2005).

The A-not-B task is a common delayed response task used to study executive functioning and involves the functions of the frontal neocortex (Diamond, 1990, 1992). The procedure is as follows. An infant watches as a toy is hidden on the left or right, in one of two locations. A few seconds after the toy is relocated, the infant is encouraged to

find the hidden toy. In order to correctly perform the task, the infant must keep in mind where the toy has been hidden and simultaneously inhibit a dominating urge to search for the toy in the first hiding place.

Research using delayed-response-type tasks like the A-not-B task to examine differences in executive functioning between children born at term and children born preterm has yielded contradicting results. Matthews, Ellis, and Nelson (1996) found, for example, that 6- to 14-month-old, low-risk infants born preterm (born at least 14 days early and weighing less than 5.5 pounds) outperformed infants born at term at a reaching as well as a non-reaching version of the AB task, suggesting an advantage of extrauterine experience of children born preterm in comparison to children born at term. When the researchers compared performance at chronological age (not adjusted), performance between the preterm and full term infants did not differ. The authors argue that development of the brain structure(s) that mediate modified AB performance is strongly influenced by experience in the postnatal environment.

However, a more recent study found contradictory results. Sun et al. (2009) examined 8-month-olds (corrected age for infants born preterm, average GA: 28 weeks) with the A-not-B task. The degree of difficulty of the task was manipulated by increasing the delay between hiding the object and being allowed to retrieve it. There were also three task levels: 1-cup, 2-cup, and 3-cup. In addition, infants were given a planning task that required one to three obstacles along to the path to reach the toy. Infants born preterm (both high and low risk) consistently obtained lower scores on the executive

function tasks than did the infants born at term. Thus, the A-not-B task yields varying results in children born preterm.

The few studies that have investigated working memory during the preschool years yield similar results to each other and Sun et al. (2009) (Espy, Stalets, McDiarmid, Senn, Cwik, & Hamby, 2002; Woodward, Edgin, Thompson, & Inder, 2005). Using an age appropriate A-not-B task at 2 years of age, children born preterm (mean GA: 27.9 weeks) showed overall poorer performance than children born at term (Woodward et al., 2005). Also, children born preterm were nearly twice as likely to make non-perseverative errors than were children born at term, whereas children born at term tended to make the anticipated perseverative error. Differences between the findings of Woodward et al. (2005) and Matthews et al. (1996) may be explained because of the different tasks used and the populations examined. Recall that Matthews et al. examined healthy, low risk infants born preterm up to the age of 14 months with a task suitable for infants. However, Woodward et al. (2005) examined executive functioning in children born very preterm and very low birth weight at 2 years of age. The different tasks and populations used may explain the different findings from studies of executive functioning in infants and children.

Additional research with older children also reveals deficits in children born preterm. Using two delayed-response-type tasks, similar in format to the AB task, Espy et al. (2002) compared 2- to 3-year-old, low-risk children born preterm (≥ 28 weeks GA; mean GA: 32.4 weeks) with full-term peers. Although children born preterm performed comparably on a Spatial Reversal task (a measure of flexibility and shifting) to children

born at term, children born preterm chose a previously un-rewarded location more often than children born at term in the Delayed Alternation task (considered a measure of working memory) instead of the more common and expected error of repeatedly reaching toward a previously rewarded location. Espy et al. (2002) argue that this response bias of persistently choosing a maladaptive and unrewarding strategy might be viewed as an early indication of the frequently observed executive dysfunction at school-age in children born preterm.

Considering that, to correctly perform this task, a toddler has to hold in mind the information from the previous test, it was concluded that working memory is adversely influenced by the premature birth because of the preterm children's poorer performance. This conclusion is consistent with findings evidencing the impairment of spatial working memory in schoolchildren born prematurely (Luciana, Lindeke, Georgieff, Mills, & Nelson, 1999). The data from the Woodward et al. (2005) and Espy et al. (2002) work consistently testify to a partial deficit of working memory (i.e., the ability to manipulate information kept in a short-term memory buffer) in preterm children born both high risk (e.g., Woodward et al., 2005) and low risk (Espy et al., 2002). Beginning from the end of the first year of life, this partial deficit is already manifested in the development of these premature infants. It is believed that the data on infants' behaviors are indicative of the vulnerability of the prefrontal cortex in extremely premature infants (Espy et al., 2002).

In sum, taking into account the more consistent results from preschool studies using delayed-response tasks, it seems that problems with executive functioning become more apparent with increasing age, even in low-risk infants born preterm. Surprisingly,

however, preschoolers born preterm do not seem to have problems with inhibition of a previously rewarded response, but rather with inhibiting attention to irrelevant task-features or distracters (such as the cup that covered the toy or other hiding wells) (van de Weijer-Bergsm et al., 2008). This pattern of errors suggests difficulties with higher-level control of sustained attention that already can become visible in infancy.

These differences in executive functioning between children born at term and children born preterm may be due to differences in the brain structure. There is considerable evidence that tasks which require the holding of information in memory involve the dorsolateral and ventro-lateral prefrontal cortex (Diamond, Kirkham, & Amso, 2002). Tasks that require planning a sequence of steps are also regulated by the dorsolateral prefrontal cortex (Levin, Fletcher, Kufera, Harward, Lilly, Mendelsohn, et al., 1996). The deficits in all measures of executive function observed in preterm infants, particularly in those with higher perinatal risk, may be associated with the adverse effects of premature birth and the related medical complications on the prefrontal cortex which is very immature and sensitive during this period of development (Diamond & Lee, 2000). Mouradian, Als, and Coster (2000) suggest that deficits in executive function might be due to late maturing cortical organization, particularly of the prefrontal regions. Myelination of the brain has been demonstrated to occur in a systematic fashion starting at the end of the first trimester and continuing at least until the end of the second year (Battin, Maalouf, Counsell, Herlihy, Rutherford, Azzopardi, & Edwards, 1998). Between 23 and 32 weeks of gestation, structural differentiation of the central nervous system is at its most rapid (i.e., neuronal differentiation, glial cell growth, myelination, axonal and

dendritic growth and synapse formation). The very preterm infants in most of the studies mentioned were born between 24 and 32 weeks gestation just at this time of brain development. That is, the process of the differentiation of the central nervous system may be interrupted due to preterm birth, altering the brain structure of infants and children born preterm, and influencing performance on executive functioning tasks. In addition, authors have argued that attentional networks may be compromised, which is consistent with the diffuse white matter injury that is observed in approximately 75% of children born very preterm in infancy (Inder, Wells, Mogridge, Spencer, & Volpe, 2003; Woodward, Anderson, Austin, Howard, & Inder, 2006). Thus, due to brain injury and disturbed processes of maturity, children born preterm may have altered brain structures that affect their attention and executive functioning abilities.

Global Assessment

Using experimental tasks that tap into specific cognitive processes, researchers have found differences in attention during infancy and early childhood, suggesting the differences in attention seen in school are present in children born preterm even in the first year (Butcher et al., 2002; Rose et al., 1988, 2001; Stroganova et al., 2005; Thanh Tu et al., 2007). Therefore, assessments in the neonatal follow-up programs need to have an attentional component that can accurately assess these different processes associated with attention. Currently, global assessments are commonly used in follow-up programs as a broad-based assessment of children born preterm (Howard, 2008). However, a major problem with interpreting the results from such global measures is that they are often poor predictors for later functioning (Hack et al., 2005; Siegel, 1989), because these

measures usually tap into various and numerous underlying functions and abilities (Cheatham et al., 2006). They may not be specific enough to detect deficits in attention patterns in children born preterm that could lead to attentional issues in later childhood.

It is unknown how performance on the attention component of these global assessments relates to performance in attention tasks commonly used in experimental research. It is important to examine how these tasks relate to each other because if the global assessment is not tapping into all of the variety of cognitive abilities that infants and children use in attention, the global assessments may not be a powerful or specific enough tool to find underlying attentional issues. Therefore, the relationship between performance on both the global measure and an attention task may reveal which abilities the global measures are accessing.

To our knowledge, there have not been studies that specifically examined relations in attention components between global assessments and specific attention abilities. However, a recent study did examine relations between domain-general and domain-specific tests. Pitchford, Johnson, Scerif, and Marlow (2011) used a combination of standardized domain-general and experimental domain-specific tests to investigate the development of language and color cognition in very preterm preschool children compared with term-born controls. The authors argue that in order to determine whether or not development differs from the typical performance pattern, domain-specific tests are needed that require children to perform different cognitive functions on the same set of items or identical task demands on items controlled for perceptual differences. This methodology has been applied successfully to understanding the underlying nature of

other developmental disorders (e.g., Pitchford, 2000; Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004) and provides insight into the nature of difficulties shown in very preterm children.

The study consisted of 22 children born preterm (GA < 30 weeks, $M = 46.41$ months, range 37-58 months) and 30 full-term children ($M = 44.5$ months, range 27-55 months) that were tested between 2 and 5 years of age. There were two domain-general standardized tests. First, the Preschool Language Scale-3 (PLS-3) was used to assess children's language abilities through two subscales: (1) auditory comprehension to measure receptive language and (2) expressive communication to measure expressive language skills. In the auditory comprehension subscale, children are required to point to one of several pictures, or gesture, in response to spoken instructions by the experimenter (e.g., 'Show me what you can ride'; 'Which one is big?'). In the expressive communication subscale, children are required to elicit spoken responses to questions asked by the experimenter (e.g., 'Tell me what you do with a spoon'; 'What do you do when you're sleepy?'). Scores on all scales were standardized scores. The Leiter International Performance Scale-Revised (Leiter-R) was used to assess general cognitive functioning. Leiter-R scales include: (1) associative memory, immediate recall of familiar or random pairs of objects; (2) sequential memory, precise recall of sequences of familiar images; and (3) sustained attention, cancellation exercises requiring children to cross out targets located among distracters, maximizing the number of correct responses (sustained focus), and minimizing errors (discrimination and/or impulsive responding). Again, scores were scaled.

For the domain-specific test, children were given tasks of color discrimination, comprehension, and naming of 11 basic colors, as well as attention to different basic colors. Dependent measures were search speed (mean time to hit each target), total errors (touching distracters), and search path (mean distance between successive touches), with higher values indicating poorer performance. Domain-general standardized tests showed significantly depressed levels of receptive and expressive language in preschool children born very preterm. Results from the Leiter-R showed that very preterm children achieved lower mean scores for associative and sequential memory and sustained attention than the full-term children, but the main effects of group were not statistically significant. The authors pose that a significant deficit may be found on tests of attention and memory other than the ones tapped by the Leiter-R. In the domain-specific test, the preterm children showed delays in naming some basic colors. When comparing the global domain-general measurements and the domain specific measures, the study found that there was relationship in how children born preterm performed on the PLS-3 and the color task. However, there was no relationship in language skills between the measures in children born full-term.

The authors suggest that the use of domain-specific experimental measures has revealed that the underlying processes by which preterm children develop language, attention, and memory, especially for the domain of color, appear to be typical, but delayed, during the preschool years. Thus, these findings have important implications for educational practice and highlight an optimal window for early intervention to reduce the likelihood of long-term cognitive deficits. Interventions targeted during the preschool

years to support the speed by which typical processes utilized for language, attention, and memory develop could help to decrease later scholastic difficulties associated with very preterm birth (Pitchford et al., 2011). Scaled scores of a global/domain-general assessment may not allow for enough variability for significant group differences. More specific measures of attention, like the selective attention color task used by Pitchford and colleagues, may reveal significant differences in the attention of children born preterm where the global assessments may not.

The Current Study

The current study examined both specific, experimental, measures of attention as well as performance on a standardized global assessment in toddlers and preschoolers born full-term and preterm. There were four main goals of the study. First, we examined differences in attention measures between toddlers and preschoolers born full-term in the distractibility and multiple-object tasks in order to understand the development of attention in early childhood. Recall that endogenous attention is the fourth system of attention, and it develops from the end of the first year throughout the preschool years. Differences in the development of endogenous attention in toddlers and preschoolers born fullterm are important to examine in order to understand the development of attention as a whole in the preterm population. In the typical distractibility paradigm, infants or children focus on an object, and there is a distractor in the periphery. By examining the latency to turn to the distractor as well as other measures (proportion of turns, looking to the distractor), researchers are able to assess distractibility and examine how distractible children are in different states of attention. Distractibility research is

used extensively in the research on the development of attention because it measures how infants and children allocate their attention (Kannass & Colombo, 2007; Lansink & Richards, 1997; Oakes et al., 2002; Ruff & Capozzoli, 2003; Ruff & Rothbart, 1996). It has also been shown that performance in a distractibility paradigm during infancy is related to attention performance in toddlerhood (Kannass et al., 2006). We predicted that the preschoolers would show more mature patterns of attention (more attention to the toys, fewer episodes of inattention), consistent with previous research demonstrating the development of endogenous attention in early childhood (Colombo, 2001; Kannass & Colombo, 2007; Ruff & Capozzoli, 2003).

In addition, children participated in a multiple object free play task. In multiple object free play tasks, infants and children are presented with several objects simultaneously and their ability to hold and sustain their attention is measured (Kannass & Oakes, 2008; Power et al., 1985; Ruff & Lawson, 1990). In this task, children have multiple items to which they can attend, and so exogenous features of the toy (e.g., familiarity) may have a weaker influence on attention allocation than endogenous (internally driven) influences (Kannass & Oakes, 2008). Additionally, the surrounding toys may act as distractors as they are competing for the child's attentional focus (Power et al., 1985). Thus, the child must ignore these other stimuli when focused on an object. Because the multiple object task involves the presentation of several items simultaneously, it yielded additional measures of attention and inattention and how children hold and switch their attention among multiple stimuli. These measures of attention (i.e., looking to toys) and attentional switches are similar to measures used in

the study of how children with attentional problems and typically developing children maintain their attention to multiple toys (e.g., Alessandri, 1992; DeWolfe et al., 2000; Roberts, 1990). We predicted the preschoolers would again demonstrate more mature patterns of attention (fewer attentional shifts, fewer episodes of inattention) during the multiple object task compared to the toddlers. This would again be consistent with previous research (e.g., Colombo, 2001; Kannass & Colombo, 2007; Ruff & Capozzoli, 2003) demonstrating the development of endogenous attention in early childhood.

Because of the relationship between early attention patterns and later attention demonstrated in research (e.g., Kannass et al., 2006; Rose et al., 2001; Rose et al., 2002), early differences in attention may indicate possible issues in the future. Detecting these early differences in toddlers and preschoolers with a valid measure is extremely important. These age groups, 2-year-olds and 3-year-olds, were chosen for two reasons. First, children at these ages have the physical abilities and coordination through which they can participate in the tasks. Thus, differences in measures will not be the result of variations in physical development. Second, research examining the development of attention has demonstrated that endogenous attention continues to mature throughout early childhood (Kannass & Colombo, 2007; Ruff & Capozzoli, 2003). Thus, examining sessions of both toddlers and preschoolers provided additional insight into the development of endogenous attention.

For our second goal, we examined differences in attentional behaviors between children born preterm and children born full-term to see if early attentional differences are present in toddlerhood. To our knowledge, this was the first study to compare the two

populations (preterm and fullterm) in a distractibility paradigm. Recall that previous studies have demonstrated various results when examining attention in children born preterm (Ruff et al., 1990; Thanh Tu et al., 2007). That is, depending on the task and measures, children born preterm can show deficits in attention or even advantages. Because endogenous attention measures between these populations had not previously been compared, the study was exploratory in how children born preterm may differ from children born full-term. We expected there to be differences in the distractibility measures by the children born preterm showing a different pattern of attention. However we were unsure which measures may detect these differences. For example, children born preterm may have less attention to the toys, or they may be more distracted by the distractor. Either way, the children born preterm would demonstrate a different, more immature, pattern of attention from their full-term peers. In addition, we expected children born preterm to have more attentional switches during the multiple-object task.

Differences in executive functioning between children born preterm and children born full-term were also examined. In addition to the measures from the endogenous attention tasks, other measures of attention were obtained using an A-not-B executive functioning task, similar to Espy et al. (2002). Research has revealed that infants and children born preterm have different patterns of performance in working memory tasks (Espy et al., 2002; Woodward et al., 2005). The current study included an executive functioning task that had been previously studied in children born preterm and children born full-term and a second executive functioning task that, to date, had only been used with children born full-term. We predicted that, consistent with Espy et al. (2002) and

Woodward et al. (2005), children born preterm would demonstrate deficits in executive functioning.

Third, we examined how performance in endogenous attention tasks relates to other measures of attention in toddlers and preschoolers. Relationships between measures of attention can provide insight into what processes are elicited in the different tasks. If the measures were related, one could argue that similar processes are elicited. If there was no relationship, separate processes may be elicited by the different measures. By using measures of executive functioning, examination of how the differences in preterm and fullterm children in the working memory tasks relate to measures of endogenous attention in both populations was possible. The study also examined relations with additional measures, the Child Behavior Checklist (CBCL), regarding the health and behaviors of the child completed by the parent or guardian to provide additional information regarding attention. By examining the parental report and its relationship with endogenous attention and executive functioning, we gained insight into what processes are elicited by these different tasks and how they relate to parental report of a child's behavior. We predicted that the CBCL would not be related to performance on the endogenous attention or executive functioning measures. The more specific, behavioral measures (e.g., looking to the toy) may be more fruitful in detecting differences than simply the few questions regarding attentional behaviors from the questionnaire.

Fourth, to assess the validity of global assessment, we performed additional correlational analyses to examine relations across tasks to compare attention measures

with children's scores from the global assessment. The study compared attention measures with a standardized global assessment. Using the Battelle Developmental Inventory, 2nd Edition (BDI-2), a well known and commonly used assessment, the experimenter administered the items from the BDI-2 that are used to assess attention and obtained raw and scaled scores for the child's performance using the testing protocols from the manual. The relationship between the global assessment and attention measures provides data on the ability of the global assessment to provide information about attentional abilities. In addition, the relationship between the laboratory measures of attention as well as the global assessment provides information as to how valid the measures are in obtaining information regarding the attentional development of toddlers born preterm and toddlers born full term. Again, we predicted that the global assessment would not be related to the experimental measures of attention. The specific behaviors elicited by the endogenous attention and executive functioning may demonstrate differences between children born fullterm and children born preterm; but the global assessment will not be specific enough to detect these differences.

CHAPTER THREE

METHODOLOGY

Participants

Seventy-seven healthy toddlers and preschoolers participated in this project. Six toddlers did not contribute usable data due to refusal to play ($n = 3$), hearing impairment ($n = 1$), and technical/experimenter errors ($n = 2$). The final sample consisted of 71 2-year-old toddlers and 3-year-old preschoolers. The toddler sample (range 24 to 27 months of age, $M = 25.53$, $SD = 29.16$ days) consisted of 29 children born full-term (15 boys and 14 girls) and 14 children born preterm (7 boys and 7 girls). The preschoolers sample (range 36 to 39 months of age, $M = 36.98$, $SD = 28.51$ days) consisted of 25 children born full-term (12 boys and 13 girls) and 3 children born preterm (2 boys and 1 girl). Participants were primarily Caucasian ($n = 61$) with representatives from other racial/ethnic backgrounds: African-American ($n = 2$), Asian-American ($n = 4$), bi-racial/other ($n = 4$).

The participants born full-term were all born healthy at or above 37 weeks gestation. The participants born preterm were all healthy children born under 37 weeks gestation (range 25 to 36 weeks, $M = 32.91$ weeks, $SD = 3.41$ weeks) with no history of additional medical complications commonly associated with prematurity (e.g., cerebral palsy, intraventricular hemorrhage, retinopathy of prematurity). By omitting children with these medical complications, their performance on the attentional tasks and

assessment was not confounded by other health issues. The criteria used in this study for healthy children born preterm (born prematurely with the absence of any obvious congenital, physical, or neurological abnormalities) has been used in numerous studies when investigating children born full-term and preterm (e.g., Caravale, Mirante, Vagnoni, & Vicari, 2012; Lindström, Lindblad, & Hjern, 2011; Lowe, Duvall, MacLean, Caprihan, Ohls, Qualls, & Phillips, 2011; Pitchford et al., 2011; Pizzo, Urban, Van der Linden, Borradori-Tolsa, Freschi, Forcada-Guex, Huppi, et al., 2010).

Children were recruited in three ways. First, at a local neonatal follow-up program, families of toddlers born prematurely of the correct age and criteria were given a handout explaining the study and invited to participate. Second, toddlers were recruited from local parent groups (e.g., Moms of Multiples) through fliers, meetings, and postings on their website. Third, participants were recruited through a commercial supplier. Letters were sent to the families describing the study and then follow-up with phone calls were made to schedule appointments. At the end of the study, children received a small prize for their participation.

Apparatus

Sessions were conducted in a testing room located at a psychology laboratory at Loyola University Chicago. Children were recorded using a camcorder positioned approximately 100 cm (6 feet) from the table, and they were seated in a child-sized chair. The camera filmed the child's torso, head and arms. The parent/guardian sat behind and to the side of the child and was out of view.

The sessions were recorded on a Panasonic DVR hard-drive and subsequently burned onto DVDs. The distractors were presented on a 81.28cm (32-inch) LG LCD wide screen television monitor using a Panasonic DVD player. Similar to Anderson, Choi, and Lorch (1987) and Choi and Anderson (1991), the monitor was located to the child's right and approximately .91m (3 feet) from and at a 90° angle to the child. A mirror was located on the wall behind the child and positioned to capture the reflection of the distractor, thus being recorded on videotape for coding purposes.

The distractor was a child-friendly video which has a colorful presentation and auditory changes and has been used in previous research (Colombo et al., 2004; Wyss, Kannass & Haden, 2013). It consisted of randomly ordered segments of a television program, and in between those segments were intervals of blank (black) tape. Similar to the distractors used by Anderson et al. (1987) and Choi and Anderson (1991), the intervals of blank tape were 5, 10, 15, 20, and 25 seconds in duration, and the order of these intervals was randomly determined. Each time the distractor was presented, it played for seven seconds so that the children could have the opportunity to notice and turn to the distractor, without the chance to watch a significant portion.

Coders then used Panasonic DVD players and television sets to watch the data after the sessions, and Macintosh computers were used to code the attention data using the program Habit (Cohen, Atkinson, & Chaput, 2004).

Procedure and Stimuli

The experiment was separated into four separate sections (a distractibility task, a multiple object free play task, two executive functioning tasks, and a global assessment).

The order of the tasks was standardized because one goal of the project was to examine individual differences. The total time of the study was approximately 50 minutes for each child.

Distractibility task. Each child first participated in a distractibility task used in previous studies (Colombo et al., 2004, Kannass et al., 2006). During the testing, four age appropriate toys were placed on the table, one at a time, each for three-minute trials with the distractor presented on a television set located to the side (90 degrees) of the participant. The toys consisted of colorful blocks of various shapes and sizes, 6-piece wooden puzzles that were replaced upon completion, a Magnadoodle, and a plastic construction site with two cars and ramps. Similar target objects have been used in distractibility research with young children (Kannass et al., 2006). After giving the toy to the child, the experimenter said, “Look at this toy! Can you play with this toy?” and started the distractor DVD.

Multiple object task. In multiple object free play tasks, infants and toddlers are presented with several objects simultaneously and their ability to hold and sustain their attention is measured (Power et al., 1985; Ruff & Lawson, 1990). In this task, toddlers have multiple items to which they can attend, and so exogenous features of the toy (e.g., familiarity) may have a weaker influence on attention allocation than endogenous (internally driven) influences (Kannass & Oakes, 2008). Additionally, the surrounding toys may act as distractors as they are competing for the child’s attentional focus (Power et al., 1985). Thus, the child must ignore these other stimuli when focused on an object. The stimuli for this task were a shape sorter with shapes to insert, Legos of various

shapes, colors, and sizes, a school bus with a removable toy driver, a rainstick tube with colorful beads, and a wooden peg board with shapes. These stimuli are similar to those used previously in multiple object free play tasks with toddlers (Kannass et al., 2006; Kannass & Oakes, 2008). For this task, the experimenter introduced each toy one at a time and demonstrated the toy's function (e.g., put a shape into the shape sorter). Once all the toys are placed on the table, the experimenter said "(Child's name), can you play with all of these toys?" The child then had seven minutes to play with the toys simultaneously.

Executive functioning tasks. For the first executive functioning task, the procedure was similar to that used in previous research with 2- and 3-year-old preterm infants using a modified A-not-B task (Woodward et al., 2005). Research has revealed that infants and children born preterm have different patterns of performance in working memory tasks (Espy et al., 2002; Woodward et al., 2005). By using this measure of executive function, the study examined how the differences in preterm and fullterm children in the working memory task relate to measures of endogenous attention in both populations. Just as in Woodward et al. (2005), the testing apparatus consisted of a 55 cm x 60 cm x 30 cm wooden box with an opaque side door through which the experimenter hid a treat (chosen by the mother) and a plexiglass front panel (see Figure 1). Below the front window was a narrow gap that allowed for stimulus objects to be presented to the child, but did not allow direct retrieval of the treat. In addition, a covered foam barrier was used to conceal stimuli. The hiding stimuli consisted of opaque plastic bowls each attached to a colored wooden shape by a long piece of string. A treat

was placed into one bowl and then placed at the back of the box, with the attached shape being placed on the testing tray below the plexiglass window. One difference between the proposed study's procedure and the method of Woodward et al. (2005) was the choice of treat. Woodward et al. used M&M® chocolates or Pez® candy as their treats. Because all M&Ms are processed in the same facilities, there is a chance that the chocolate candies contain traces of nuts, an ingredient to which many children have a severe and dangerous allergy. To avoid the potential allergy, pretzels and animal crackers were used.

The testing procedure involved three phases: (1) training, (2) pre-switch and (3) post-switch. During training, the child was taught the three steps needed to retrieve a reward: remove the foam barrier; select the shape; pull the shape to retrieve the treat. The experimenter modeled each step and then asked the child 'Can you find the (pretzel)?' Correct retrieval was praised and rewarded with the treat. The training ended when the child independently executed the retrieval sequence without assistance. Following successful training, pre-switch trials began using three new novel stimuli. For each pre-switch trial, the experimenter made sure the child was watching, placed a treat into the opaque bowl at A, and said "I am hiding the (pretzel) in this one." Immediately following the placement of the foam barrier over the shapes by the experimenter, each trial commenced with the child being encouraged to search for the treat. Each trial ended when the child removed the foam barrier and pulled one of the strings. Pre-switch trials were repeated until the child reached a criterion of three consecutive correct trials. For all children who reached the pre-switch criterion, post-switch trials were administered.

These trials were identical to pre-switch, but with the treat being visibly hidden at a different (B) location. Post switch trials were repeated until the child found the treat, failed repeatedly (on three consecutive trials), or lost interest.

The second executive functioning task was a procedure (reverse categorization) that had not previously been used to examine differences in executive functioning between preterm and fullterm toddlers. The proposed study used the same methodology from the Carlson, Mandell, and Williams (2004) research who also examined differences in executive functioning tasks between toddlers (24-month-olds) and preschoolers (3-year-olds). For the toddlers, the children were required to sort big and little blocks according to their size into big and little buckets and then to reverse this categorization scheme so that the big blocks went into the little bucket and vice versa. The experimenter demonstrated six preswitch trials (three of each size), stating the rule on each trial (e.g., “Here’s a *big* block, it goes in the *big* bucket”), and then asked children to sort the remaining six blocks. The experimenter then emptied the buckets and introduced the test trials, saying, “Okay, now let’s play a silly game. Let’s put all the *big* blocks in the *little* bucket and put all the *little* blocks in the *big* bucket.” The experimenter restated the rule and identified the size of the block before each trial. This task is similar to Perner and Lang’s (2002) Reversal Shift task for older children, which uses cards with pictures rather than three-dimensional objects (see also Brooks, Hanauer, Padowska, & Rosman, 2003). Carlson et al. (2004) posed that these single-dimension switch tasks are easier, and therefore more age-appropriate for studying younger children.

For the preschoolers, the task was modified slightly to remain consistent with the Carlson et al. (2004) study. The experimenter introduced the preschoolers to six pairs of toy zoo and farm animals. Each pair will consist of a large (“mommy”) and small (“baby”) model of the same animal (dog, tiger, polar bear, sheep, pig, zebra). Children were shown two different buckets, one with a picture of a woman (“mommy”) attached to it, the other with a picture of a baby. The rest of the procedure was exactly parallel to that of the toddler task, except that the experimenter only reminded children of the rules before the first and seventh trials, rather than on every trial.

Global assessment. Using the Battelle Developmental Inventory, 2nd Edition (BDI-2), a well-known and commonly used assessment, the experimenter administered the items from the cognitive portion subsections to calculate scaled scores of cognitive development. There are three subsections of the cognitive portion of the BDI-2: Attention and Memory, Reasoning and Academic Skills, and Perception and Concepts. The Attention and Memory component included items such as reciting lines memorized from songs or books, searching for items hidden in a scene, and repeating digits. In the Reasoning and Academic skills component, test items included nesting cups, matching colors, and logic questions (e.g., “Why do we have clothes?”). The Perception and Concepts components included items such as matching shapes, sorting, and identifying colors of familiar objects (carrot, grass) not in view.

Parental questionnaires. During the testing, the parent or guardian completed questionnaires regarding the health and behaviors of the child. Parental questionnaires, (e.g., Ages and Stages Questionnaires, Parent Report of Children's Abilities-Revised,

Child Behavior Checklist) have shown significant agreement with standardized developmental test scores in children born at term (Bortolus, Parazzini, Trevisanuto, Cipriani, Ferrarese, & Zanardo, 2002; Squires, Bricker, & Potter, 1997) and in those born preterm (Flamant et al., 2011; Johnson, Wolke, Marlow, & Preterm Infant Study Group, 2008; Liao, Wang, Yao, & Lee, 2005; Skellern, Rogers, & O'Callaghan, 2001).

Consequently, a standardized report of attention and attentional behaviors was completed using the Child Behavior Checklist for ages 1.5 to 5 years (CBCL/1.5-5; Achenbach & Rescorla, 2000). The CBCL is a screening instrument commonly used in research and clinical practice for identifying a variety of behavioral and psychiatric problems, including attention problems (see Bérubé & Achenbach (2006) for an extensive bibliography). Reliability and validity for the CBCL have been established for general populations and for groups of children referred for specific behavior and psychiatric problems (Achenbach & Rescorla, 2000; Biederman, Faraone, Hirshfeld-Becker, Friedman, Robin, & Rosenbaum, 2001). The Revised CBCL/1.5–5 asks parents/caregivers to rate 99 specific child behaviors (e.g., cannot settle down) as 0 (Not True of the child), 1 (Somewhat or Sometimes True), or 2 (Very True or Often True) and provides parents/caregivers an opportunity to write in three additional problem behaviors. Using the scoring program from the developer, a score of the Attention Problems scale was obtained. A score of 0-5 is considered to be within the normal range. Scores of 6 are considered to be “borderline” abnormal, and scores at 7 or above are considered clinically significant for a diagnosis of behavior problems, or, in this case, attentional issues. The parent also completed a background health questionnaire regarding the current health of

the child, demographics, and birth measures (e.g., gestational age, birthweight). The questionnaire also contained questions regarding the home environment and experiences (e.g., the amount of television exposure per week, if the child has taken any classes like music).

Coding and Measures

Distractibility task. Reliable coders coded the attention of the child by using developed measures from previous attention research (Kannass & Colombo, 2007; Kannass & Oakes, 2008; Oakes et al., 2002). Coders examined the videos for three measures of attention and inattention: duration of looking to the task/toy, duration of looking to the distractor and duration of inattention. We used the duration of looking (attention) to the tasks as an indicator of how long children hold or sustain their attention to a stimulus. Past research on attention in a distractibility task has used duration of looking and duration of play episodes as indicators of how children sustain their attention to a stimulus in the midst of competition for attentional focus (Kannass et al., 2010; Kannass & Colombo, 2007; Schmidt et al., 2008). For looking to the toy, coders watched the sessions and pressed a key on a Macintosh keyboard whenever it was judged that the child was looking at the task and held it as long as the child continued to look at the toy. Reliability for each behavior was assessed by correlating the duration of each individual look as recorded by the two coders. When a child looked at the stimulus for at least 1 second, it qualified as a look. If the child glanced away from the toy for less than 1 second and then looked again at the toy, the computer recorded this as one continuous look. Two coders recorded the behavior for at least 25% of the sample coded for that

measure. The average interobserver reliability was .97 for duration of individual looks (mean difference = .18 seconds). The computer recorded the duration of these key presses as the duration of looking and calculated the total amount of looking in each trial (Cohen et al., 2004). In addition, the computer recorded the number of looks (by the number of key presses) for each trial. From this attention information, the total amount of looking to the tasks and the average length of individual looks (dividing the total duration of looking by the number of looks) were calculated for each child. Duration of looking to the distractor had the same criteria for a look (1 second) and reliability for at least 25% of the sample was good, $r = .96$ (mean difference = .35 seconds). In addition, duration of looking to the distractor was also recorded as an indicator of how long toddlers attend to the distractor and distractibility. Coders pressed the key when the child turns to the television and looked at the screen. Reliability for at least 25% of the sample was good, $r = .96$ (mean difference = .19 seconds).

Inattention was recorded using the same procedure, but the key was pressed when the child looked at anything besides the task (e.g., the parent, the experimenter, the floor) or walked off screen (termed “active inattention”). Past research has revealed developmental differences in inattention during free play in infancy, toddlerhood, and early childhood (e.g., Ruff & Lawson, 1990; Ruff et al., 1998; Sarid & Breznitz, 1997) as well as stability over time and consistency across different contexts (Kannass et al., 2006; Ruff et al., 1990; Ruff, et al., 1998). Moreover, research indicates that typically developing children show less inattention during free play than do children with attention problems (Alessandri, 1992). Inattention had the same criteria as looking to the toy (1

second) to qualify as an inattention episode. If the child was looking away from the toy, glanced back to the toy for less than 1 second, and again looked away from the toy, the computer recorded this as one continuous inattention episode. The computer recorded the number of inattention episodes in each trial.

Finally, using established measures from previous research (e.g., Kannass et al., 2002; Kannass et al., 2006; Lansink & Richards, 1997; Oakes, et al., 1991; Ruff, 1990; Ruff et al., 1992; Ruff & Lawson, 1990; Ruff & Rothbart, 1996) coders determined the degree of attentional focus (i.e., focused or casual attention) and recorded the latency (the amount of time between the onset of the distractor until the child looked to the tv) to turn to the distractor using the Macintosh computer program. Reliability for at least 25% of the sample was good, $r = .99$ (mean difference = .33 seconds). Coders received a list of times that correspond with the onsets of each distracting event. They then observed the child's behavior at these times and judged whether he or she was in a state of casual attention (looking at the toy but not engaged in active learning), a state of focused attention (concentrating and actively learning about the toy), or looking at something other than the target toy (e.g., the television, the experimenter). Coders used a combination of facial cues (e.g., pursed lips, furrowed brow), gaze direction, and object manipulation to determine the child's attentional state. Two observers coded each child and the average agreement between the two coders for the child's attentional state at each distractor was 92% (ranging from 78% to 100%). All disagreements were resolved, and the resolved codings were used in the final analyses. Finally, we calculated the proportion of turns to the distractor by calculating the amount of times the child turned to

the distractor and the total number of distractor presentations. Previous research has examined how turns the distractor vary with the degree of attentional focus (Colombo et al., 2004; Kannass et al., 2006; Lansink & Richards, 1997; Oakes, Tellinghuisen, & Tjebkes, 2000; Ruff et al, 1996).

Multiple object task. Using coding procedures used in previous research (e.g., Kannass & Oakes, 2008), reliable coders calculated the duration of looking to the toys, as well as the number of inattention episodes (i.e., when a child directs his/her attention away from the toys, looking, at the experimenter or parent, etc.). Because the multiple object task involves the presentation of several items simultaneously, this paradigm also presents competition for attentional focus (Power et al., 1985). The task yields additional measures of attention and inattention, such as how children hold and switch their attention among multiple stimuli. These measures of attention (i.e., looking to toys) and attentional switches are similar to measures used in the study of how children with attentional problems and typically developing children maintain their attention to multiple toys (e.g., Alessandri, 1992; DeWolfe et al., 2000; Roberts, 1990). Coders again watched for attention to the toys and inattention and used the Habit computer program to press the key to record durations as described above. Reliability for at least 25% of the sample was good for both attention to the toys, $r = .97$ (mean difference = .22 seconds) and inattention episodes, $r = .98$ (mean difference = .16 seconds). Coders also calculated how many times a child switched their attention between toys during the seven minutes. For example, if the child built a tower with the Legos, drove the bus, and then played with the rainstick, the child switched his/her attention twice (switching to the bus and

then to the rainstick). Remaining on the same task was judged as the same “look”. For example, putting a shape into the shape sorter was counted as one task, not two looks, even though the child looked at the shape then the container the shape was put in. The number of total switches between toys/tasks was recorded. Two observers coded each child and agreement between the two coders for the number of attentional switches was 98% (ranging from 95% to 99%).

Executive functioning task. For the first executive functioning task (modified A-not-B), different measures of task performance were recorded. These included: (1) the number of pre-switch trials to first correct retrieval, (2) the number of pre-switch trials discontinued or repeated, (3) achievement of pre-switch criterion (yes or no), and (4) the search location for post-switch trials. For the reverse categorization task, scores were the proportions of correctly sorted blocks or animals.

Global assessment. Performance was calculated from the test items administered by using the test manual to correctly record a raw and scaled score for each child. Each child received an overall cognitive scaled score. Both the cognitive score and the scaled score from the Attention and Memory components were used in the analyses.

CHAPTER FOUR

RESULTS

There were four general purposes of the analyses. First, we analyzed measures of endogenous attention in order to understand the development of attention in early childhood by examining (1) differences in attention measures (e.g., looking to the toy, number of inattention episodes, looking to the television) in the distractibility task between full-term toddlers and preschoolers and (2) differences in attention measures (e.g., looking to the toys, number of inattention episodes, number of attentional shifts between toys) in the multiple object task between full-term toddlers and preschoolers. Second, we examined differences in attentional behaviors between children born preterm and children born full-term in endogenous attention and executive functioning tasks. Third, we conducted correlational analyses to examine how performance in endogenous attention tasks relates to each other and to executive functioning measures of attention in toddlers and preschoolers. Finally, we performed additional correlational analyses to examine how measures of attention across tasks compare with children's scores from the global assessment.

Differences in Endogenous Attention as a Function of Age

Distractibility task. The following section discusses analyses on (1) attention to the toys, (2) the number of inattention episodes, (3) looking to the distractor and (4) attentional state. To examine the development of endogenous attention, we first

examined attention measures in the distractibility task in the typically developing toddlers (2-year-olds) and preschoolers (3-year-olds) born full-term. Given past research examining attention over time (Hale & Flaughner, 1977; Kannass & Colombo, 2007; Oakes et al., 2000; Tellinghuisen & Oakes, 1997), we were interested in how attention may differentially change across the session in the two age groups. The duration of total looking to the toys is used in research to obtain an overall duration of looking during the session (Ruff & Capozzoli, 2003). Additionally, the average length of individual looks is a useful indicator of attention, has been found to be stable in infancy and toddlerhood, and is used often in research (Colombo et al., 2004; Kannass et al., 2006). To calculate this number, we divided the total duration of looking by the total number of looks. We performed two separate Mixed Model Analyses of Variance (ANOVA) with trial as the within-subjects factor and age and gender as the between-subject factors on total looking to the toys and average length of individual looks to the toys. Analyses on the total duration of looking revealed a main effect of trial, $F(3, 48) = 64.58, p < .01, \eta_p^2 = .80$ and a main effect of age $F(1, 50) = 8.00, p < .01, \eta_p^2 = .14$ with toddlers looking less to the toys ($M = 108.87$ seconds, $SE = 3.73$) than did the preschoolers ($M = 124.68$ seconds, $SE = 4.02$). Interestingly, there was a trial by age interaction, $F(3, 48) = 3.62, p < .05, \eta_p^2 = .18$ (see Figure 2). After setting the alpha value to .0083 to control for family-wise error, we compared the total amount of looking between trials. Post-hoc analyses revealed that total looking to the toys increased in the toddlers from Trial 1 ($M = 67.10$ seconds, $SE = 5.52$) to Trial 2 ($M = 125.75$ seconds, $SE = 8.89$), $t(28) = 4.69, p < .0083$. Looking remained stable across Trials 2 and 3, $t(28) = .88, ns$. However, the duration of looking

decreased between Trial 3 ($M = 134.92$ seconds, $SE = 4.15$) and Trial 4 ($M = 108.20$ seconds, $SE = 4.91$), $t(28) = 3.91$, $p < .0083$. In the preschoolers, looking to the toys increased from Trial 1 ($M = 92.66$ seconds, $SE = 5.94$) to Trial 2 ($M = 131.53$ seconds, $SE = 9.57$), $t(24) > 6.01$, $p < .0083$ and remained high throughout Trials 2, 3 ($M = 138.55$ seconds, $SE = 4.47$), and 4 ($M = 135.27$ seconds, $SE = 5.29$), t 's (24) < 1.44 , *ns*.

Alternatively, we can compare the total duration of looking in each trial between the two age groups. Post-hoc analyses revealed that toddlers had less attention to the toys in Trial 1 $t(52) = 3.15$, $p < .01$, and Trial 4, $t(52) = 3.80$, $p < .01$, than did the preschoolers. However, looking did not differ between the age groups in Trial 2 or 3, t 's $< .63$, *ns*. There was no effect of gender, $F(1, 50) = 2.16$. *ns*.

Analyses on the average length of individual looks to the toy yielded consistent results. There was a main effect of trial, $F(3, 48) = 37.63$, $p < .01$, $\eta_p^2 = .70$ and a main effect of age $F(1, 50) = 7.33$, $p < .01$, $\eta_p^2 = .13$ with toddlers having shorter average looks to the toy ($M = 11.08$ seconds, $SE = 0.74$) than did the preschoolers ($M = 14.09$ seconds, $SE = 0.80$). There was a marginal age by trial interaction $F(3, 48) = 2.72$, $p = .05$, $\eta_p^2 = .14$ (see Figure 3). After setting the alpha value to .0083 to control for family-wise error, post-hoc analyses revealed that the average length of individual looks to the toys increased in the toddlers from Trial 1 ($M = 5.98$ seconds, $SE = .50$) to Trial 2 ($M = 13.44$ seconds, $SE = 1.31$), $t(28) = 4.67$, $p < .0083$. Looking remained stable across Trials 2 and 3, $t(28) = 1.17$, *ns*. However, the duration of looking decreased between Trial 3 ($M = 15.68$ seconds, $SE = 1.47$) and Trial 4 ($M = 9.23$ seconds, $SE = 1.16$), $t(28) = 5.23$, $p < .0083$. In the preschoolers, looking to the toys increased from Trial 1 ($M = 8.76$ seconds,

$SE = .54$) to Trial 2 ($M = 13.97$ seconds, $SE = 1.41$), $t(24) > 7.19$, $p < .0083$ and remained high throughout Trials 2, 3 ($M = 17.99$ seconds, $SE = 1.58$), and 4 ($M = 15.64$ seconds, $SE = 1.25$), t 's (24) < 2.16 , *ns*. Again, there was no effect of gender, $F(1, 50) = .57$, *ns*.

We again compared each trial between the two age groups. Post-hoc analyses revealed that toddlers had less attention to the toys in Trial 1 $t(52) = 3.78$, $p < .01$, and Trial 4, $t(52) = 3.77$, $p < .01$, than did the preschoolers. However, looking did not differ between the age groups in Trial 2 or 3, t 's < 1.07 , *ns*. In sum, analyses on the total duration and average length of individual looks reveals that the toddlers had less attention to the toys than did the preschoolers and showed different patterns of attention over time with preschoolers more consistently sustaining their attention over time.

Further analyses were conducted on the number of inattention episodes and looking to the distractor to compare additional measures of endogenous attention in the distractibility task. A Mixed Model ANOVA was conducted on the number of inattention episodes with trial as the within-subjects factor and age gender as the between-subjects factors. The results reveal a main effect of Trial, $F(3, 48) = 43.86$, $p < .01$, $\eta_p^2 = .73$ and a main effect of age $F(1, 50) = 24.54$, $p < .01$, $\eta_p^2 = .33$. There was also a trial by age interaction, $F(3, 48) = 4.39$, $p < .01$, $\eta_p^2 = .22$ (see Figure 4). After setting the alpha value to .0083 to control for family-wise error, post-hoc analyses revealed that the number of inattention episodes decreased in the toddlers from Trial 1 ($M = 11.38$, $SE = .73$) to Trial 2 ($M = 5.86$, $SE = .77$), $t(28) = 7.43$, $p < .0083$. The number of inattention episodes then remained stabled from Trials 2, 3 ($M = 4.52$, $SE = .57$), and 4

($M = 5.90$, $SE = .62$), $t's < 1.72$, *ns*. Similarly, the number of inattention episodes decreased in the preschoolers from Trial 1 ($M = 6.00$, $SE = .74$) to Trial 2 ($M = 2.76$, $SE = .46$), $t(24) = 5.08$, $p < .0083$ and then remained stable from Trials 2, 3 ($M = 3.00$, $SE = .50$), and 4 ($M = 2.92$, $SE = .45$), $t's < .40$, *ns*. There was no effect of gender, $F(1, 50) = 1.50$, *ns*.

We then conducted four paired-sample t-tests to compare the number of inattention episodes between toddlers and preschoolers across trials. In Trials 1, 2, and 4 toddlers had more episodes of inattention than did the preschoolers, $t's(52) > 3.32$, $p < .0125$. However, in Trial 3, there was no difference in the number of inattention episodes between toddlers and preschoolers. In sum, analyses on the inattention measure reveal toddlers are more inattentive across the trials.

The final measures of attention involve looking to the distractor. We first examined how attention to the distractor may have changed over the course of the session. We conducted a 2 by 4 Mixed Model ANOVA on the total duration of looking to the distractor with age and gender as the between subjects factors and trial as the within-subjects factor. The analyses revealed a main effect of Trial, $F(3, 48) = 44.02$, $p < .01$, $\eta_p^2 = .73$. There was also a trend for a trial by age interaction $F(3, 48) = 2.23$, $p = .10$, $\eta_p^2 = .12$ (see Figure 5). There was no effect of gender, $F(1, 50) = .20$, *ns*.

After setting the alpha level to .0083 to control for family-wise error, post hoc comparisons were conducted to analyze how looking to the distractor differentially changed over time between toddlers and preschoolers. In toddlers, looking to the distractor continually decreased from Trial 1 ($M = 37.52$, $SE = 4.11$) to Trial 2 ($M =$

17.54, $SE = 2.80$), Trial 3 ($M = 12.14$, $SE = 1.97$), and Trial 4 ($M = 8.13$, $SE = 2.04$), t 's (28) > 4.88 , $p < .0083$. In contrast, preschoolers had high looking to the distractor in Trial 1 ($M = 47.32$, $SE = 4.43$), but looking then decreased between the first and subsequent trials (t 's(24) > 7.07 , $p < .0083$) and remained low in Trials 2 ($M = 14.75$, $SE = 6.38$), Trial 3 ($M = 15.73$, $SE = 3.06$), and Trial 4 ($M = 13.22$, $SE = 3.17$) with no significant differences in trials 2, 3, and 4 $t(24) < 2.60$, ns . In sum, toddlers and preschoolers demonstrated different patterns in looking to the distractor with toddlers continually decreasing attention to the distractor and preschoolers initially decreasing attention to the distractor but then remaining stable over the session.

In addition to the total looking to the distractor, we examined how the latency to turn to the distractor changed over time. We conducted a 2 x 2 x 4 Mixed Model ANOVA on latency with gender and age as the between subject factors and Trial as the within-subjects factor. We found a main effect of Trial, $F(3,48) = 16.95$, $p < .01$, $\eta_p^2 = .51$ with latencies to turn to the distractor increasing from Trials 1 ($M = 4.60$, $SE = .37$), 2 ($M = 7.31$, $SE = .62$), and 3 ($M = 10.58$, $SE = .78$), t 's (53) > 3.68 , $p < .017$. Latencies then decreased from Trial 3 to Trial 4 ($M = 6.09$, $SE = .57$), $t(53) = 5.55$, $p < .017$. There was also a main effect of gender, $F(1, 50) = 10.68$, $p < .01$, $\eta_p^2 = .18$ with boys ($M = 6.10$, $SE = .47$) turning faster to the distractor than did the girls ($M = 8.26$, $SE = .47$). Finally, there was a marginal effect of age, $F(1, 50) = 3.61$, $p = .06$ with toddlers ($M = 6.56$, $SE = .45$) tending to turn faster to the distractor than the preschoolers ($M = 7.81$, $SE = .48$).

Further analyses were conducted to examine how the effects of attentional state may differ between toddlers and preschoolers. First, we conducted a 2 by 2 by 2 Mixed Model ANOVA on latency with gender and age as the between subjects factors and attentional state (i.e., focused and casual attention) as the within-subjects factor to examine the latency to turn to the distractor. There were no main effects of attentional state or age, F 's < 1.01 , *ns*. Girls ($M = 2.21$, $SE = .16$) tended to have longer latencies than did the boys ($M = 1.83$, $SE = .17$) $F(1, 48) = 2.76$, $p = .10$, $\eta_p^2 = .05$. There was also a significant interaction of attentional state by gender by age. Posthoc analyses reveal that in toddlers there is no difference between girls' ($M = 2.04$, $SE = .21$) and boys' latencies ($M = 2.34$, $SE = .26$) during focused attention $t(27) = .91$, *ns*, but girls ($M = 2.52$, $SE = .44$) had longer latencies during casual attention than did the boys ($M = 1.38$, $SE = .19$), $t(26) = 2.39$, $p < .05$. In contrast, in preschoolers, there was a marginal difference between girls' ($M = 2.34$, $SE = .17$) and boys' ($M = 1.81$, $SE = .21$) latencies during focused attention, $t(23) = 1.95$, $p = .06$, but no difference between girls ($M = 1.93$, $SE = .27$) and boys ($M = 1.93$, $SE = .33$) during casual attention, $t(24) = .004$, *ns*.

We also examined the proportion of turns to the distractor as a function of attentional state. Using a 2 by 2 by 2 Mixed Model ANOVA with gender and age as the between-subjects factors and attentional state as the within-subjects factor, we analyzed how turning to the distractor differs between toddlers and preschoolers as a function of their attentional state. Children tended to turn more to the distractor during casual attention ($M = .72$, $SE = .04$) than during focused attention ($M = .66$, $SE = .04$), $F(1, 48) = 2.73$, $p = .10$, $\eta_p^2 = .05$. The boys and girls had similar proportions of turns, $F(1, 48) =$

2.76, $p = .10$, $\eta_p^2 = .05$. There was also a significant age by attentional state interaction $F(1, 50) = 4.25$, $p < .05$, $\eta_p^2 = .08$. Post-hoc analyses reveal that in toddlers, there was no difference, $t(28) = .29$, *ns*, in the proportion of turns to the distractor between focused ($M = .67$, $SE = .05$) and casual attention ($M = .66$, $SE = .05$). In contrast, there is a significant difference in preschoolers with children turning more to the distractor during casual attention ($M = .79$, $SE = .05$) than during focused attention ($M = .68$, $SE = .05$). In sum, toddlers turn equally to the distractor no matter what the attentional state. However, preschoolers turn less frequently when in a state of focused attention compared to when they are in a state of casual attention.

Summary. In sum, there were significant age differences in endogenous attention measures from the distractibility task. Preschoolers consistently demonstrated more mature patterns of attention with more total looking to the toys, longer average looks to the toys, and fewer episodes of inattention. That is, preschoolers were better at holding and maintaining their attention over time. In addition, preschoolers initially decreased attention to the distractor but then remained stable over the session, but toddlers continually decreased attention to the distractor over time. Preschoolers also were less distractible with longer latencies to turn to the distractor, and they had different proportions of turns to the distractors depending on their attentional state: they turned more often when in a state of casual attention than when in a state of focused attention. In contrast, toddlers turned equally to the distractor regardless of attentional state. Thus, preschoolers demonstrated more mature attention patterns across the distractibility task measures.

Multiple-object task. To further examine the development of endogenous attention, we examined attentional measures from the multiple-object task in toddler and preschoolers born full-term. The following section discusses the analyses on (1) attention to the toys, (2) the number of inattention episodes, and (3) the number of attentional shifts. First, we examined attention to the toys as a function of age and gender. We conducted two age by gender ANOVAs on the total looking to the toys and the average length of individual looks to the toys. We found a main effect of age $F(1, 50) = 10.56, p < .01, \eta_p^2 = .17$ with toddlers ($M = 286.61$ seconds, $SE = 11.47$) looking less to the toys than did the preschoolers ($M = 341.39$ seconds, $SE = 12.35$). There was no effect of gender $F(1, 50) = 2.31, ns$. For the average length of individual looks, we found a main effect of age $F(1, 50) = 7.97, p < .01, \eta_p^2 = .14$ with toddlers ($M = 17.55$ seconds, $SE = 5.24$) having shorter average looks than did the preschoolers ($M = 38.42$ seconds, $SE = 5.42$). There was marginal effect of gender $F(1, 50) = 3.32, p = .07, \eta_p^2 = .06$ and a marginal age by gender interaction, $F(1, 50) = 3.28, p = .08, \eta_p^2 = .06$. In boys, looking did not differ, $t(25) = 1.53, ns$, between toddlers ($M = 17.52$ seconds, $SE = 2.93$) and preschoolers ($M = 24.99$ seconds, $SE = 14.28$). However, in girls, toddlers ($M = 17.59$ seconds, $SE = 2.12$) had shorter looks to the toys than did the preschoolers ($M = 51.84$ seconds, $SE = 14.28$), $t(25) = 2.46, p < .05$.

We next examined how attention to the toys changed as a function of time. We broke the session down into two Blocks in order to assess the initial attention and attention at the end of the session. Measures of initial performance are regularly used because research has found that individual differences in processing and attention are

stronger in how children and infants *first* respond to new information in a task (e.g., Kannass et al., 2006; Tamis-LeMonda & Bornstein, 1989). Thus, to compare changes in attention over time we used measures taken from the initial part of the session for Block 1 (Minutes 1 and 2) and the final minutes of the session (Minutes 6 and 7) for Block 2. We conducted a 2 by 2 by 2 Mixed Model ANOVA on total looking to the toys with age and gender as the between-subjects factors and Block as the within-subjects factor. We found a main effect of block, $F(1, 50) = 13.19, p < .01, \eta_p^2 = .21$ with children looking more to the toys in Block 1 ($M = 97.83$ seconds, $SE = 2.32$) than in Block 2 ($M = 83.26$ seconds, $SE = 3.74$). There was also a main effect of age, $F(1, 50) = 12.80, p < .01, \eta_p^2 = .20$ with preschoolers looking more to the toys ($M = 99.05$, $SE = 3.48$) than did the toddlers ($M = 82.04$, $SE = 3.24$). There was no effect of gender, $F(1, 50) = 1.07, ns$.

We also examined the number of inattention episodes. Again, we split the session into Blocks: Block 1 (Minutes 1 and 2) and Block 2 (minutes 6 and 7). We again found a main effect of Block $F(1, 50) = 12.18, p < .01, \eta_p^2 = .20$ with children having more episodes of inattention in Block 2 ($M = 3.60$, $SE = .32$) than in Block 1 ($M = 2.28$, $SE = .32$). We also found a main effect of age $F(1, 50) = 6.95, p < .05, \eta_p^2 = .12$. Toddlers ($M = 3.62$, $SE = .35$) had more episodes of inattention than did the preschoolers ($M = 2.26$, $SE = .38$). In sum, analyses on looking to the toys and inattention reveal that children look less at the toys and have more inattention as the session progresses. In addition, preschoolers had more attention to the toys and fewer inattention episodes than did the toddlers.

The final analyses on endogenous attention in the multiple-object task examined the amount of attentional shifting during the task. Recall that in this task, children have multiple items to which they can attend, and so exogenous features of the toy (e.g., familiarity) may have a weaker influence on attention allocation than endogenous (internally driven) influences (Kannass & Oakes, 2008). Additionally, the surrounding toys may act as distractors as they are competing for the child's attentional focus (Power et al., 1985). Thus, measuring the amount of attentional switching between toys provides additional information regarding children's endogenous attentional abilities. Due to the coding procedures for this measure, we were unable to examine how attentional shifting changed over the course of the task by minute or block. However, we were able to analyze the total number of shifts to examine if there were any effects of age or gender. We conducted an age by gender ANOVA on the number of attentional switches. We found a main effect of age, $F(1, 50) = 4.96, p < .05, \eta_p^2 = .09$ with toddlers ($M = 15.20, SE = .99$) having more attentional switches than did the preschoolers ($M = 11.96, SE = 1.07$). There was no effect of gender, $F(1, 50) = .01, ns$.

Summary. Consistent with the results from the distractibility measures, attention measures from the multiple-object task revealed a more mature attention pattern in the preschoolers when compared to the toddlers. The preschoolers had more attention to the toys, fewer episodes of inattention, and fewer attentional shifts than did the toddlers. In sum, results revealed developmental age differences in endogenous attention measures with preschoolers demonstrating more mature patterns of attention.

Differences in Attention as a Function of Birth Status

This section discusses the results comparing full-term and preterm toddlers. These results include analyses on (1) the home environment, (2) the global assessment, (3) the distractibility task, (4) the multiple object task, and (5) the executive functioning measures.

Home environment. We first examined whether there were any differences between the preterm and full-term toddlers' home environment and background. We conducted independent samples t-tests to examine how the children's environments may have been different. We first examined television exposure in the children. We looked at the amount of the child's television viewing, the amount of *Sesame Street* viewing, and the total amount of television viewing in the home. We found that children born preterm watched more *Sesame Street* per week ($M = 2.14$ hours, $SE = .63$) than did the children born full-term ($M = .66$ hours, $SE = 1.19$), $t(41) = 2.77$, $p < .01$. The other measures were not significant, $t's < 1.03$, *ns*. We also examined the home environment to see if there were any differences in the child's early education. There were no differences between children born preterm and children born fullterm, $t's < 1.58$, in the amount of children's books in the home, the number of classes the child had attended, or the number of times the child had been on an educational outing (zoo, museums). Thus, children born preterm and fullterm came from similar home environments.

Global assessment. We next examined the global assessment scores in order to determine if there were any differences in performance scores between the toddlers born preterm and the toddlers born full-term. Consistent with our predictions, there was no

difference in the toddlers' Attention and Memory subscale scores, $t(41) = 1.25$, *ns* with children born preterm ($M = 12.86$, $SE = .42$) having similar scores to the children born full-term ($M = 13.69$, $SE = .42$). Similarly, there was no difference in the toddlers' overall cognitive composite scores, $t(41) = 1.34$, *ns* with children born preterm ($M = 39.43$, $SE = 1.95$) having similar scores to the children born full-term ($M = 42.79$, $SE = 1.47$). In sum, children born preterm and children born full-term performed comparably on their global assessment scores.

Distractibility task. To examine how attention may vary as a function of prematurity on endogenous attention, we first analyzed attention measures in the distractibility task. This section discusses the analyses on (1) attention to the toys, (2) the number of inattention episodes, (3) looking to the distractor, and (4) attentional state. We first compared the full-term toddlers to the preterm toddlers by conducting two ANOVAs on the total looking and the average length of looks to the toys with gender and birth status as the between-subjects variables. There was no main effect of birth status, $F(1, 42) = 1.69$, *ns*. Children born preterm ($M = 396.23$, $SE = 25.11$) had similar total durations of looking to the toys as did the children born full-term ($M = 435.97$, $SE = 17.46$). There was no main effect of gender, $F(1, 42) = .16$, *ns*. Girls ($M = 410.06$, $SE = 21.75$) had similar amounts of looking compared to the boys ($M = 422.13$, $SE = 21.51$). Analyses on the average length of individual looks yielded consistent results. There was no main effect of birth status, $F(1, 42) = .10$, *ns*. Children born preterm ($M = 10.59$, $SE = .95$) had similar amounts of looking to children born full-term ($M = 10.22$, $SE = .66$).

There was no main effect of gender, $F(1, 42) = 2.03$, *ns*. Girls ($M = 10.07$, $SE = .83$) had similar amounts of looking compared to the boys ($M = 10.75$, $SE = .82$)

We also examined how the total duration of looking to the toys may have changed over time. We conducted a 2 by 2 by 4 Mixed Model ANOVA with birth status and gender as the between subjects factors and trial as the within-subjects factor. Again, there was no effect of birth status, $F(1, 39) = 1.69$, *ns*, with children born preterm ($M = 99.06$, $SE = 6.28$) having similar amounts of looking to the toys across trials as the children born full-term ($M = 108.99$, $SE = 4.37$). Consistent with the analyses comparing preschoolers and toddlers, there was a main effect of trial for the total duration of looking to the toys, $F(3, 39) = 43.59$, $p < .01$, $\eta_p^2 = .77$. After setting the alpha level to .016 to control for family-wise error, post hoc comparisons were conducted to analyze how looking to the toys changed over time. Looking to the toys increased from Trial 1 ($M = 62.61$, $SE = 4.75$) to Trial 2 ($M = 118.37$, $SE = 8.54$), $t(42) = 6.11$, $p < .01$. Looking then remained consistent from Trial 2 to Trial 3 ($M = 130.41$, $SE = 4.20$), $t(42) = 1.51$, *ns*. Finally, looking to the toys then decreased between Trial 3 and Trial 4 ($M = 111.30$, $SE = 4.84$), $t(42) = 3.38$, $p < .01$.

Analyses on the average length of individual looks revealed similar results. Again, there was no effect of birth status, $F(1, 39) = .001$, *ns*, with children born preterm ($M = 11.15$, $SE = 1.09$) having very similar average lengths of individual looks as the children born full-term ($M = 11.11$, $SE = .76$). There was a main effect of trial, $F(3, 39) = 28.36$, $p < .01$, $\eta_p^2 = .69$. The average length of individual looks increased from Trial 1 ($M = 5.87$, $SE = .40$) to Trial 2 ($M = 12.59$, $SE = 1.23$), $t(42) = 5.75$, $p < .01$. The length

of individual looks than remained consistent from Trial 2 to Trial 3 ($M = 15.95$, $SE = 1.21$), $t(42) = 2.15$, *ns*. Finally, the length of individual looks then decreased between Trial 3 and Trial 4 ($M = 9.99$, $SE = .73$), $t(42) = 5.74$, $p < .01$. There were no effects of gender, F 's < 1.13 , *ns*.

We then examined the number of inattention episodes as a function of birth status. We conducted a 2 x 2 x 4 Mixed Model ANOVA on the number of inattention episodes with birth status and gender as the between-subjects factors and Trial as the within-subjects factor. There was a marginal effect of birth status, $F(1, 41) = 2.97$, $p = .09$, $\eta_p^2 = .07$. Contrary to our hypotheses, toddlers born preterm ($M = 5.48$, $SE = .68$) tended to have fewer episodes of inattention than did the toddler born fullterm ($M = 6.91$, $SE = .47$). There was also a main effect of trial $F(3, 39) = 30.86$, $p < .01$, $\eta_p^2 = .70$, consistent with the results above on the number of inattention episodes in toddlers born full-term, with a decrease in inattention from Trials 1, 2, and 3, but an increase in the number of inattention episodes in Trial 4. There was no main effect of gender, $F(1, 39) = .01$, *ns*.

We next examined how looking to the distractor may have differed between toddlers born preterm and toddlers born fullterm. We conducted a 2 by 2 by 4 Mixed Model ANOVA on the total looking to the distractor with gender and birth status as the between subjects factors and trial as the within-subjects factor. There was a marginal effect of birth status, $F(1, 39) = 3.56$, $p = .07$, $\eta_p^2 = .08$. Toddlers born preterm ($M = 27.05$, $SE = 3.58$) tended to look more to the distractor than toddlers born fullterm ($M = 18.83$, $SE = 2.49$). There was also main effect of trial, $F(3, 37) = 18.82$, $p < .01$, $\eta_p^2 = .60$. After setting the alpha level to .0083 to control for family-wise error, we compared total

looking to the distractor over each trial. Analyses revealed that toddlers looked more to the distractor in Trial 1 ($M = 40.04$, $SE = 3.09$) than in Trials 2 ($M = 20.11$, $SE = 2.98$), Trial 3 ($M = 14.76$, $SE = 2.41$) and Trial 4 ($M = 11.00$, $SE = 2.53$), $t(42) > 5.46$, p 's $< .0083$. There was also a significant difference between Trial 2 and Trial 4, $t(42) = 4.29$, $p < .0083$ but no difference between Trial 3 and Trial 4, $t(42) = 2.30$, ns . There was also a marginal effect of gender $F(1, 39) = 3.30$, $p = .08$, $\eta_p^2 = .08$. Girls ($M = 26.89$, $SE = 3.10$) tended to look more to the distractor than did the boys ($M = 18.99$, $SE = 3.06$).

To examine the role of attentional state, we conducted analyses on the latency to turn to the distractor as a function of birth status and attentional state. Using a 2 x 2 x 2 Mixed Model ANOVA with gender and birth status as the between subjects factors and attentional state as the within-subjects factor, we analyzed differences in the latencies to turn to the distractor. There was a main effect of birth status, $F(1, 37) = 5.19$, $p < .05$, $\eta_p^2 = .12$. Children born preterm ($M = 1.47$, $SE = .21$) had shorter latencies to turn to the distractor than did children born full-term ($M = 2.06$, $SE = .15$). There was also marginal effect of attentional state, $F(1, 37) = 3.50$, $p = .07$, $\eta_p^2 = .08$ with children tending to have longer latencies to turn to the distractor during periods of focused attention ($M = 1.97$, $SE = .14$) than during periods of casual attention ($M = 1.57$, $SE = .19$). There was also a birth status by gender by attentional state interaction. Post-hoc analyses revealed that, in boys, there was no difference between full-term and preterm toddlers in their latencies during casual attention (Preterm: $M = 1.42$, $SE = .37$; Full-term: $M = 1.38$, $SE = .19$), $t(18) = .10$, ns , nor in their focused attention (Preterm: $M = 1.83$, $SE = .18$; Fullterm: $M = 2.34$, $SE = .26$), $t(20) = 1.28$, ns . However, in girls, preterm toddlers ($M = .94$, $SE = .15$)

turned faster during casual attention than did the toddlers born fullterm ($M = 2.52$, $SE = .44$), $t(19) = 2.46$, $p < .05$. However, there was no difference in girls' latencies during focused attention (Preterm: $M = 1.67$, $SE = .31$; Fullterm: $M = 2.04$, $SE = .21$), $t(19) = 1.00$, *ns*.

Finally, using a 2 x 4 Mixed Model ANOVA with birth status and gender as the between subjects factor and trial as the within-subjects factor, we analyzed how latency to the distractor changed over time. There was a no effect of birth status $F(1, 41) = 2.48$, *ns*. Toddlers born full-term ($M = 6.56$, $SE = .48$) and toddlers born preterm ($M = 5.18$, $SE = .69$) exhibited similar latencies to turn to the distractor. In addition, there was a main effect of trial $F(3, 39) = 7.91$, $p < .01$, $\eta_p^2 = .38$. Latency to turn to the distractor increased from Trial 1 ($M = 3.45$, $SE = .38$) to Trial 2 ($M = 6.31$, $SE = .74$) and Trial 3 ($M = 8.41$, $SE = .99$). Latencies to turn to the distractor then decreased in Trial 4 ($M = 5.25$, $SE = .60$). There was no effect of gender, $F(1, 39) = .87$, *ns*. Analyses on the proportion of turns to the distractor showed that there were no effects of attentional state or birth status, $F's < 1.08$, *ns*. Toddlers born full-term ($M = .74$, $SE = .04$) had similar proportions of turns to the distractor to the toddler born preterm ($M = .73$, $SE = .06$). In sum, we do see differences in attention patterns in attention to the distractor and latencies to turn to the distractor as a function of prematurity.

Summary. Analyses from the distractibility task revealed some differences between children born preterm and children born full-term. Although the total looking and average length of individual looks were similar, children born preterm had fewer episodes of inattention than did the children born full-term. In addition, there were

differences in distractibility. Children born preterm tended to look more to the distractor than did the children born full-term. In sum, there are differences in distractibility between children born preterm and children born full-term, but not all measures detect these differences.

Multiple-object task. The following section discusses the analyses on the children born full-term and children born preterm on (1) the attention to the toys, (2) the number of inattention episodes, and (3) the number of attentional shifts in the multiple-object task. We conducted an independent samples t-test to compare total looking to the toys between preterm and full-term children. The results were not significant $t(41) = 0.81, ns$. The total amount of looking to the toys did not differ between children born preterm ($M = 303.68, SE = 19.71$) and children born full-term ($M = 286.61, SE = 11.28$). Similarly, we conducted an independent samples t-test to examine the average length of individual looks to the toys. Again, the results were not significant, $t(41) = .33, ns$. The average length of individual looks did not differ between children born preterm ($M = 10.59, SE = 1.10$) and children born full-term ($M = 10.21, SE = .61$).

We next examined how attention to the toys changed as a function of time and birth status. We again broke the session down into two Blocks, Block 1 (Minutes 1 and 2) and Block 2 (Minutes 6 and 7). We conducted a mixed model ANOVA with block as the within-subjects factor and birth status and gender as the between-subjects factors on the total looking to the toys. Results revealed there was no significant difference between the children born full-term ($M = 82.04, SE = 3.78$) and children born preterm ($M = 89.99, SE = 5.43$), $F(1, 39) = 1.45, ns$. However, there was a main effect of Block, $F(1, 39) =$

5.29, $p < .05$ with looking decreasing from Block 1 ($M = 92.20$ seconds, $SE = 3.52$) to Block 2 ($M = 79.84$ seconds, $SE = 4.89$). There was no effect of gender, $F(1, 39) = 1.08$, ns .

We also examined the number of inattention episodes. We conducted an independent samples t-test to compare the number of inattention episodes between preterm and full-term toddlers. The results reveal a main effect of birth status $t(41) = 2.50$, $p < .05$ with children born preterm having fewer episodes of inattention ($M = 7.71$, $SE = .99$) than did the children born full-term ($M = 12.14$, $SE = 1.13$). To examine the inattention as a function of time and birth status, we again split the session into Blocks: Block 1 (Minutes 1 and 2) and Block 2 (minutes 6 and 7). We performed a 2 x 2 mixed model ANOVA with block as the within-subjects factor and birth status and gender as the between-subjects factors. There was a main effect of birth status, $F(1, 39) = 10.15$, $p < .01$, $\eta_p^2 = .20$ with children born full-term having more episodes of inattention ($M = 3.62$, $SE = .30$) than did the children born preterm ($M = 1.93$, $SE = .44$). Thus, consistent with the distractibility task measurements, children born preterm exhibited fewer episodes of inattention than did their full-term peers. We also found a main effect of Block, $F(1, 39) = 4.22$, $p < .05$, $\eta_p^2 = .09$ with the number of inattention episodes increasing from Block 1 ($M = 2.34$, $SE = .37$) to Block 2 ($M = 3.21$, $SE = .30$). There was no main effect of gender, $F(1, 39) = .01$, ns .

The final analyses on endogenous attention in the multiple-object task examined the amount of attentional shifting during the task. We conducted an independent samples t-test and surprisingly found there was no difference, $t(41) = .33$, ns , between the number

of attentional shifts in children born preterm ($M = 15.79$, $SE = 1.25$) and children born full-term ($M = 15.21$, $SE = 1.05$).

Summary. Consistent with the distractibility task, toddlers born preterm had fewer episodes of inattention in the multiple-object task than did the toddlers born full-term. However, children born preterm did not show any differences in their duration of looking to the toys, the average length of looks, or their number of attentional switches. Thus, like the distractibility task, we again see differences in some, but not all measures of endogenous attention in children born preterm.

Executive functioning. To examine the differences in executive functioning between children born preterm and children born full-term, we analyzed the executive functioning scores from both the reverse categorization task and the A-not-B task. First, we compared performance on the reverse categorization task using the proportion of correctly sorted blocks. Analyses revealed no difference between the scores of the children born preterm ($M = 3.00$, $SE = 1.05$) and the scores of the children born full-term ($M = 2.83$, $SE = .57$), $t(41) = .16$, *ns*. Children born preterm and full-term also had similar scores for the A-not-B task. There was no difference in the number of repeated trials, number of trials to first correct retrieval, nor the final search location, $t(41) < 1.39$, *ns*. In sum, there was no effect of birth status on the executive attention tasks used in this study.

Relations Between Endogenous Attention Measures

We were interested in how the different measures of attention relate to each other as a function of age and birth status. Previous research has found relationships between

attention measures and executive function (Davis, Burns, Snyder, & Robinson, 2007; McGuigan & Núñez, 2006). How the measures relate, however, may depend on the age and the birth status of the children. For example, the relationship between the tasks may be stronger in older children and/or those born fullterm. Other research has found that relations between tasks can be found in older children, but not in younger children (e.g., Kannass et al., 2006). This section describes the relations between (1) executive functioning and multiple object measures, (2) executive functioning and distractibility measures, and (3) multiple object and distractibility measures in toddlers and preschoolers and then in children born preterm and children born full-term.

Toddlers versus preschoolers.

Executive functioning and multiple-object. First, we were interested in how and if the executive functioning planning tasks related to performance in the multiple-object task in the full-term toddlers and full-term preschoolers. We analyzed the multiple object measures that are consistently used in research (e.g., Kannass et al., 2006; Kannass & Oakes, 2008): total duration of looking to the toys, Block 1 (initial) duration of looking to the toys, the total number of inattention episodes, number of inattention episodes in Block 1, and the number of attentional switches. For the executive functioning tasks, we analyzed the four measures that we collected: reverse categorization score, and three from the A-not-B task: number of trials to correct first retrieval, number of trials repeated, and search location. For the preschoolers, there were numerous relationships found (see Table 1). For example, performance on the reverse categorization task was correlated with the total duration of looking to the toys, $r(25) = .48, p < .05$, and the

initial duration of looking to the toys in Block 1, $r(25) = .41, p < .05$. In addition, performance on the reverse categorization task was negatively correlated with the number of inattention episodes in Block 1, $r(25) = -.45, p < .05$. Thus, the higher the preschoolers' scores on the reverse categorization task, the better attention (more attention to the toys, fewer inattention episodes) they had in the multiple-object task. Similarly, there were relationships between the attention measures and the A-not-B task. The number of trials to the first correct retrieval and the number of trials repeated were both negatively correlated with the total duration of looking during the multiple object task. That is, preschoolers who performed better (with fewer mistakes) in the A-not-B task, had more attention to the toys during the multiple-object task. In contrast, in the toddlers, we did not find many relationships between the executive functioning and multiple-object measures, and the two significant correlations were unpredicted (see Table 2). Surprisingly, there was a positive relationship between the reverse categorization score and the number of attentional switches, $r(29) = .41, p < .05$. That is, the higher the score in the reverse categorization task, the more the toddlers switched their attention during the multiple-object task. In addition, the higher the score for the search location (1 was correct, 0 was incorrect), the more inattention episodes the toddlers had over the multiple-object task, $r(29) = .50, p < .01$. Thus, children who found the treat in the A-not-B task, had more episodes of inattention during the multiple-object task.

In sum, there was more consistency across tasks in the preschoolers. There were relationships between both executive functioning tasks and numerous attention and

inattention measures from the multiple-object task. However, in the younger children, there was very little consistency across tasks. Only two relationships were found, and they were contradictory with our predictions.

Executive functioning and distractibility. Second, we were interested in how executive functioning scores related to the attention measures in the distractibility task. Again, we analyzed the executive functioning scores and compared them with all of the measures that are consistently used in distractibility research (Colombo et al., 2004; Colombo & Kannass, 2007; Wyss et al., 2013): Total duration of looking to the toys, average length of individual looks to the toys, the number of inattention episodes, and the duration of looking to the distractor. Surprisingly, for the preschoolers, there were no relationships between the executive functioning scores and the distractibility task (see Table 3). In addition, there were no relationships between the measures for the toddlers (see Table 4). Thus, for both the preschoolers and the toddlers, performance on the executive functioning measures had no relationship with how the children paid attention and acted during the distractibility task.

Multiple-object and distractibility. Third, we analyzed how attention performance in the multiple-object task related to attention performance in the distractibility task in preschoolers and toddlers. For the preschoolers, we found significant relations between the tasks (see Table 5). For example, there was a negative relationship between the number of inattention episodes in the distractibility task and the initial amount of looking to the toys in the multiple object task, $r(25) = -.41, p < .05$. That is, children with fewer inattention episodes in the distractibility task had higher

amounts of looking to the toys in Block 1 of the multiple-object task. There was also consistency across inattention measures. The number of inattention episodes in the distractibility task was positively correlated with the number of inattention episodes in the multiple-object task, $r(25) = .54, p < .01$. Analyses on the toddlers also demonstrated relationships between the tasks (see Table 6). The number of inattention episodes in the distractibility task was positively correlated with the number of inattention episodes in the multiple-object task, $r(29) = .55, p < .01$. In sum, attention measures in the distractibility and multiple-object tasks demonstrated consistency across tasks for both preschoolers and toddlers.

Summary. Analyses comparing performance across tasks demonstrated differences between preschoolers and toddlers. In preschoolers, there are relationships between performance in both executive functioning tasks and the attention measures in the multiple-object task. In contrast, toddlers had few relationships between executive functioning and multiple-object measures, and the two relationships that were found are inconsistent with our predictions. Analyses revealed that, for the distractibility task, there were no relationships between attention measures and the executive functioning tasks for either age group. Finally, we did see relationships for both preschoolers and toddlers when examining performance across the two endogenous attention (distractibility and multiple-object) tasks.

Birth status. We then examined how the relationships in attention measures may change as a function of prematurity. We examined (1) executive functioning and

multiple object measures, (2) executive functioning and distractibility measures, and (3) multiple object and distractibility measures.

Recall that for the full-term toddlers, there was a relationship between the executive functioning scores and multiple object task, but they were inconsistent with our predictions. For the toddlers born preterm, there were no relationships between any of the executive functioning tasks and any of the multiple object measures (see Table 7). Consistent with the toddlers born full-term, we again found no relationship between the executive functioning tasks and the distractibility measures (see Table 8). Finally, we examined how performance in the distractibility task related to performance in the multiple-object task. While we found relations in the toddlers born full-term (e.g., the number of inattention episodes across tasks), there were no relationships between the endogenous attention measures in the toddlers born preterm (see Table 9). That is, performance in the distractibility task did not relate to performance in the multiple-object task. In sum, toddlers born preterm did not demonstrate any relations across any of the measures from the executive functioning, distractibility, or multiple-object tasks.

Parental report. Finally, we examined the CBCL scores and examined relations between the questionnaire and executive functioning and endogenous attention measures to see if there was a relationship between the attention measures and the attention score obtained from the CBCL for the full-term toddlers and preschoolers or children born preterm. There was no relationship in full-term toddlers or full-term preschoolers between the CBCL attention scores and any of the multiple object or distractibility measures (toddlers: $r's(29) < .25$, preschoolers: $r's(25) < .31$). In addition, there was no

correlation between the CBCL parental report and the executive functioning measures (toddlers: $r(29) < .17$, preschoolers: $r(25) < .22$). For the toddlers born preterm, there was no relationship between the CBCL or any of the endogenous attention measures (attention to the toys, inattention, attention to the distractor) or executive functioning measures : (r 's(14) $< .41$, *ns*). In sum, there are no relations between the CBCL and endogenous attention or executive functioning tasks in children born full-term or children born preterm.

Relations Between the Global Assessment and All Other Attention Measures

In order to assess the validity of global assessment, we performed additional correlational analyses to compare attention measures with children's scores from the global standardized assessment. The relationship between the global assessment and attention measures presents data on the ability of the global assessment to provide information about attentional abilities. In addition, the relationship between the laboratory measures of attention as well as the global assessment provides information as to how valid the measures are in obtaining information regarding the attentional development of toddlers born preterm and toddlers born full term. Thus, we examined how the BDI-2 scores (Attention and Memory, and Overall Cognitive Composite) related to the (1) executive functioning scores, (2) the distractibility measures, and 3) the multiple-object measures.

BDI-2 and executive functioning. We conducted analyses to examine how global assessment scores relate to the measures of endogenous attention and executive functioning. We were first interested in learning how this relationship may differ

between toddlers and preschoolers born full-term. We examined how scores on the BDI-2, specifically the Attention and Memory (AM) scaled score and the Overall Cognitive Composite score, related to measures of executive functioning. We found that, in toddlers, the reverse categorization score was correlated with both the AM score, $r(29) = .47, p < .05$ and the composite scores, $r(29) = .55, p < .01$ (see Table 10). That is, the higher the reverse categorization score, the higher the global assessment scores. There was also a negative relationship between the number of trials repeated in the A-not-B task and the AM, $r(29) = -.46, p = .05$ and the composite scores, $r(29) = -.65, p < .01$. Toddlers with fewer mistakes on the A-not-B task had higher global assessment scores. In preschoolers there was again a relationship between reverse categorization and the AM, $r(25) = .40, p < .05$ and the composite scores, $r(29) = .50, p < .05$. However, the A-not-B task did not relate to either global assessment score in the preschoolers, $r(25) < .15, ns$. In sum, we do see a relationship between the global assessment scores and some, but not all, of the executive functioning measures.

BDI-2 and distractibility. We next examined how the global assessment scores relate to the attention measures in the distractibility task in full-term toddlers and preschoolers. In toddlers, we found that neither the total duration of looking to the toys, $r's(29) < .14, ns$, nor the number of inattention episodes, $r's(29) < .21, ns$ related to either global assessment score in toddlers (see Table 12). However, there was a surprising relationship between the AM score and the total amount of looking to the distractor: children with higher AM scores had higher amounts of looking to the distractor $r(29) = .37, p < .05$. In preschoolers, there were no relationships with the AM score and any of

the distractibility measures (see Table 13). However, there was a relationship between the composite score and the number of inattention episodes, $r(25) = -.43, p < .05$. That is, children with higher overall composite scores had fewer inattention episodes. In addition, consistent with the toddlers, there was a positive relationship between the composite score and the duration of looking to the distractor, $r(25) = .42, p < .05$. Again, preschoolers with higher scores on the global assessment composite score had more looking to the distractor in the distractibility task. In sum, there were very few relations and some surprising findings between the global assessment scores and the distractibility measures.

BDI-2 and multiple-object. We then examined how the global assessment scores related to attention measures from the multiple object task. In full-term toddlers, there were no relations between the AM score or composite score and any of the multiple-object measures, r 's (29) $< .23, ns$ (see Table 14). However, in full-term preschoolers we did find relations between the global assessment and multiple-object task (see Table 15). For example, both the AM and composite score were positive correlated with the total duration of looking in the multiple-object task, r 's(25) $> .69, p < .01$. Thus, preschoolers with high global assessment scores also had higher amounts of looking to the toys. In addition, global assessment scores were negatively correlated with the number of inattention episodes, r 's(25) $> -.47, p < .05$. That is, children with higher global assessment scores had fewer episodes of inattention. In sum, toddlers did not show any relationship between the global assessment scores and the multiple-object measures. However, there were relations between the global assessment and the attention

and inattention measures for the preschoolers. Thus, the older children have more relations between the global assessment and performance in the multiple-object task.

BDI-2 relations in toddlers born preterm. We then examined how the global assessment related to attention measures and executive functioning in children born preterm. Recall that both executive functioning scores (reverse categorization and number of repeated trials) related to the attention and memory and overall composite scores in the full-term toddlers. In toddlers born preterm, there was no relationship between the AM score and any executive functioning score (number to first retrieval, number of trials repeated, search location, and reverse categorization), $r(14) < .32$, *ns* (see Table 16). For the overall composite score, there was a negative relationship with the number of repeated trials, $r(13) = -.56$, $p < .05$. That is, consistent with the toddlers born full-term, toddlers born preterm with higher overall cognitive scores had fewer mistakes in the A-not-B task. In addition, consistent with the toddlers born full-term, there was a positive relationship between the overall cognitive score and the reverse categorization score, $r(14) = .76$, $p < .01$. That is, children with high cognitive composite scores also had high reverse categorization scores. For the distractibility task, although there was a relationship between looking to the distractor and the AM score in toddlers born full-term, there were no relations between the global assessment scores and the distractibility measures in toddlers born preterm (see Table 17). Finally, consistent with toddlers born full-term, there were no relations between the global assessment scores and the multiple-object measures (see Table 18). In sum, there are a few relations between the global assessment and executive functioning measures, but, in toddlers born preterm, there are

no relationships between the global assessment scores and the endogenous attention measures.

Summary. We were interested in exploring how global assessment scores related to measures of attention from the executive functioning, distractibility, and multiple-object tasks. We found that there were relations in both toddlers and preschoolers between the executive functioning tasks and the global assessment scores. However, in the distractibility task there was no relationship between the global assessment and the attention to the toys or inattention measures in toddlers. In preschoolers, we did see relations between the number of inattention episodes and the global assessment score. Surprisingly, in both toddlers and preschoolers there was a positive relationship between the global assessment score and the duration of looking to the distractor. Finally, we saw no relations between the global assessment and multiple object measures in toddlers. However, in preschoolers, the duration of looking to the toys was correlated to the global assessment scores. For the toddler born preterm, there was a relationship between the global assessment scores and the executive functioning, but no relationship with any of the endogenous attention measures. In sum, the global assessment was related to executive functioning performance, but only rarely to the endogenous attention tasks.

CHAPTER FIVE

DISCUSSION

The results support our hypotheses in many respects, and the discussion is organized according to the goals and hypotheses presented in the introduction. Recall there were four main goals in this experiment. First, we examined changes in attention as a function of age. Second, we examined attentional differences as a function of birth status. Third, we explored the relationship between endogenous attention and executive functioning tasks. Fourth, we examined the relations between the global assessment (BDI-2) and the endogenous attention and executive functioning measures. We discuss each of these elements in the following section as well as implications of this study for educators, practitioners, and parents for future use.

Preschoolers Demonstrate More Mature Attentional Patterns

The analyses revealed more mature attentional abilities in the 3-year-old preschoolers when compared to the 2-year-old toddlers, consistent with previous work demonstrating increases in endogenous attention from infancy into the preschool years (Kannass et al., 2009; Kannass & Colombo, 2007; Ruff et al., 1998; Ruff & Cappazoli, 2003; Ruff & Lawson, 1990). In the distractibility task, preschoolers looked more to the toys, had longer average lengths of individual looks to the toys, and fewer episodes of inattention than did the toddlers. Additionally, preschoolers and toddlers had different patterns of attention over time. Toddlers increased their attention (longer total looking,

longer average length of individual looks) from Trial 1 to Trial 2. Their looking remained stable across Trials 2 and 3, but then decreased in Trial 4. In contrast, preschoolers increased their attention from Trial 1 to Trial 2, and were then able to maintain and hold their attention to the toys across the remaining trials. The decrease in attention in the younger children over the course of the session is consistent with previous research. For example Ruff and Lawson (1990) examined attention in a free-play task in 1-year-olds, 2-year-olds, and 3.5-year-olds using both single-object and multiple object tasks. At the first timepoint in the Ruff and Lawson (1990) study, the 1-year-olds were given 2 minutes to play with a single object (the single-object task) and then another 2 minutes with six different toys presented simultaneously (the multiple object task). The 2-year-olds had five minutes of free-play with multiple objects and the 3.5-year-olds had 7 minutes with multiple objects. Ruff and Lawson (1990) found that the children maintained focused attention longer as they grew older. Additionally, the 1-year-olds showed a steady decrease in their focused attention as the session went on, suggesting limitations in their attention span. However, this was not observed in the older ages. The authors propose that because the 1-year-olds had a decline in focused attention in both the single and multiple-object conditions, this may be due to habituation. However, at the older ages, the increase in focused attention was attributed to complexity of play and increases in endogenously controlled attention. The older children were not focused on the physical characteristics of the toys. Instead, the children were goal-oriented with tasks (e.g., construction of a tower). In the current study, the children showed similar patterns over time as the Ruff and Lawson (1990) results. That is, the toddlers showed a

decrease in attention as the session went on, but the more mature preschoolers demonstrated an increase in attention.

Although Ruff and Lawson (1990) did not find a decrease in attention in the 2-year-olds over time, our study did reveal a decrease in attention over the course of the session. By the fourth trial, the toddlers were on the 10th to 12th minute of the task, well beyond the 5 minutes used in the Ruff and Lawson study for 2-year-olds. Thus, our study may have pushed the toddlers further toward the end of their attention spans, allowing us to see differences across time between toddlers and preschoolers where Ruff and Lawson (1990) did not. Ruff and Lawson examined how children hold their attention in a multiple object task. In contrast, the current study found differences in a distractibility task.

The different tasks may account for the reasons we found differences between toddlers and preschoolers where Ruff's previous work had not. Consider the distractibility task. For this task, children have one target toy to focus on during each trial. When the intermittent distractor turns on, the child must resist this distraction by maintaining his attention to the target toy. An important measurement for this task is if and how quickly the child orients to the distractor. Attentional control in this distractibility context is influenced by both exogenous factors such as characteristics of the target and the distractor (Oakes et al., 2000; Ruff & Cappazoli, 2003), but it is also influenced by endogenous attention such as the child's attentional state (Oakes & Tellinghuisen, 1994; Ruff et al., 1996). The presence of an intermittent distractor with only one target toy creates an environment where the demands of attention in the last

trials may demonstrate differences in the immature toddlers where a 5 minute multiple-object task may not such as in Ruff's work.

While multiple-object tasks also involve competition for attentional focus, the task has different demands for the child. In multiple-object tasks, the competition for attentional focus is constant because of the presence of numerous toys. While the distractibility task in the current study involved an intermittent presentation of a distraction, the multiple-object task consistently had competition for attention in the various other toys on the table. Additionally, the type of competition for the child's attention is different. As the child explores one of the toys, the other toys act as potential distractions and potential targets for attention. Thus, an important measure in this context is the number of attentional switches among the toys and researchers can measure how children hold and sustain attention. In multiple-object tasks, children must ignore a constant distractor, while in the distractibility task, children ignore an intermittent distraction while focusing on one target toy. This important difference in these tasks may explain why children may be able to hold and maintain their attention during multiple-object, but the demands of the intermittent distractor are more difficult to inhibit and ignore, thus we see differences in distractibility tasks.

Both the current study and Ruff and Lawson (1990) reveal that there are age related changes in the patterns of attention over time. As children develop, their play becomes more advanced. Children become more focused on what can be done with the toys (e.g., construction) than exploring the toys as objects (Ruff & Lawson, 1990). The

current study adds to our knowledge of how patterns of attention change over time by revealing the different patterns between toddlers and preschoolers

In addition to the age differences in attention to the toys and inattention measures, there were age differences in children's distractibility. Preschoolers had high initial looking to the distractor in the first trial, but then their looking to the television decreased and remained low across the subsequent trials. In contrast, toddlers had high looking in the first trial, but continuously decreased their attention to the distractor across all trials. This decrease in attention to the distractor over time is consistent with other research with toddlers (Wyss et al., 2013). The differences in distractibility suggest that preschoolers were better able to allocate their attention, quickly being able to ignore the distractor. In fact, they may have been able to completely process the information from the distractor and habituate to it. However, toddlers decreased their attention to the distractor continuously, suggesting they were still learning about the distracting event, even throughout the fourth trial. This decrease in distractibility and quicker habituation time in the older children is consistent with previous research. Indeed, numerous studies have found incremental decreases in distractibility over infancy and early childhood (Kannass & Colombo, 2007; Ruff & Cappazoli, 2003; Tellinghuisen & Oakes, 1997).

In addition to looking at the distractor, we saw age differences in the amount of turns to the distractor in regards to attentional state. Recall that toddlers had similar proportions of the turns to the distractor in casual and focused attention. That is, whether they were simply looking at the toy (casual) or actively engaged and learning (focused), they were just as likely to turn to the distractor. In contrast, preschoolers turned more to

the distractor during casual attention states than they did during focused attention states. Thus, the preschoolers demonstrated that they were better able to allocate their attention. Recall that as the higher level attentional processes develop (i.e., endogenous attention), children have more voluntary control of their attention and ability to ignore distractions (Ruff & Rothbart, 1996). Toddlers demonstrated a more immature pattern of attention because they turned to the distractor during periods of focused attention. It has been shown that infants can allocate their attention: they are less likely to turn to the distractor during periods of focused attention (Oakes et al., 2002; Oakes et al., 2000). Unlike infants, attention during toddlerhood is not determined by features of the toy (novel vs. familiar), but by their complex play, goal-oriented actions (Ruff & Lawson, 1990). Thus, the ability for complex play and goal oriented actions determines how toddlers and preschoolers allocate their attention. The current study reveals that toddlers are less able to allocate their attention because they turned at similar rates regardless of their attentional state. However, by preschool age, children are better able to resist distraction and inhibit responses based on their attentional state. Thus, there is a development in endogenous attention between toddlerhood and the preschool years in children's ability to allocate their attention and inhibit responses to distractors. Again, this development of the ability to allocate attention is consistent with previous research that has demonstrated older children are more able to ignore distractions and allocate their attention more efficiently than do younger children (Kannass & Colombo, 2007; Oakes et al., 2002).

During the multiple-object task, preschoolers again demonstrated more mature attentional abilities through their longer lengths of individual looks to the toys and fewer

episodes of inattention. There were also differences in the number of attention shifts over the session. Recall that this additional measure, attention shifts, is similar to measures of how children with ADD/ADHD and typically developing children maintain their attention to multiple toys (e.g., Alessandri, 1992; DeWolfe et al., 2000; Roberts, 1990). During free play with toys, children with ADHD engage in more shifts of attention (i.e., the amount of attentional movement from one activity to another) than do typically developing children (Alessandri, 1992). Thus, more shifts of attention indicate less mature patterns of attention. Past research has demonstrated developmental differences in attentional shifting. In younger children, Kannass et al. (2009) found that 18-month-olds had fewer shifts in attention than did 12-month-olds, suggesting a developmental increase in attentional abilities in the second year of life. Consistent with this previous work, our analyses revealed that preschoolers had fewer attentional shifts between the toys than did the toddlers, indicating an increase in attentional functioning during the third year of life. Overall, our findings comparing attention in toddlers and preschoolers add to the growing body of literature demonstrating gains in endogenous attention in early childhood.

Toddlers Born Preterm Demonstrate Different Patterns of Attention

Distractibility task. Another main goal of the study was to examine the effects of prematurity on attentional functioning in a variety of contexts. In the distractibility task, children born preterm had different patterns of attention to the distractor. The children born preterm had more total attention to the distractor. This measure indicates that the children born preterm have more immature patterns of attention. Thus, there are

differences in children born preterm when there is active competition for their attentional focus (e.g., a distractibility task). Previous studies have demonstrated that older and more mature infants and children are less distractible than those who are younger, with more immature attention patterns (Kannass et al., 2006; Kannass & Colombo, 2007; Oakes, et al., 2002, Tellinghuisen & Oakes, 1997). Thus, increased distractibility in toddlerhood would indicate an immaturity in endogenous attention when compared to full-term toddlers of the same age. In total, the preterm children's increased attention to the television reveals different, more immature, patterns of attention.

In contrast, children born preterm appeared to have better attention because they had fewer episodes of inattention. However, upon further examination of the results, we see that children born preterm had less opportunity for inattention episodes because they were looking more at the distractor. Indeed, the toddlers born preterm tended to look more to the distractor than did the toddlers born fullterm. Thus, because these children born preterm spent their time off-task looking at the distractor, they would have fewer episodes of inattention as we defined it (looking at anything but the toys and television). Anecdotally, it appeared to the experimenter that toddlers born preterm seemed to be more off-task when examining attention to the television and the duration of inattention. Toddlers born preterm may have actually spent similar or increased amounts of time off-task, but their attention was drawn towards the TV as opposed to other aspects of the room (the experimenter, their parent). Indeed, when we compared the duration of inattention and attention to the distractor, we see that children born preterm are off-task more than the children born full-term. Future research should compare the duration of

inattention (instead of the number of inattention episodes) and duration of looking to the distractor in children born preterm and children born full-term to further examine their off-task behaviors. The duration of off-task behaviors between groups would reveal more insight into the differences of children born preterm and children born full-term.

Why are toddlers born preterm more distractible? This finding is intriguing as it suggests a difference in how television attracts the attention of preterm versus full-term children. Why would children born preterm be more attracted to the television than children born full-term? Children born preterm may have looked more to the distractor because they were familiar with the images. Recall that the distractor consisted of segments of *Sesame Street*, and children born preterm watched significantly more of the show (over two hours per week) than did the children born full-term (.66 hours per week). Infants and children can show familiarity preferences and be more attracted to stimuli they have already seen than those they have never seen before (Bahrick, Gogate, & Ruiz, 2002; Roder, Bushnell, & Sasseville, 2000). Because the children born preterm watched more of the distractor images at home and were arguably more familiar with the show, they may have been more drawn to the images during the session. As this was the first study to examine prematurity in a distractibility task, more research is needed to further examine why children born preterm look more at the distractor. For example, it would be interesting to examine distractibility in infants born preterm using different types of distractors where familiarization may not be a potential confound.

Alternatively, the difference in distractibility may be due to differences in the brain development of children born preterm. Recall that different parts and pathways of

the brain (e.g., locus coeruleus, cholinergic pathway, anterior cingulate) are used in the different aspects of attention (e.g., alertness, endogenous attention). Brain scans in infants have demonstrated differences in brain structure in children born preterm and children born full-term (Inder, Warfield, Wang, Huppi, & Volpe, 2005; Peterson, Anderson, Ehrenkranz, Staib, Tageldin, Colson, Gore et al., 2003). Peterson et al. found that magnetic resonance imaging scans (MRI) demonstrated differences in children born preterm in their grey and white matter in the cortex, cerebellum, and brain stem. Interestingly, differences in brain volume were correlated with neurodevelopmental outcomes at 8 years of age. Thus, the early differences in brain structures as infants may affect the overall development of the child. The exact pathways and areas of the brain associated with the attention are also different as demonstrated in a recent study. Shi, Wang, Ceschin, An, Lao, Vanderbilt, and Nelson, et al. (2013) examined specific areas of the brain in more detail. They found specific differences in the putamen, a portion of the basal ganglion. The authors argue that because the putamen is intercorrelated with the prefrontal cortex, the structural differences may underlie the risk of development of executive function and attentional dysfunction. Thus, due to their prematurity, children in the current study may act differently towards distraction because of these structural differences in the preterm brain.

Finally, other measures such as environment and child characteristics may have influenced how the children reacted to the distractor. For example, a recent study demonstrated that differences in children's temperaments influence their distractibility (Brand & Dixon, 2013). Specifically, children who were more difficult to soothe as

infants was a predictor of attention problems in school-age. If temperament impacts attention problems, that temperament may affect distractibility. The temperament of the children born preterm in the current study may have been different as a group compared to the children born full-term. That is, children born preterm may have had more difficult temperaments. While we did not have a temperament rating for the study, it may be possible to examine aspects of the CBCL to determine if there may have been group differences. Follow-up research and coding with the data may be able to demonstrate differences in temperament, suggesting another reason why the children born preterm looked more to the distractor.

In addition, it has been suggested that early television viewing may have causal effects of attentional disorders, depending on the programming (Zimmerman & Christakis, 2007). While the authors pose that educational programs, such as *Sesame Street*, may be beneficial or have less harmful effects than more violent programs, a randomized study to assess causality between television and attentional disorders has yet to be completed. Because the impacts and effects of television exposure are not truly known, the American Academy of Pediatrics suggests no screen media under the age of 2, and limited exposure afterwards (American Academy of Pediatrics, <http://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Pages/Media-and-Children.aspx>). In addition, it is well documented that children born preterm are at-risk for overstimulation and parents of premature infants are already encouraged to limit visual and auditory stimulation (Aita & Goulet, 2003). The increased attention to the television in the current study provides additional evidence that children's television

exposure should be limited, especially in children at-risk for attentional disorders (e.g., children born preterm). Regardless of television exposure in the home, the different patterns of attention to the television of children born preterm and children born full-term suggest that toddlers born preterm may be different from the children born full-term in their endogenous attention, specifically their distractibility.

Multiple-object task. In addition to distractibility, we also examined attention and inattention in the multiple object task. Surprisingly, children born preterm again had fewer episodes of inattention. This is contradictory to our hypotheses as the previous research reported in the literature review above suggests that children born preterm have more immature patterns of attention and so should show more episodes of inattention in the endogenous attention measures. Thus, having fewer episodes of inattention would suggest the children born preterm had better attentional abilities. Upon further examination of the tasks, we pose that there may be other causes for this surprising result. For the multiple-object task, this finding may be due to our inattention coding process. Both the preschoolers and the toddlers were seated at a child-sized table. While this was beneficial in order to keep the stimuli and tasks consistent to compare ages, it allowed for the toddlers to get out of their chair. To avoid this issue, in other studies with toddlers (e.g., Colombo et al., 2004; Kannass et al., 2009), children sit on their parent's laps. However, to be consistent with the preschoolers, the children sat at the table at both ages. When toddlers were out of their seats and off camera (this was rare for preschoolers), the coders measured this behavior as "active inattention" and it was coded as an inattention episode. However, if the period of inattention lasted for a long period (more than 20

seconds), the experimenter would attempt to guide the child back to the chair and on camera. Because there was then an interaction, the coding stopped as the experimenter was influencing the child's attention and behaviors. Thus, the inattention of preterm children may, in fact, have been more active and greater if the experimenter did not interact to guide them back on screen. Because we did not differentiate between inattention in their chair and active inattention, we are unable to analyze this variable. Other researchers have found stability in the amount of active inattention from 2 to 3.5 years, and at each age, it was also negatively related to focused attention to the toys during free play (Ruff et al., 1990). Active inattention is also consistent across various situations from 2.5 to 4.5 years of age (Ruff & Rothbart, 1996).

Activity provides stimulation and individuals vary in the level of stimulation most satisfying to them (Zentall & Zentall, 1983). That is, highly active individuals prefer more stimulation. It is argued that children who seek higher levels of stimulation habituate more quickly and pay less overall attention to toys as they move on, in search of novel items (Ruff & Rothbart, 1996). The ability to inhibit motor responses in the preschool years develops as children deliberately control their activity level because they want to, or feel they should, pay attention to a task. While children do have periods of quiet inattention, where they are visually off-task, it is a more mature pattern of inattention because they are still controlling their motor activity (Ruff & Rothbart, 1996). Thus, examining how the toddlers differed in their active attention could give additional insight into their attentional abilities. Because it is a stable measure in toddlers and preschoolers, active inattention is an important variable that should be included for the

preterm population. Thus, future work comparing active versus inactive inattention would be interesting to examine if children born preterm do, in fact, have different inattention patterns, as seen in active inattention, during multiple-object tasks.

Similar performance on executive functioning tasks. Finally, recall that attentional differences were only found in toddler born preterm in the endogenous attention tasks. Contrary to other studies, we did not find differences in the executive function measures or the global assessment. The A-not-B-task was adapted from Woodward et al. (2009), and has previously been used in children that were born very preterm ($M = 27$ weeks) and very low birthweight ($<1500\text{g}$). Recall that the range for the current study included children born at 36 weeks ($M = 32$ weeks), and so our sample was significantly older in gestational age. In contrast to the current study, the children in Woodward et al. also had some motor impairments. Indeed, in Woodward et al. an extra step (an additional barrier) was omitted because pilot data showed that the preterm children had greater motor difficulties than did the full-term children. Thus, we also eliminated this extra step to be consistent with the task. Perhaps if we had retained this additional step, we may have found more group differences. However, we also chose participants who were extremely healthy and lacked any motor coordination delays. By omitting children with medical complications, their performance on the attentional tasks and assessment was not confounded by other health issues (e.g., cerebral palsy, intraventricular hemorrhage, retinopathy of prematurity). Thus, our sample may simply have been less at-risk from Woodward's sample, and so there may not be differences in this task in a healthier population.

For the reverse categorization task, we were interested in using a measure that had not been previously used with children born preterm. The similarity in performance between the full-term and preterm children may have occurred because the task was not timed, and children were able to inhibit responses. Timed tasks in executive functioning reveal information about speed of processing and planning, while untimed tasks can detect differences in inhibition. It may be that during toddlerhood, preterm children do not differ on these untimed tasks. Indeed, in a meta-analysis, Mulder, Pitchford, Hagger, and Marlow (2009) argue that differences in the tasks used to assess executive functioning may account for findings such as ours. Children born preterm have been shown to have slower speed of processing skills in infancy (Rose et al., 2002) and in childhood (Marlow et al., 2005). Mulder and colleagues pose that when an outcome is mainly measured as a function of speed, group differences between preterm and term children are likely to be shown, but not necessarily in untimed tasks, thus making it harder to establish whether the preterm children have a genuine difficulty with executive function. When we were choosing our measurements, we wanted to use a task that had previously shown differences between children born preterm and children born full-term (A-not-B) and also wanted to generalize by including a task never before used with children born preterm (reverse categorization). A closer examination of the literature after the study was concluded revealed that time was an important factor. We may have been more likely to see differences if a task with time as a measure had been used. An important area for future research is to assess differences in preterm toddlers and preschoolers on timed tasks. Because the reverse categorization task did not include any

speed of processing measurements, the similarities could suggest that preterm children may be efficient at some measures of executive functioning (e.g., inhibition), but not others (planning).

Differences in some attention measures, but not all. The idea that differences are present and detectable in some areas of attention (distractibility) but not in others, is intriguing and the basis of the original hypothesis of the study. We examined the numerous measures of attention because we expected differences to be only in some tasks, but not all of them because researchers do not always see differences in every measure in a given task. In the distractibility task, we found differences in toddlers born preterm and toddlers born full-term in their distractibility (shorter latencies to turn to the distractor, more attention to the television), but not in other measures from the same task such as total and average attention to the toys during the task, which is actually consistent with research with premature infants. Recall that Sigman and Parmelee (1974) found that infants born preterm looked at stimuli for the same amount of time as infants born full-term, but differences were found in novelty preferences, suggesting that the preterm infants were processing the stimuli in a different way. Thus, even though we did not find differences in the total amount of looking to the toys between the children born preterm and the children born full-term, perhaps they were processing the data differently or at a slower rate. An important area for future work with these data is to examine the total amount of time spent in a focused attention state throughout the multiple object task to determine how much time the children born preterm spend actively learning and engaged with a toys. It may be the toddlers born preterm looked at the toys in a way that is not

optimal for their learning because they had less focused attention. Indeed, Ruff et al. (1990) found differences in the amount of focused attention between children born full-term and children born preterm in a multiple object task. It would be interesting to examine if there were also differences in our sample.

Our measures did detect differences in endogenous attention the children born preterm. Specifically, how children are able to hold and maintain their attention to toys, as well as resist distraction, appears to be affected by their birth status (preterm vs full-term). Differences in the development of endogenous attention could be influenced by brain pathways. Neuropsychological models of attention support the view that attention is multifaceted and represented by several neural networks. Attention domains are thought to be associated with distinct neural networks (Mirsky et al., 1991; Posner et al., 2006), and these distinct networks may be altered to differing degrees due to prematurity. Studies report that executive function and attention skills, such as distractibility and holding attention, follow different developmental trajectories in children born full-term (Brocki & Bohlin, 2004; Huizinga et al., 2006). It would not be difficult to assume that these skills have different pathways in children born preterm as well. Our results indicate that, in toddlerhood, some facets of attention (e.g., distractibility) are delayed in children born preterm, while other areas are typically developing and similar to that of children born full-term. As these areas are controlled and executed through different areas of the brain (Mirsky et al., 1999; Posner et al., 2006), the different injuries that occur to the preterm brain may account for the different patterns (delayed and typically developing) of attention in children born preterm.

As explained previously, different attention measures and tasks may reflect different attentional abilities at different ages. For example, during infancy short looking times and long looking times are both attributed to positive cognitive outcomes because they may be tapping into different processes (e.g., habituation and object examination) at different ages (Colombo & Janowsky, 1998; Colombo & Mitchell, 1990; Kopp & Vaughn, 1982; Ruff, 1990). Similarly, giving young children the same task at different ages may not be efficient in examining the same attentional component because of the children's mental, cognitive, and attentional development. Caravale and colleagues (2005) found that children born preterm had lower performance scores than their full-term peers at three years of age on a sustained attention task. However, using some of the same sample at five years of age, the differences in attention seemed to have dissipated (Caravale et al., 2012). The authors pose that attentional differences seemed to disappear between 3 and 5 years of age because, at 5 years, they no longer found attentional differences between the two groups (preterm versus full-term). They argue that in children born preterm and at low risk, attention seems to improve more rapidly than other neuropsychological abilities (e.g., visual perception). However, because the rate of ADHD and attentional disorders is significantly higher in the preterm population than the full-term population in childhood, we argue that there must be some differences in early childhood that persist. It may be that these differences in attention do not disappear by age 5 as Caravale and colleagues proposed. Instead, the task may not be assessing the differences that actually exist, or you may see differences at once age in one task, and then differences in another task at another age (see Colombo et al., 2004). The

sustained attention task used in the Caravale and colleagues research may have been eliciting different attentional abilities at the two ages. Indeed, research has demonstrated that the same measure may reflect distinct processes at different ages, tapping a difference process or presenting a different level of challenge (Colombo & Jankowsky, 1998). Thus, a sustained attention task used in 3 year olds may have been tapping into a different process at 5 years of age and may not be detecting differences that do exist between the populations.

Although we did not expect differences in all of the attentional measures, we did hypothesize that children born preterm would have more attentional switches during the multiple-object task. Because children with ADHD engage in more shifts of attention than do typically developing children (Alessandri, 1992; Roberts et al., 1984), we know that more shifts of attention indicate less mature patterns of attention. Thus, with our hypothesis that children born preterm have more immature patterns of attention, we predicted they would have more attentional shifts. The fact that we did not see differences in that measure or in the executive functioning tasks may be because of the population of our study. Recall that in order to ensure the children could perform the battery of tasks and the global assessment, we recruited only healthy children born preterm. Research with children born preterm use both healthy and more “unhealthy” (e.g., with congenital defects, cerebral palsy, developmental delays) children as a way of studying the impact of prematurity (Anderson et al., 2011; Butcher et al., 2002; Petrie Thomas, Whitfield, Oberlander, Synnes, & Grunau, 2012). However, our sample was not only healthy, but they also came from very supportive environments to enhance their

development. Indeed, parents in our sample were highly educated and spent numerous hours a week reading to their child. These developmentally appropriate and high socioeconomic conditions may have facilitated our sample's development, and their overall development and attentional abilities were closer to the term-born children's skills. It has been consistently shown that preterm children from families with higher socioeconomic status (SES) develop fewer problems later in life than children from low SES families (Hack et al., 1992; Roberts, Bellinger, & McCormick, 2007). Thus, we may find differences in attentional shifting or in how children born preterm look to the toys/tasks if we examine children who do not come from such supportive environments that may buffer the impact of prematurity. Studies focusing on the low SES population of children born preterm are an important direction for future research. Indeed, low SES has been well documented to be a risk-factor for premature birth and associated with negative outcomes (American Psychological Association, Fact Sheet: Women & Socio-economic status). In fact, a study in 1994 examined 243 children born preterm living in poverty and found only 26 of those children were within the normal range of cognitive development as three-year-olds (Bradley et al., 1994). Thus, while the current study did not find differences in all of the measures between the children born preterm and children born full-term, there may be delays across all areas of attention in children from low SES, less developmentally appropriate, environments.

Relations Between Attention Measures

Our last goals of the study involved examining the relationship between measures. As expected, we did find relations between the multiple-object and distractibility task in

preschoolers and toddlers. That is, there was consistency across endogenous attention tasks. While the tasks were difference in their amount of target toys and distraction, both endogenous attention tasks require the child to inhibit additional stimuli and maintain focus. Thus, it was expected that children's measures in one endogenous attention task would relate to the other. Ruff et al. (1998) found consistency across tasks in toddlers and preschoolers in both attention and inattention. For example, increased attention during free-play was associated with increased attention in a visual attention task. In addition, attention was negatively correlated with inattention in the other task. Similarly, in the current study, preschoolers and toddlers inattention in the one task (e.g., distractibility) was negatively correlated with attention in the other endogenous attention task. Thus, the results from the current study are consistent with previous work that demonstrates relations across tasks in endogenous attention.

In the children born preterm, however, there was no consistency across measures. The full-term toddlers had relations between endogenous attention measures across the multiple-object and distractibility tasks. In contrast, the toddlers born preterm did not have any consistency across the endogenous attention tasks. Thus, we must argue that the children born preterm are exhibiting different patterns of attention. It may be the toddlers born preterm have more immature attentional abilities, and their lack of relations between tasks is due to those developmental reasons (Kannass et al., 2006). It may also be that the tasks are somehow eliciting different processes, and the different structure of the preterm brain is affecting how the children respond across the tasks (Colombo & Jankowsky, 1998; Colombo et al., 2004; Kopp & Vaughn, 1982). Recall that differences

in the preterm brain structure are in specific areas that are known to involve attention and inhibition. The brain pathways in children born preterm may be separate in the needs for the different tasks. That is, the ability to inhibit and maintain focus is similar in children born full-term. The different demands of an intermittent distractor and the constant presence of other distracting toys may elicit different responses in children born preterm, and so we do not see consistency across tasks. Future work with older children born preterm may help determine why the toddlers born preterm do not show relations between endogenous attention tasks. If preschoolers and school-aged children demonstrate consistency across tasks, the lack of relations in the current study could be attributed to more immature attention abilities. However, if these inconsistencies continue as children's attentional abilities mature and improve, there must be another reason (e.g., brain structure and pathways) behind the differences.

Lack of Relations in Executive Functioning

We also examined how the executive functioning tasks related to the endogenous attention measures. For example, endogenous attention measures from the distractibility task (e.g., attention to the distractor) were not related to measures of executive functioning. Thus, it would appear these different tasks are eliciting unrelated processes in toddlers and preschoolers. Executive functioning skills are assessed as a top down, higher function. It may be that there are differences in the demands of the planning task (e.g., attention to the buckets/toys in reverse categorization), compared to the demands of distractibility tasks. Thus, while researchers have found stability of attention across endogenous attention tasks in toddlers and preschoolers (e.g., Kannass et al., 2006; Ruff,

et al., 1998), we did not find relations in attention between executive functioning and distractibility. Executive functioning requires planning and more complex thought processes. For example, to accurately complete the reverse categorization, the children were inhibiting previous physical responses and maintaining the new rule in their working memory. In contrast, in distractibility, the child is mostly focused on inhibiting the reaction to a distractor. As research has demonstrated, attention abilities are consistent across tasks as children mature (Kannass et al., 2006, Ruff et al., 1998). Performance on endogenous and executive functioning tasks may relate to each other later in life as the children mature. Thus, another important area of research is to examine the relationship between executive functioning and endogenous attention in older preschoolers and in early school-aged children to assess if a relationship exists later in childhood.

Although there were not any relations between executive functioning and distractibility measures, we did find some relationships between the multiple-object task and the executive functioning measures. However, only a few measures of attention correlated with one another, and there was no consistency between relationships across ages. In preschoolers, higher scores on the reverse categorization and A-not-B task were related to better attention (i.e., more attention to the toys, fewer episodes of inattention) in the multiple-object task. This may be consistent with the demands of the tasks. As mentioned previously, the executive functioning tasks required more maintenance of attention as the children stayed on task and planned their behaviors. Similarly, multiple-object tasks require children to maintain attention in complex play. Recall that children's attention to toys increases during free-play as the complexity of their play (building a

tower with blocks versus looking at blocks) increases. Both executive functioning and multiple-object free play tasks are tapping into a child's planning and inhibition abilities. Thus, it is not surprising that there were relations in these tasks in the older children. However, in toddlers there was a lack of relations, and the few that exist are contradictory to our predictions. For example, in toddlers, high reverse categorization scores were related to more attentional switches during the multiple-object task, and better A-not-B task scores were related to higher numbers of inattention episodes. The data on preschoolers, demonstrating consistency across tasks, are similar to previous studies demonstrating that older children have consistency across tasks, but younger children do not (Kannass et al., 2006, Ruff et al., 1998).

Global Assessment and its Relations with Experimental Measures

Both toddlers and preschoolers showed consistency across the global assessment scores and the executive functioning measures. For example, higher scores on the attention and memory subscale and the overall composite score were associated with higher scores in the reverse categorization task. In addition, preschoolers had consistency across the global assessment and the endogenous attention measures. For example, inattention in both the distractibility and multiple object tasks was negatively correlated with preschoolers' composite scores. In other words, the higher the children scored on the global assessment, the less inattention they demonstrated during the endogenous attention tasks. However, there was no relationship between performance on the global assessment and any of the endogenous attention measures for the toddlers. Again, consistent with past research, preschoolers demonstrated more consistency across tasks,

repeating the pattern that older children's performance is associated across tasks, while younger children may not show these same consistencies (Kannass et al., 2006; Ruff et al., 1998). In addition, children born preterm showed zero relations between their global assessment and any of their attentional measures from the executive functioning or endogenous attention tasks. While we found differences in experimental procedures, the global assessment was not sensitive to these differences.

The Importance of Early Detection of Attentional Differences

While examining the development of attention in later childhood is important, the reason we chose the younger ages (2 and 3 year olds) in the current study was because of the importance of early detection of attentional differences. If the global assessments that are typically used to assess attention in toddlers are not sensitive to the differences in attention present in very young children, interventions cannot be used to assist the children. As the current study demonstrates, children born preterm did not differ in their performance on the global assessment in the overall cognitive or their attention subscale scores. However, we did find differences in the children's distractibility. Thus, as we predicted, the global assessment is not sensitive to the differences that are, in fact, present during toddlerhood. Children tested only with global assessments may not be diagnosed with attentional delays until they are in school, missing the opportunity for early intervention. It is imperative to detect differences and assess children, especially those at-risk for attentional disorders (e.g., children born preterm) with sensitive measures so that any intervention needed can be implemented

The importance of early intervention is well documented (Hebbeler, Spiker, Bailey, Scarborough, Malik, Simeornsoon, & Singer, 2007) and is essential to implement during early childhood (Center on the Developing Child at Harvard University, 2008, 2010). The Center on the Developing Child at Harvard University argues for the importance of intervention in the early years of development because of how the brain develops. First, the brain develops based on early experiences. In the first few years of life, 700 new neural connections are formed every second. After this period of rapid growth, connections are reduced through a process called pruning, so that brain circuits become more efficient. Sensory pathways like those for basic vision and hearing are the first to develop, followed by early language skills and higher cognitive functions. Connections multiply and prune in a prescribed order, with later, more complex brain circuits built upon earlier, simpler circuits. Thus, early differences and delays in the attentional networks may alter how these pathways are formed, changing the make-up of the brain. This is consistent with Posner's and Mirsky's theories of children's brain pathway development (Mirsky et al., 1991; Posner et al., 2006). Second, the brain becomes less malleable as the child develops. The brain is most flexible, or "plastic," early in life to accommodate a wide range of environments and interactions, but as the maturing brain becomes more specialized to assume more complex functions, it is less capable of reorganizing and adapting to new or unexpected challenges. Early plasticity means it is easier and more effective to influence developing brain architecture than to rewire parts of its circuitry in the adult years. Because of brain development, intervention

at the earliest possible time can assist a child by affecting the neural pathways and altering the brain structure at a more pliable time.

Recall that attention is stable in childhood and that it affects numerous areas of development, such as language and motor skills, and is related to later cognitive abilities like memory and IQ (Colombo et al., 2004; Kopp & Vaughn, 1982; Rose & Feldman, 1997; Ruff, 1990). Thus, delays in attention could affect a child's later attention, motor development, language development, and memory. Early detection of attentional differences is essential so children can be given interventions at the optimal time of development, the earlier the better. Children at-risk for attentional disorder (e.g., they were born preterm) should be assessed using measures that can accurately detect early differences in attention in toddlerhood or infancy. As the current study demonstrates, the global assessments are not tapping into specific attentional abilities, and are not sensitive to all differences. In contrast, laboratory measures did detect differences in the children born preterm. The development of an assessment that can be used in the neonatal follow-up programs and pediatrician offices to detect attentional differences in children would be an extremely useful tool. With early detection and placement in intervention, professionals could reduce the effects and prevalence of attentional disorders and assist children to develop to their fullest potential.

Future Work

As the first study to examine distractibility in children born preterm, the current project makes important contributions to the field. Future research should examine how the extent of a child's prematurity contributes to their distractibility. Although it was

originally believed that effects of “late preterm” birth were minimal, recent evidence suggests that these children born between 34 and 36 weeks gestation are also at risk for a variety of cognitive (e.g., lower math and reading scores in first grade, greater incidences of special education and retention in kindergarten) and attentional delays (Escobar, McCormick, Zupancic, Coleman-Phox, Armstrong, Greene, et al., 2006; Khashu, Narayanan, Bhargava, & Osiovich, 2009; Morse, Zheng, Tang, & Roth, 2009; Wang, Dorer, Fleming, & Catlin, 2004). Previous research has shown differences in children born preterm based on if they were very preterm (under 28 weeks gestation) or “late preterm” (34-36 weeks gestation) in the prevalence of developmental delays, suggesting gestational age seems to be a major factor in determining the risk for developing general cognitive problems for preterm children (Bhutta et al., 2002; Johnson, 2007; Marlow, 2005). For example, Saigal and colleagues showed that 72% of adolescents born very preterm (with a less than 750 g birthweight), and 53% of late preterm had school difficulties. These difficulties were apparent even in children without neurosensory impairments and normal intelligence quotient (IQ) (Saigal et al., 2000). In addition, children born very preterm have greater deficits in inhibition and speed of processing (Bhutta et al., 2002; Marlow et al., 2005).

The current study had a large range of gestational ages in our preterm sample (25 to 36 weeks). There may be differences in attentional delays based on gestational age of very preterm or “late preterm” birth. However, our sample did not provide us with the opportunity to explore this variable. Thus, the importance of gestational age on the development of distractibility and endogenous attention is crucial area for future research.

Children born at different gestational ages may be more susceptible to endogenous attention delays.

Importantly, the children born preterm in our study currently had a diagnosis for attentional problems, and it is unknown who may or may not develop attentional dysfunction at a later point in time. While the rate of ADHD is three times higher in the preterm population compared to the general population, the rate is 16% (Bhutta et al., 2002). Thus, 84% of children born preterm do not develop attentional disorders or any attentional issues. The fact that there are attentional differences in distractibility is intriguing because it demonstrates a difference in how toddlers born preterm are able to hold and maintain their attention. The differences indicate that children born preterm have a different pattern of development compared to children born full-term. Recall that this was the first study to use and examine distractibility in children born preterm. Future research looking at the development of distractibility in infants, preschoolers, and school-aged children born preterm is important to further examine how their pattern of attention may differ from typically developing, full-term children.

Conclusions

In closing, the current study provides important contributions to the field of attention research. Our results give additional insight into the development of endogenous attention from toddlerhood into the preschool years. Importantly, our study was the first to examine endogenous attention tasks (distractibility, multiple-object) in children born preterm. The fact that there were differences found in the distractibility task but not the global assessment provides evidence for parents, teachers, and

practitioners for the most accurate ways to assess attention in young children. The lack of relationship between the attention measures where we did find differences and the global assessment that found no differences suggests a need for a more sensitive and accurate assessment to be used by professionals in the hospital. By conducting additional research and developing and implementing new assessments, we can hopefully reduce the incidences of attentional disorders in children and allow them to develop to their fullest potential.

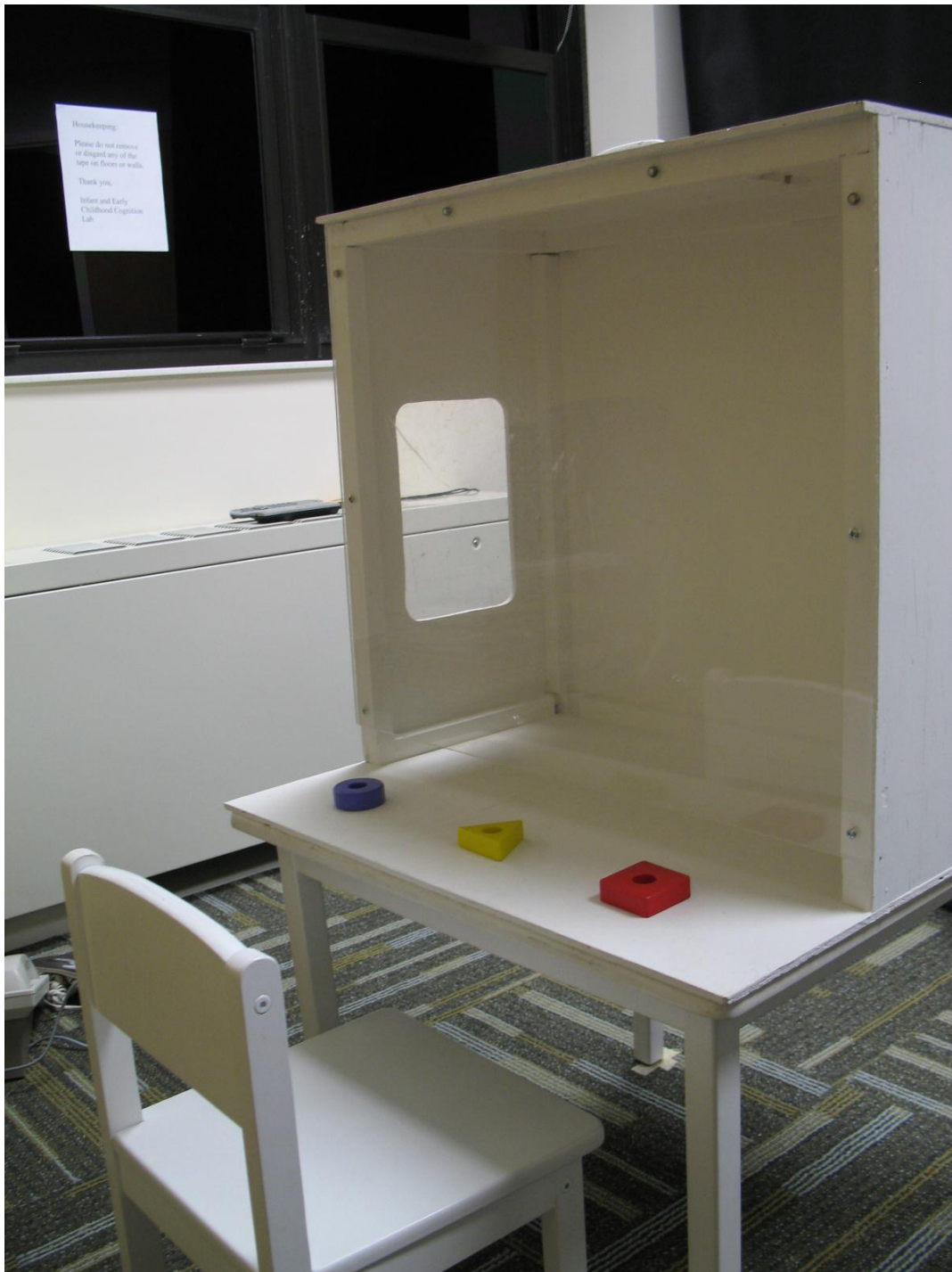


Figure 1. Image of A-not-B Task

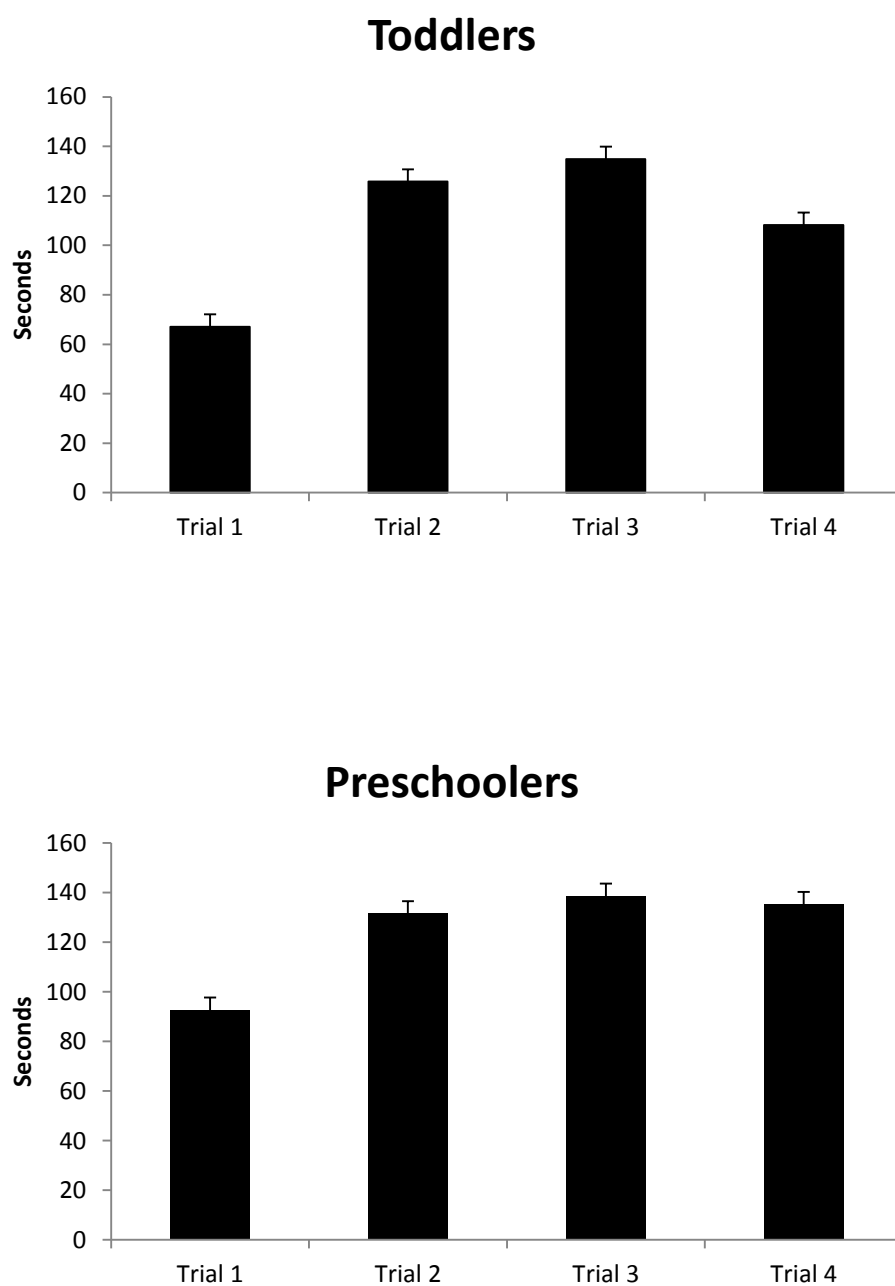


Figure 2. Total Duration of Looking for Toddlers and Preschoolers

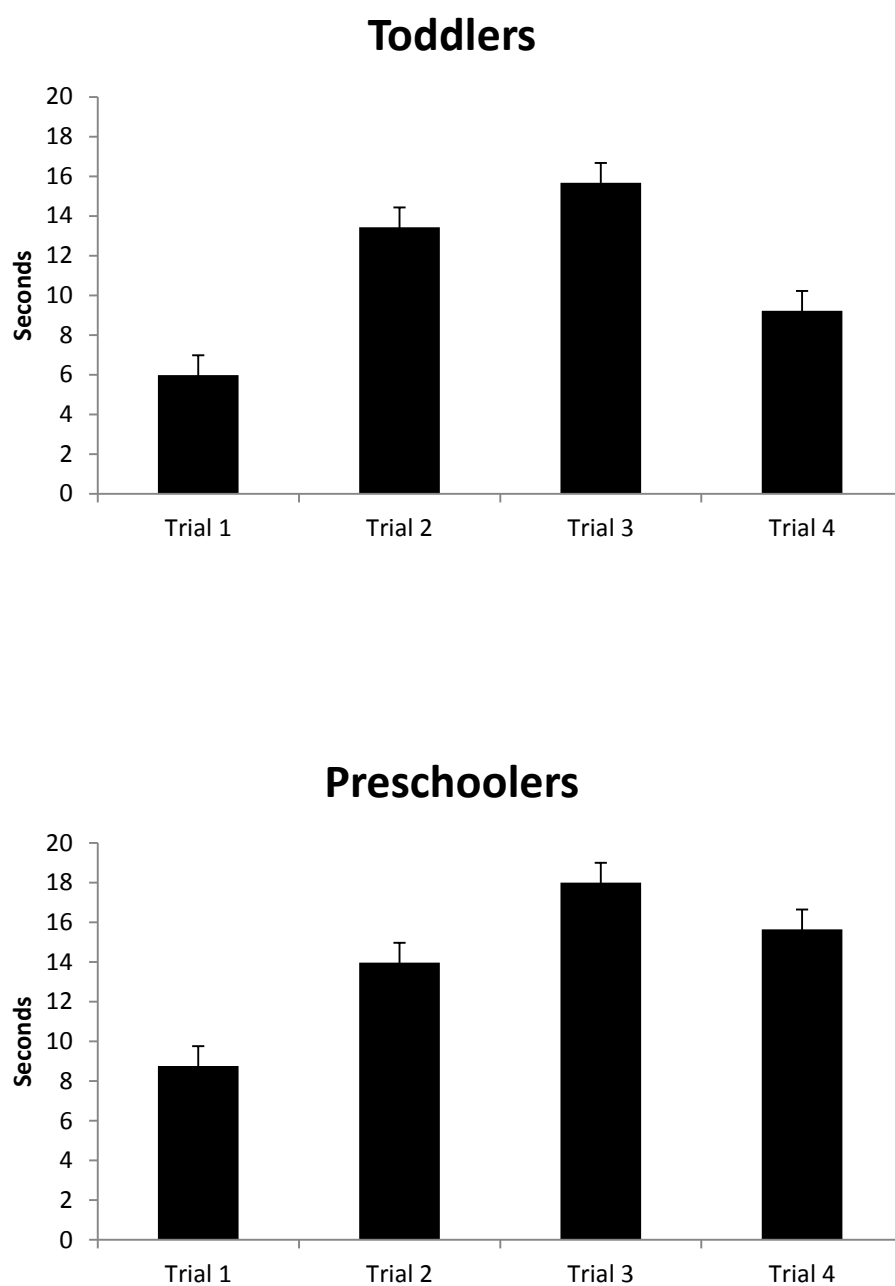


Figure 3. Average Length of Individual Looks for Toddlers and Preschoolers

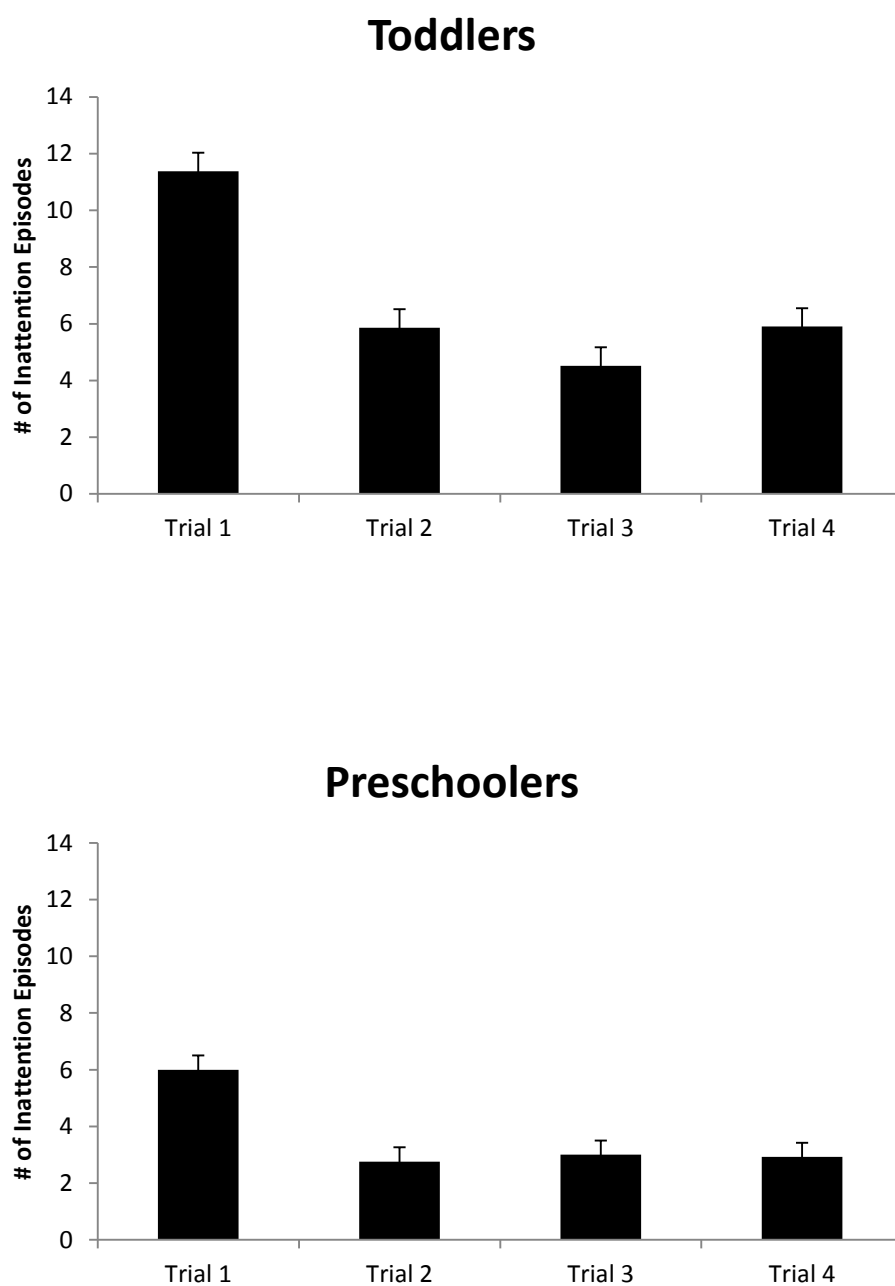


Figure 4. Number of Inattention Episodes in Toddlers and Preschoolers

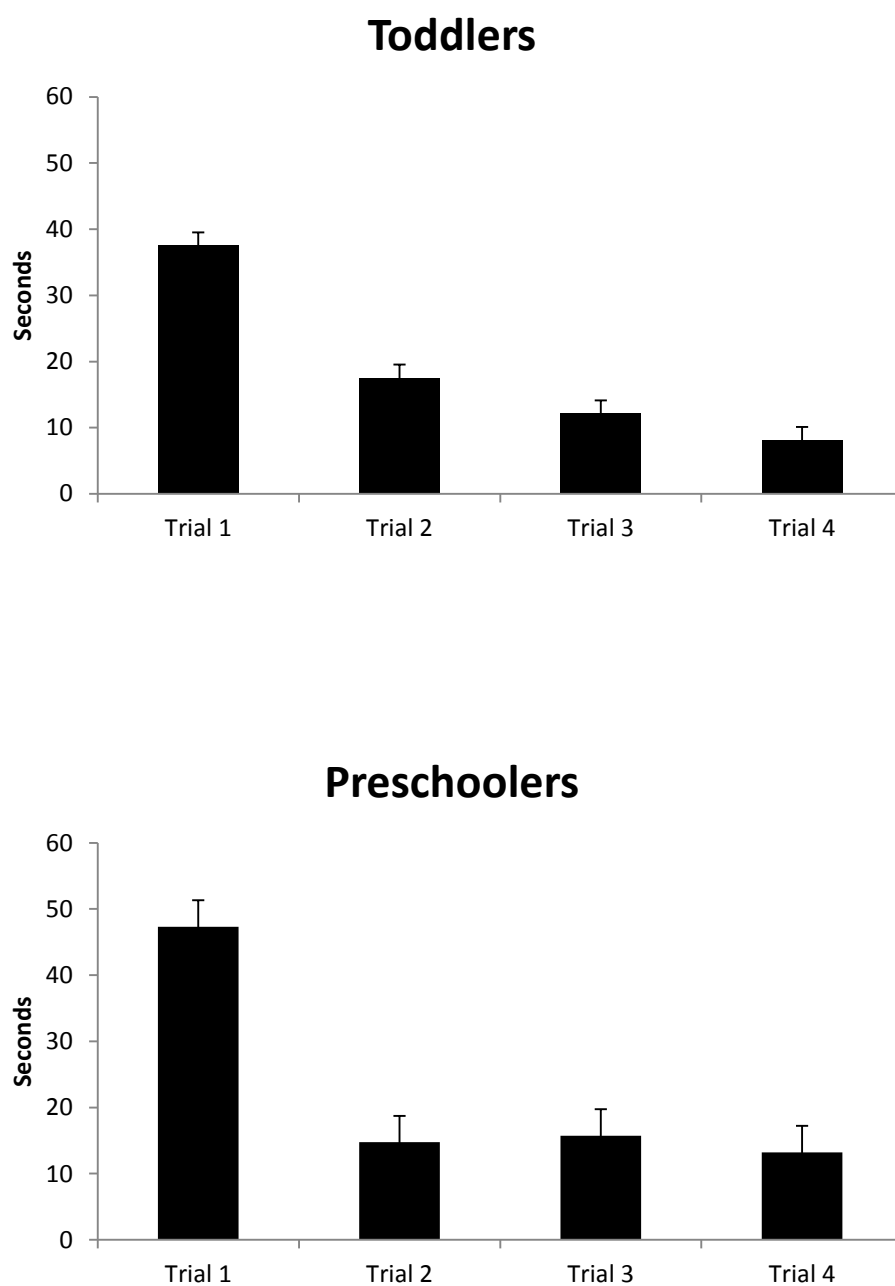


Figure 5. Duration of Looking to the Distractor in Toddlers and Preschoolers

Table 1. Relations between Executive Functioning and Multiple Object Measures in Toddlers

	Reverse Cat.	Trials to Correct First Retrieval	# of Trials Repeated	Search Location	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
Reverse Cat.		-0.04	-0.36	0.04	.41*	-0.03	0.16	0.16	-0.03
Trials to Correct First Retrieval	-0.04		.80**	-0.32	-0.1	0.1	-0.01	-0.1	0.25
# of Trials Repeated	-0.36	.80**		-0.33	0.07	0.13	-0.03	-0.18	0.18
Search Location	0.04	-0.32	-0.33		0.15	-0.36	0.09	.50**	0.32

* $p < .05$ ** $p < .01$

Table 2. Relations between Executive Functioning and Multiple Object Measures in Preschoolers

	Reverse Cat.	Trials to Correct First Retrieval	# of Trials Repeated	Search Location	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
Reverse Cat.		-.52**	.52**	.55**	-.21	.48*	.41*	-.31	-.45*
Trials to Correct First Retrieval	-.52**		1.00**	-.55**	.04	-.44*	-.10	.03	-.06
# of Trials Repeated	.52**	1.00**		-.55**	.05	-.44*	-.10	.03	-.06
Search Location	.55**	-.55**	-.55**		.08	.10	-.10	.24	.17

* $p < .05$ ** $p < .01$

Table 3. Relations between Executive Functioning and Multiple Object Measures in Preschoolers

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
Reverse Cat.	0.05	-0.14	-0.14	0.21
Trials to Correct First Retrieval	0.03	0.13	0.16	-0.22
# of Trials Repeated	-0.04	0.04	0.28	-0.27
Search Location	-0.19	-0.33	0.25	0.35

Table 4. Relations between Executive Functioning and Multiple Object Measures in Toddlers

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
Reverse Cat.	0.09	-0.10	-0.24	0.26
Trials to Correct First Retrieval	0.21	0.28	-0.07	-0.31
# of Trials Repeated	0.21	0.28	-0.07	-0.31
Search Location	0.01	-0.07	0.03	0.07

Table 5. Relations between Multiple Object and Distractibility Measures in Preschoolers

	Dist. Total Toy	Dist. Avg Toy	Dist. # Inattn	Total TVLK
MO # attention Switches	.25	.29	.07	-.17
MO Block 1 Toy Look	.11	.13	-.41*	.39
MO Total Toy Look	.13	.07	-.25	.24
MO # Inattention	-.25	-.17	.54**	-.13
MO Block 1 # Inattention	-.19	-.21	.55**	-.21

* $p < .05$ ** $p < .01$

Table 6. Relations between Multiple Object and Distractibility Measures in Toddlers

	Dist. Total Toy	Dist. Avg Toy	Dist. # Inattn	Total TVLK
MO # attention Switches	0.20	-0.08	0.11	0.21
MO Block 1 Toy Look	0.14	-0.15	-0.05	0.03
MO Total Toy Look	0.18	0.11	-0.14	-0.2
MO # Inattention	-.37*	-.53**	.55**	.45*
MO Block 1 # Inattention	-.44*	-.45*	.64**	.25

* $p < .05$ ** $p < .01$

Table 7. Relations between Executive Functioning and Multiple Object Measures in Toddlers Born Preterm

	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
Reverse Cat.	-0.28	0.35	0.13	0.004	0.36
Trials to Correct First Retrieval	.07	-.06	.13	-.14	-.006
# of Trials Repeated	.06	-.12	.12	-.06	-.06
Search Location	.05	-.24	-.12	.06	.05

Table 8. Relations between Executive Functioning and Distractibility Measures in Toddlers Born Preterm

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
Reverse Cat.	0.02	0.004	-0.25	0.11
Trials to Correct First Retrieval	-0.23	-0.19	0.40	0.47
# of Trials Repeated	-.20	-.21	.40	.35
Search Location	.34	.30	-.36	-.29

Table 9. Relations between Multiple Object and Disattractibility Measures in Toddlers Born Preterm

	Dist. Total Toy Look	Dist. Avg Toy	Dist. # Inattention	Total TVLK
MO # attention Switches	-.18	-.18	.44	-.28
MO Block 1 Toy Look	.41	.06	-.42	.31
MO Total Toy Look	.28	.01	-.39	.49
MO # Inattention	-.31	-.02	.19	.18
MO Block 1 #				
Inattention	-.31	-.14	.19	.33

Table 10. Relations between the Global Assessment and Executive Functioning in Toddlers

	Reverse Cat.	Trials to Correct First Retrieval	# of Trials Repeated	Search Location
AM	.47*	-0.18	-0.46*	.10
Composite	.55**	-.31	-.65**	.06

* $p < .05$ ** $p < .01$

Table 11. Relations between the Global Assessment and Executive Functioning in Preschoolers

	Reverse Cat.	Trials to Correct First Retrieval	# of Trials Repeated	Search Location
AM	.40*	-0.07	-0.07	-0.02
Composite	.50*	-0.15	-0.15	-0.04

* $p < .05$

Table 12. Relations between the Global Assessment and Distractibility in Toddlers

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
AM	-0.12	-0.11	0.01	.37*
Composite	-0.03	-0.03	-0.14	0.32

* $p < .05$

Table 13. Relations between the Global Assessment and Distractibility in Preschoolers

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
AM	0.05	0.05	-0.38	0.38
Composite	0.05	0.06	-.43*	.42*

* $p < .05$

Table 14. Relations between the Global Assessment and Multiple Object in Toddlers

	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
AM	.23	-.15	.05	.14	-.10
Composite	.09	-.23	.06	.13	-.13

Table 15. Relations between the Global Assessment and Multiple Object in Preschoolers

	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
AM	-.16	.70**	.79**	-.59**	-.68**
Composite	-.10	.70**	.80**	-.47*	-.64**

Table 16. Relations between the Global Assessment and Executive Functioning in Toddlers Born Preterm

	Reverse Cat.	Trials to Correct First Retrieval	# of Trials Repeated	Search Location
AM	0.47	-0.32	-0.33	0.3
Composite	.76**	-0.54	-.56*	.52

* $p < .05$ ** $p < .01$

Table 17. Relations between the Global Assessment and Distractibility in Toddlers Born Preterm

	Total Toy Look	Avg Toy Look	Total # Inattention	Total TV Look
AM	-.26	-.16	-.17	.38
Composite	.02	.05	-.41	.15

Table 18. Relations between the Global Assessment and Multiple Object in Toddlers Born Preterm

	# of Attentional Switches	Total Duration of Looking	Block 1 Duration of Looking	Total # of Inattention	Block 1 #of Inattention
AM	-.26	.37	.12	-.15	.35
Composite	-.36	.43	.27	-.11	.42

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