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Inattention And Hyperactivity Among Preschool Age Children Born Prematurely

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INATTENTION AND HYPERACTIVITY AMONG PRESCHOOL AGE CHILDREN BORN PREMATURELY

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CHAPTER 1: INTRODUCTION

Current estimates suggest that approximately 15 million children are born premature each year worldwide (Blencowe et al., 2012). There are numerous causes of preterm birth, which can be split into two groups: spontaneous preterm birth and provider-initiated preterm birth. What causes spontaneous preterm birth is often unknown, but it has been associated with a family history of preterm birth, low maternal body mass index, maternal age, multiple pregnancies, and infections (Goldenberg, Culhane, Iams, & Romero, 2008). Provider-initiated preterm birth is defined as induction of labor or caesarean section before 37 completed weeks of gestation (Goldenberg et al., 2012). In undeveloped countries, provider-initiated preterm births are extremely rare, but they have become increasingly common in developed countries. Provider-initiated births often occur in the absence of a well-defined medical indication (Reddy, Ko, Raju, & Willinger, 2009). However, they are commonly attributed to preeclampsia, which is characterized by high blood pressure, fluid retention, and abnormal quantities of protein in the urine (Koopmans et al., 2009). Another common risk factor for provider-initiated preterm birth is oligohydramnios, which is a deficiency in amniotic fluid (Gyamfi-Bannerman, Fuchs, Young, & Hoffman, 2011). Beyond the increased prevalence of provider-initiated preterm births, numerous other factors have resulted in larger rates of premature birth. One factor is the increased use of assisted reproductive technologies (ART) (Barrington & Janvier, 2013). In ART there are often three or more embryos implanted, thus increasing the likelihood of multiple pregnancies, leading to a much higher risk of premature birth (Blondel & Kaminski, 2002). Furthermore, there is increased risk for prematurity among singletons in ART (Williams & Sutcliffe, 2009). Yet, it is still unclear what causes the increased risk for singletons with some speculation that it may result from increased maternal age and a history of subfertility (Jackson, Gibson, Wu, & Croughan, 2004). There are also environmental factors including exposure to air pollution, lead exposure, and drug use which may lead to increased risk of prematurity (Lin, Hwang, Marshall, & Marion, 1998).

In addition to the increased rates of premature birth, improvements in perinatal care have increased the chances of survival for children born preterm, unfortunately not without cost (Chang et al., 2013). The children who survive are at a greater risk for developing severe disabilities, including cerebral palsy and mental retardation (Moster, Lie, & Markestad, 2008). Although the majority do not develop severe disabilities, a growing body of literature suggests that survivors of preterm (PT) birth develop more subtle deficits that impact multiple aspects of neuropsychological functioning (McCormick, Litt, Smith, & Zupancic, 2011). Specifically, these children are at risk for developing deficits in behavioral and cognitive functioning (Chapieski & Evankovich, 1997). Yet, it has proven to be an extremely difficult task to identify the specific preterm children who are at greatest risk for these problems (Arpi & Ferrari, 2013).

The lack of consensus within the field may be due to the variability within the PT population. The group of infants that encompasses the term "preterm" is exceptionally heterogeneous. Any child born before 37 weeks of gestation is considered premature. Yet, with the current advances in hospital care, children born as early as 22 weeks are capable of surviving. These children born extremely preterm (EPT) (<26 weeks) are at a greater risk for behavioral problems than very preterm (VPT) (26-33 weeks), and mildly preterm (MPT) (34-37 weeks) children (Sansavini, Guarini, & Caselli, 2011). The inter-study variability in gestational age has led to difficulties in summarizing this body of literature, as individual studies are assessing different degrees of prematurity (with the accompanying variability in perinatal risk), and as a result arrive at different conclusions. Within each of these studies there are also multiple risk factors that can vary across preterm-birth samples. In sum, birth weight, gestational age, maternal characteristics (e.g., age, parity, etc.) , and prenatal complications can confound the effects of prematurity on behavior and need to be accounted for (Halmøy, Klungsøyr, Skjærven, & Haavik, 2012). The focus of this proposal will be on the perinatal factors that may influence behavioral variability in the PT population.

Literature Review

Overview of the literature on attentional outcome. A literature review was conducted using Web of Knowledge and PubMed. Search terms included "prematur*", "low birth weight", "behavior", "ADHD", "attention", "hyperactivity", "neurobehav*", and "risk factors." The bibliographies of the identified articles were also examined for research articles on the topic. Altogether, 36 studies were found that examined the relationship between prenatal risk factors and attentional outcome. This review of the literature was conducted as the literature contains only narrative reviews that do not pay sufficient attention to methodological variability. Of these studies, 17 used cohorts of children born after the year 1990. Unlike infants born prior to 1990, premature infants born after 1990 were served in the modern neonatal intensive care unit (NICU). In the modern NICU children are treated with more gentle ventilators and have access to surfactant replacement therapy (Enhorning et al., 1985). Surfactant is a protein complex that reduces the surface tension in the lungs, and children born PT are often unable to produce this protein on their own. Without this protein, it is common for children to develop respiratory distress syndrome, which can result in severe disabilities or death (Herridge, 2011). In addition, these children have access to steroids that can accelerate the growth of their lungs and reduce the risk of respiratory distress syndrome (Cosmi, 1992). Therefore, children treated in the modern NICU tend to have better outcomes than those children treated before 1990, also known as the pre-surfactant era (Choi, Park, Cho, Ma, & Hwang, 1999). As a result, the current review will focus only on the children born in the modern NICU. Table 1 summarizes the methodological features and findings of these 17 studies. For each study the main methodological characteristics (e.g. sample size, birth weight, gestational, inclusion/exclusion criteria, and outcome measures) are presented.

Assessment of attention in preterm-born cohorts. Attention functioning can be assessed in a multitude of ways, for the present review outcome measures were split into two categories: behavioral questionnaires or performance measures. Behavioral questionnaires are forms filled out by an observer (i.e. parent, teacher, psychologist) rating the behavior of the child, or the person may self-report their own behavior. On these forms the rater will either endorse or deny particular behaviors that the child displays (e.g. unable to sit still, can't focus). These behavioral questionnaires differ from performance measures where the child is given a standardized task and the examiner rates their performance on this task at that moment (e.g. remembering a string of numbers, matching paired symbols).

Both behavioral questionnaires and performance measures will be utilized as it is important to assess attention problems in numerous ways. Although behavioral questionnaires do provide a great amount of information, they are profoundly impacted by the bias of the rater, and there is often little consensus between multiple raters of the same individual (Achenbach, McConaughy, & Howell, 1987) This is especially true in parents of PT children, where the child has often experienced multiple perinatal complications. In these situations, parents are likely to be overprotective and less inclined to report externalizing problems (Weisglas-Kuperus, Koot, Baerts, Fetter, & Sauer, 1993). These behavioral questionnaires differ from performance measures where there is direct assessment of child's attention and concentration at that moment. Individually administered measures provide a standardized and objective way to directly gauge the level of dysfunction in the person, yet these measures are not without their own flaws. Performance measures only capture an individual's functioning at the time of the assessment, and may not portray how they perform in all circumstances or settings. Therefore, the two types of measures will complement each other and help create a clearer picture of the child's actual behavior.

Comparisons between Preterm and Full Term Children

Behavior ratings of ADHD Symptoms or Attention Problems. As Table 1 shows, of the 17 studies that used children born in the modern NICU, 14 included behavioral questionnaires of attention problems as an outcome measure (Anderson et al., 2011; Baar, Vermaas, Knots, Kleine, & Soons, 2009; Chu et al., 2012; de Kieviet, van Elburg, Lafeber, & Oosterlaan, 2012; Delobel-Ayoub et al., 2006; Elgen et al., 2012; Farooqi, Hägglöf, Sedin, Gothefors, & Serenius, 2007; Heinonen et al., 2010; Huddy, Johnson, & Hope, 2001; Jaekel, Wolke, & Bartmann, 2013; Johnson, Hollis, Kochhar, Hennessy, & Wolke, 2010; Lindström, Lindblad, & Hjern, 2011; Perricone, Morales, & Anzalone, 2013; Shum, Neulinger, O'Callaghan, & Mohay, 2008). Within these 14 studies, all except two (Huddy et al., 2001; Lindström et al., 2011) conducted between-groups analyses, where PT or LBW children were compared to FT controls. The three other studies that were analyzed only included performance measures and will be discussed later (Caravale, Tozzi, Albino, & Vicari, 2005; Espy et al., 2003; Saavalainen et al., 2007). Before investigating whether differences exist within the PT/LBW group, it is important to establish that differences exist between term-born children and PT/LBW children. Overall, not surprisingly, the majority of studies that compared FT children to PT/LBW children found that PT/LBW individuals had higher rates of inattention and hyperactivity, as measured by behavioral questionnaires. Only one out of the fifteen studies did not find a significant difference between the FT and PT/LBW children on behavioral questionnaires of inattention and hyperactivity (Heinonen et al., 2010).

Children born Mildly Preterm (< 37 weeks)/Low Birth Weight (<2500 grams). As shown in Table 1, four studies (Baar et al., 2009; Chu et al., 2012; Heinonen et al., 2010; Perricone et al., 2013) compared attention deficits in MPT/LBW children to FT controls. Of these four studies, three found differences between groups (Baar et al., 2009; Chu et al., 2012; Perricone et al., 2013) yet these differences depended on the type of rater. Chu et al., (2012) conducted a retrospective study on 195 children diagnosed with ADHD and 212 age and sex-matched controls. The patients were diagnosed by child psychiatrists based on DSM-IV-TR criteria. To further characterize the symptoms in the ADHD and control groups, symptom severity was rated by psychiatrists on the ADHD Rating Scale-IV (ADHD-RS IV) and Clinical Global Impression-Severity (CGI-S). The ADHD-RS IV is an interview instrument of ADHD symptom severity consisting of an inattention, hyperactivity, and total score for boys and girls aged 5-17 years old (G. DuPaul et al., 1998). Similarly, the CGI-S is a clinician-rated scale of severity of psychopathology on a scale from 1 to 7 (Busner & Targum, 2007). Chu and colleagues found that preterm birth was significantly associated with scores on the inattention, hyperactivity, and total scales on the ADHD-RS IV as well as symptom severity as assessed by the CGI-S.

Baar and colleagues (2009) found higher rates of inattention, hyperactivity, and impulsivity in a sample of 377 MPT school age children (7-9 years) on the ADHD Symptom Questionnaire (Scholte & van der Ploeg, 2004) compared to 182 FT controls. The ADHD Symptom Questionnaire is a report form that can be filled out by parents or teachers of children aged 4 to 18. The questionnaire provides a total score in addition to subscale scores for attention deficit, impulsivity, and hyperactivity symptoms of ADHD. Specifically, they found that mother ratings yielded group difference between MPT and FT controls on all three subscales. Yet, father ratings of the two groups resulted in no differences between the groups, and teacher ratings only yielded differences in ratings on the inattention subscale.

Similarly, Perricone, Morales, & Anzalone (2013) found that presence of group differences depended on the rater. They compared 50 MPT children (56-67 months) to 50 FT controls on the Attention Deficit Hyperactivity Disorder Early Detection for Parents and Teachers (Marcotto, Paltenghi, & Cornoldi, 2002) . When parents were rating their child's behavior, MPT children had higher rates of inattention and hyperactivity. These group differences were not evident in the teacher ratings, however.

In contrast to the three other studies, Heinonen et al., (2010) found no group differences in ADHD symptoms between 656 MPT children (56 months) and 172 FT controls based on parent ratings on the Conners' Hyperactivity Index – parent version (Conners, 1990). This measure is composed of ten items rated on a four point scale consisting of symptoms of ADHD.

To summarize, three of the four studies that compared ADHD symptoms in MPT children to FT controls (Baar et al., 2009; Chu et al., 2012; Perricone et al., 2013) found that MPT children were rated as having greater problems with inattention, hyperactivity, and impulsivity. Yet, these results appeared to be dependent on the type of rater. Behavioral ratings from teachers and fathers yielded no group differences. One of the three studies (Heinonen et al., 2010) did not find significant differences between the groups, even when ratings were provided by the parents.

Children Born Very Preterm (26-33 weeks)/Very Low Birth Weight (<1500 grams). Of the studies reviewed, three studies investigated group differences in VPT children compared to FT controls. All three of these studies found differences in ADHD symptoms or attention problems between the groups.

A recent study by Jaekel and colleagues (2013) compared 281 VPT/VLBW children at six and eight years of age to 286 FT controls. They specifically assessed inattention, hyperactivity, and impulsivity using five behavioral measures. One measure was the Tester's Rating of Child Behavior (Wolke, Skuse, & Mathisen, 1990), which was filled out by a psychologist as they administered an IQ test. The measure was split into two scales: Task Orientation (ability to focus on the task) and Activity (movements and hyperactivity). Children's attention was also assessed as a consensus rating between a psychologist, assistant psychologist, and pediatrician on the TEAM index scale of attention. This index scale is just a shortened version of the Tester's Rating of Child Behavior, specifically evaluating the child's ability to maintain focus throughout the entire assessment. Third, child activity and task persistence were evaluated during a play situation using the AMCIES coding system (Wolke et al., unpublished observations) by two psychologists. Fourth, children were rated by their mothers on the attention problems scale of the Child Behavior Checklist (CBCL; Achenbach, 1991), which measures symptoms of inattention, hyperactivity, and impulsivity. Finally, a diagnosis of ADHD was obtained using the Mannheimer Parent Interview (Esser, Blanz, Geisel, & Laucht, 1989). This interview is based on DSM-IV criteria, allowing for diagnosis of ADHD inattentive subtype, ADHD hyperactive-impulsive subtype, or ADHD combined subtype. VPT/VLBW children were rated as having significantly greater problems with attention (Tester's Rating of Child Behavior task orientation, TEAM rating of child behavior, AMCIES ratings of task persistence, and Attention Problems scale of CBCL) compared to FT controls, but there was no difference in hyperactivity (Tester's Rating of Child Behavior activity, AMCIES rating of activity) between the groups. In addition, VPT/VLBW children were diagnosed with ADHD inattentive subtype and ADHD combined type significantly more than FT children; however, there was no greater risk of ADHD hyperactive-impulsive subtype in the VPT/VLBW group compared to FT controls.

Similarly, a study that investigated symptoms of ADHD in 66 VPT children at 7-8 years of age also found higher ratings of inattention compared to 66 FT controls when ratings were completed by parent and teacher. Yet, there were no group differences on scores derived from behavioral measures of hyperactivity or impulsivity (de Kieviet et al., 2012). This study used the attention problems subscale of the CBCL to measure overall symptoms of ADHD. In addition, de Kieviet and colleagues differentiated between inattention and hyperactivity symptoms using two scales from the parent and teacher versions of the Disruptive Behavior Disorders rating scale (Oosterlaan, Scheres, Antrop, Roeyers, & Sergeant, 2000).

Lastly, a study by Delobel-Ayoub and colleagues (2006) used the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997) to measure deficits in attention and hyperactivity in a cohort of 1228 VPT children (3 years) in comparison to 447 FT controls. The SDQ is composed of 25 items which are split into five subscales, one of which is named hyperactivity-inattention. The authors found that the VPT group had significantly higher scores on the hyperactivity-inattention scale compared to the FT control group, with an odds ratio of 2.1 to be elevated (scoring in the top 10% of the control group) on the hyperactivity-inattention scale.

In sum, all three studies comparing VPT/VLBW children with FT controls on behavioral questionnaires (de Kieviet et al., 2012; Delobel-Ayoub et al., 2006; Jaekel et al., 2013) revealed significant group differences on attention problems scores obtained from parents, teachers, and psychologists on a variety of instruments. Two of the studies (de Kieviet et al., 2012; Jaekel et al., 2013) found that only inattentive scores were higher in the VPT/VLBW group with no group differences observed in scores of hyperactivity or impulsivity compared to FT controls. Delobel-Ayoub and colleagues did find differences in overall scores on the inattention-hyperactivity subscale of the SDQ but hyperactivity and inattention were not analyzed separately.

Children born Extremely Preterm (< 26 weeks)/Extremely Low Birth Weight (<1000g). Group differences of ADHD symptoms between EPT/ELBW and FT controls symptoms were assessed in five studies. All five of these studies found between group differences, with the EPT group having higher scores on measures of ADHD symptoms than the FT group. Anderson and colleagues (2011) reported that 189 eight-year-old EPT/ELBW children had more difficulties with inhibition and shifting attention compared to FT controls. To evaluate inhibition and shifting attention they used parent reports on the Behavioral Rating Inventory of Executive Function (Gioia, Isquith, Guy, & Kenworthy, 2000). In addition, parent reports yielded greater symptoms of inattention, hyperactivity, and impulsivity in the EPT/ELBW group compared to FT controls on the Conners' ADHD/DSM-IV Scales (Conners, 1990). This measure has three scales, split into DSM-IV Inattentive symptoms, DSM-IV Hyperactive-Impulsive symptoms, and an overall DSM-IV ADHD symptom index. Anderson and colleagues also administered several performance measures which will be discussed later.

Similarly, a study conducted on 219 11-year-old EPT children found that EPT children were 4.3 times more likely to be diagnosed with ADHD than FT controls (Johnson et al., 2010).

Of the children that met DSM-IV diagnostic criteria, the highest risk was for the inattentive subtype of ADHD. However, when children with cognitive impairment were removed from the analyses there was no longer an increased risk of ADHD in the EPT group. Farooqi, Hägglöf, Sedin, Gothefors, & Serenius (2007) also investigated a group of 86 11-year-old EPT children. They found that the EPT children were rated as having higher scores on the attention problems subscale than the FT control group based on both parent and teacher ratings on the CBCL. Elgen and colleagues (2012) assessed attention problems in a group of 255 five to six-year-old children using the SDQ. Based on parents' responses to the SDQ, the EPT/ELBW group had greater scores on the hyperactivity-inattention subscale of the SDQ than the FT group. Shum, Neulinger, O'Callaghan, & Mohay, (2008) utilized the ADHD Rating Scale-IV (DuPaul & Power, 1998) in a group of 45 seven to nine-year-olds born EPT/ELBW. The ADHD Rating Scale-IV is based on DSM-IV criteria for ADHD and consists of 18 items. The scores are split into two subscales: inattentive and hyperactive-impulsive symptoms which are combined to create an overall ADHD symptom index. They found increased rates of inattention symptoms and total ADHD symptoms but no difference in hyperactivity symptoms between the EPT/ELBW and FT group based on parent ratings. When symptoms were rated by teachers there were no significant differences between the EPT/ELBW and FT groups on any of the symptom scales.

To conclude, all five studies (Anderson et al., 2011; Elgen et al., 2012; Farooqi et al., 2007; Johnson et al., 2010; Shum et al., 2008) discovered significant differences between the EPT/ELBW and FT groups. Only two of these studies used rating instruments of problem behaviors with separate scales for inattention and hyperactivity-impulsive symptoms. One of the studies (Shum et al., 2008) found that deficits were limited to symptoms of inattention whereas

Anderson and colleagues (2011) reported that symptoms of inattention, hyperactivity, and impulsivity were all greater in the EPT group than FT controls.

Performance Measures of Attention. Of the studies that used cohorts of children born in the modern NICU, seven (Anderson et al., 2011; Baar et al., 2009; Caravale et al., 2005; de Kieviet et al., 2012; Espy et al., 2003; Saavalainen et al., 2007; Shum et al., 2008) compared PT children to FT children on performance measures of attention. All of these studies found differences between the PT group and FT group, with the PT group having greater deficits on these attention measures. However, within individual studies there were differences in the types of attention that PT children had deficits in.

Children born Mildly Preterm (< 37 weeks)/Low Birth Weight (<2500 grams). Two studies compared MPT/LBW and FT controls on performance measures of attention. A study by Baar, Vermaas, Knots, Kleine, & Soons (2009) specifically assessed sustained selective attention in a group of children ages seven to nine. To measure sustained selective attention they used the Bourdon-Vos test (Vos, 1998) which requires children to mark configurations of four dots as quickly as possible. They found that MPT children took significantly longer to complete this task than the FT control group.

Another study assessed the performance of MPT children on measures of working memory and set shifting (Espy et al., 2003). Working memory was assessed using the Delayed Alternation (DA; Espy, Kaufmann, Glisky, & McDiarmid, 2001) task where a reward is hidden under a cup out of the child's sight. The child must figure out the pattern in which the rewards are hidden to accurately find them over twenty trials. To assess set shifting the authors used the Spatial Reversal (SR; Espy, Kaufmann, McDiarmid, & Glisky, 1999) task where the child had to retrieve a reward from a specific location based on a set of rules and these ruled shifted after a certain number of consecutive correct retrievals. They found that at the ages of two and three MPT children showed deficits on the DA task compared to FT controls. In addition, the MPT children made more perseverative errors on the DA task than the FT group. However, the study did not reveal any differences in set-shifting as measured by SR between the FT and PT groups.

To summarize, both studies (Baar et al., 2009; Espy et al., 2003) found deficits in the MPT group on performance measures of attention in comparison to FT controls. Specifically, MPT children performed worse on measures of sustained attention and working memory.

Children Born Very Preterm (26-33 weeks)/Very Low Birth Weight (<1500 grams). Within the VPT population, three studies conducted between-group analyses, comparing VPT/VLBW children to FT controls on performance measures of attention. All three of these studies found differences between the groups, yet these differences were not universal across all measures used. A study by de Kieviet and colleagues (2012) assessed attention in a multitude of ways. They used a computerized task called the Attention Network Test (ANT; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005) where children had to respond as quickly as possible to a target that appeared on the left or right side of the screen by pressing a corresponding button. The data from this measure was split into three values: mu, sigma, and tau. Mu measured average processing speed, sigma measured fluctuations in processing speed, and tau measured the proportion of extremely slow responses (lapses in attention). In addition, they assessed verbal and spatial working memory. Verbal working memory was assessed using the Digit Span subtest of the WISC-III (D Wechsler, 2002). Digit span requires the child to repeat sequences of numbers within increasing length. Spatial working memory was measured with a lab task created by Nutley, Söderqvist, Bryde, Humphreys, & Klingberg (2009). In this task, children had to reproduce sequences of circles appearing in a 4x4 grid in a forward and backward condition. They found that there were no differences in mu or sigma between the VPT group and FT group but there were significant differences in tau, with the VPT having significantly more lapses in attention than the FT group. Furthermore, there were differences in visual working memory but not in verbal working memory. Further analyses revealed that tau and visual working memory completely mediated parental and teacher ratings of attention on the attention problems subscale of the CBCL. This suggests that children who had difficulties on these performance measures of attention were also rated by their parents and teachers to have deficits in attention functioning.

Research by Caravale, Tozi, Albino, & Vicari (2005) assessed spatial working memory and sustained attention in a sample of 30 VPT three to four-year-olds. The sustained attention task required the child to cross out pictures that matched a target symbol in 30-second intervals of increasing difficulty (Roid & Miller, 1997). During the spatial working memory test the child attempted to remember where an object was hidden under several cups that were moved (Cossu, Antonucci, & Nava, 2000).

Caravale and colleagues found that the VPT group obtained lower scores than the FT control group on both measures after controlling for IQ. Similarly, Saavalanainen and colleagues (2007) found deficits in spatial working memory in a group of 30 VPT children age's five to seven. They assessed spatial working memory using spatial span backwards (SSB) and spatial span forwards (SSF). In these tasks the examiner points to several different blocks in a particular order and the subject must mimic these actions (D Wechsler, 1998). Interestingly, the subjects only showed deficits in the SSB task, not the SSF task. The difference in SSB between the FTl and VPT group was significant, with the VPT group obtaining lower scores after controlling for verbal IQ and processing speed. The study also investigated verbal working memory and processing speed using several measures. Specifically, they used Digit Span in addition to Letter Number Sequencing to assess verbal working memory. Letter Number Sequencing requires the child to remember a string of alternating numbers and letters of increasing difficulty and then repeat them (D Wechsler, 1998). To assess processing speed the coding subtest of the Weschler Adult Intelligence Scale-Revised (WAIS-R) was used. This task has the child fill in symbols as fast as possible, with a two minute time limit (D Wechsler, 1981). In addition, processing speed was measured using the Mental Control subtest of the Weschler Memory Scale-III. In this subtest the subject must name aloud automatic sequences of words (days of the week, months, numbers from 1-20) as fast as possible (D Wechsler, 1998). There were no differences between the VPT and FT groups on any measure of verbal working memory or processing speed.

All three (Caravale et al., 2005; de Kieviet et al., 2012; Saavalainen et al., 2007) studies found differences in attention functioning between VPT/VLBW and FT controls in favor of the latter group. Specifically, each found that VPT children had deficits in spatial working memory and the two studies that assessed sustained attention (Caravale et al., 2005; de Kieviet et al., 2012) also found significant differences. The studies did not find differences in processing speed or verbal working memory.

Children born Extremely Preterm (< 26 weeks)/Extremely Low Birth Weight (<1000g). Two recent studies analyzed differences between EPT/LBW children and FT controls on performance measures of attention. Similar to the studies of VPT children, these studies found deficits in several areas of attention. Anderson and colleagues (2011) sought to measure all aspects of attention using the Test of Every Attention for Children (TEA-Ch; Manly, Robertson, Anderson, & Nimmo-Smith, 1999) on a group of eight-year-old EPT children. Specifically, the TEA-Ch measures selective attention, sustained attention, inhibitory control, shifting attention, and divided attention. On the selective attention subtest children had to circle target pictures as quickly as possible. During the sustained attention task, they had to count the number of beeps in a given trial and the trial was repeated 10 times each with a different number of beeps. Inhibitory control was assessed by having the children repeat the numbers one and two as they were given and then say the opposite (one for two) in the next task. Creature Counting from the TEA-Ch measured shifting attention, where children had to switch back and forth between counting the number of creatures forwards and backwards. To assess divided attention, the sustained attention and selective attention measures are administered together and there scores on each measure are combined for a total score. Finally, verbal working memory was assessed using digit span forward from the WISC-IV (Wechsler, 2003). This study found that EPT/ELBW children obtained lower scores on all measures of attention except for inhibitory control.

Similar to Anderson and colleagues, Shum, Neulinger, O'Callaghan, & Mohay (2008) used a wide variety of attention measures on a group of children that ranged from seven to nine. They assessed verbal and spatial working memory using Digit Span and Spatial Span. In addition, they measured focused attention with two measures. They used the Visual Attention subtest of the NEPSY (Korkman, Kirk, & Kemp, 1997) where the child must cross out target pictures in an array and the Trail Making Test part B (TMTB; Reitan & Wolfson, 1993) in which the child alternates between numbers and letters in ascending order. The last measure utilized was the Stroop, thought to be a measure of selective attention. The Stroop requires the individual to name colors or words as quickly as they can in the first two trials, in the final trial they must inhibit reading the word and name the color instead (Golden, 1978). Shum and colleagues found that EPT children obtained lower scores than the FT group on Spatial Span and both measures of focused attention. The EPT group did not show deficits on Digit Span or the Stroop compared to the FT group.

In sum, both studies (Anderson et al., 2011; Shum et al., 2008) found deficits on a wide array of attention measures, including measures of selective attention, sustained attention, attention encoding, shifting attention, divided attention, and visual working memory. However, only one of the studies showed that EPT/ELBW children obtained lower scores on measures of verbal working memory (Anderson et al., 2011), whereas Shum and colleagues found no difference.

Summary of literature comparing PT/LBW to FT Controls. There were 12 studies that compared PT/LBW children to FT controls on behavioral questionnaires of hyperactivity and inattention (Anderson et al., 2011; Baar et al., 2009; Chu et al., 2012; de Kieviet et al., 2012; Delobel-Ayoub et al., 2006; Elgen et al., 2012; Farooqi et al., 2007; Heinonen et al., 2010; Jaekel et al., 2013; Johnson et al., 2010; Perricone et al., 2013; Shum et al., 2008). All but one (Heinonen et al., 2010) of these studies found that PT/LBW children were rated as having greater deficits on these measures.

In addition to behavioral questionnaires, seven (Anderson et al., 2011; Baar et al., 2009; Caravale et al., 2005; de Kieviet et al., 2012; Espy et al., 1999; Saavalainen et al., 2007; Shum et al., 2008) studies used performance measures of attention. All of these studies found that the PT/LBW group performed worse on these measures than FT controls. In particular PT children had deficits in sustained attention, working memory, selective attention, and shifting attention.

Attention Outcome

Based on the literature reviewed, it is evident that there are differences in attention outcome between PT/LBW and FT children. PT/LBW children are rated as having greater problems with attention and hyperactivity, in addition to performing worse on performance measures. Yet, these studies do not reveal the specific factors that that cause certain PT/LBW children to be at a higher risk for developing these deficits. Inspection of Table 1 reveals nine studies (Anderson et al., 2011; Baar et al., 2009; Delobel-Ayoub et al., 2006; Elgen et al., 2012; Heinonen et al., 2010; Huddy et al., 2001; Jeyaseelan, O'Callaghan, Neulinger, Shum, & Burns, 2006; Lindström et al., 2011; Saavalainen et al., 2007) that analyzed the correlates of outcome on measures of attention and hyperactivity within the PT/LBW population. In all but one (Huddy et al., 2001) of these studies they found significant correlates

Preschool Age. Table 1 displays two studies (Delobel-Ayoub et al., 2006; Heinonen et al., 2010) study that investigated correlates of inattention and hyperactivity in preschool age children. A study by Delobel-Ayoub et al., (2006) examined the relationship between gestational age and degree of hyperactivity and inattention in 3-year-olds measured with the Strength and Difficulties Questionnaire. They found that there was not a significant association between degree of prematurity and difficulties with inattention and hyperactivity indexed by the hyperactivity-inattention scale of the Strength and Difficulties Questionnaire within their preterm group. Yet, they were able to uncover several social and medical characteristics associated with the Total Difficulties scale (includes inattention-hyperactivity, conduct problems, emotional symptoms, peer problems, pro-social behavior) on the Strength and Difficulties Questionnaire. These included maternal age at birth, low maternal education, hospitalization of the child within the last year, neurodevelopmental delay at three years, health of the child assessed by parents at three years, cerebral lesions, and hospitalization of the child in the NICU $\geq$ 13 weeks. Small for gestational age status and neonatal diagnosis of Bronchopulmonary dysplasia were not associated with the Total Difficulties scale. Similarly Heinonen and colleagues (2010) investigated if gestational age was associated with the number of ADHD symptoms endorsed by parents. In this group of four-year-olds there was no association between gestational age and ADHD symptoms measured on the Conners' Hyperactivity Index. However, the authors found that children born small for gestational age within the PT group were 3.6 times more likely to meet criteria for ADHD than PT children born appropriate for gestational age.

In sum, neither of the two studies (Delobel-Ayoub et al., 2006; Heinonen et al., 2010) that investigated the relationship between GA and attention functioning documented a significant relationship. However, Delobel-Ayoub and colleagues (2006) found several other medical and social factors that were associated with the Total Difficulties scale on the Strength and Difficulties Questionnaire in the preterm population. These included maternal age at birth, low maternal education, hospitalization of the child within the last year, neurodevelopmental delay at three years, health of the child assessed by parents at three years, cerebral lesions, and hospitalization in the NICU $\geq$ 13 weeks. In addition, Heinonen and colleagues showed that small for gestational age status may impact attention functioning above and beyond gestational age within the PT population.

School Age: Gestational Age and Birth Weight. As displayed in Table 1, there were eight other studies that conducted within-group analyses of the preterm population at school age. Seven of these studies specifically assessed the impact of degree of prematurity on inattention and hyperactivity within the preterm group. Anderson and colleagues (2011) had a group of 8-year-olds that were born before 26 weeks of gestation or below 750g and they compared this group to the rest of their preterm sample which was born between 26-28 weeks or 751g-100g. The group born before 26 weeks or below 750g did not differ from the other group on any of the performance measures within the Test of Everyday Attention for Children, which specifically assess selective attention, sustained attention, attention encoding, inhibitory control, shifting attention, and divided attention. In addition, the group of children born before 26 weeks or below 750g did not differ from the other group on the Conners' ADHD/DSM-IV Scales or Behavioral Rating Inventory of Executive Function.

Lindstrom, Lindblad, & Hjern (2011) also researched the relationship between GA and attention functioning. Specifically, they used a large national database of over 1,000,000 children ages 6 to 19. Their interesting outcome measure was the purchase of at least one prescription stimulant, indicating the presence of ADHD. In this sample, they found that as the degree of prematurity increased the odds-ratio of ADHD medication use increased, suggesting that there is a positive correlation between GA and ADHD diagnosis. To reduce the impact of environmental factors they also conducted this analysis just for mothers who had both children born PT/LBW and those at FT. The relationship between GA and prescription stimulant use still held for this analysis. They also analyzed the relationship of small for gestational age status with likelihood of ADHD medication use. Being born small for gestational age had a moderate effect on the risk of ADHD medication use. Similarly, Saavalainen and colleagues (2007) researched the relationship of gestational age with several performance measures of attention at ages five and nine. These included measures of working memory, spatial working memory, and processing speed. They found that the only measure associated with gestational age was Spatial Span Backwards, a measure of spatial working memory.

Within the MPT population, Huddy, Johnson, & Hope (2001) assessed parent and teacher ratings of hyperactivity and inattention using the Strength and Difficulties Questionnaire. They found that there was no relationship between GA and parent or teacher ratings on the Hyperactivity-Inattention scale of this measure. Baar, Vermaas, Knots, Kleinem & Soons (2009) assessed the relationship between GA and total behavior problems within a group of seven to nine-year-olds. They found that the subgroup of children born at 32-33 weeks had higher scores on the Total Problems scale of the CBCL than children born at 34-36 weeks. However, the association was only prevalent for mothers' ratings of behavior problems and was not present in either the fathers' ratings or teachers' ratings. This relationship was not present when BW was correlated with the Total Problems subscale of the CBCL. Baar and colleagues did not assess the correlation between the attention problems subscale of the CBCL and gestational age.

To summarize, two of the five studies on school age children found no association between GA and inattention or hyperactivity (Anderson et al., 2011; Huddy et al., 2001). Anderson and colleagues used a wide range of performance measures of attention in addition to two behavioral questionnaires (Conners' ADHD/DSM-IV Scales and Behavioral Rating Inventory of Executive Function), whereas Huddy and colleagues only used the Strengths and Difficulties Questionnaire. In the three studies that found associations between GA and outcome (Baar et al., 2009; Lindström et al., 2011; Saavalainen et al., 2007), they specifically found that GA correlated with a measure of spatial working memory (Spatial Span Backwards) and the Total Problems scale of the CBCL. In addition, GA was correlated with the purchase of one prescription stimulant, indicating a positive relationship between GA and ADHD diagnosis. Only one study (Baar et al., 2009) specifically assessed the relationship between BW and outcome, and they found no relationship between BW and the Total Problems scale of the CBCL. Lindström and colleagues also assessed the association of being born small for gestational age on the likelihood of ADHD medication use and they found a moderate effect.

Medical Risk Factors. In addition to GA and BW there are several other medical factors that can impact inattention and hyperactivity. Four of the studies on school age children conducted analyses on these perinatal risk factors. Anderson and colleagues (2011) found that there was an association between Necrotizing Enterocolitis and Cystic Periventricular Leukomalacia and selective attention deficits as measured by the Sky Search subtest of the Test of Everyday Attention for Children. These risk factors were not associated with any other performance measure of attention or behavioral questionnaire. Further research on perinatal risk factors associated with behavioral outcome was conducted by Baar and colleagues (2009). However, not one of the variables they investigated was associated with parent or teacher ratings on the Attention Problems subscale of the CBCL. These variables include duration of hospital stay, need for oxygen, phototherapy, and hypoglycemia. In contrast, Saavalainen and colleagues (2007) found several medical variables associated with attention deficits. Specifically, neonatal seizures and an abnormal EEG were significantly associated with measures of spatial working memory, verbal working memory, and processing speed. A need for ventilator assistance was also associated with a measure of spatial working memory within this sample.

Early Neurological Impairment. Two studies assessed the impact of early neurological impairment on outcome (Elgen et al., 2012; Lindström et al., 2011). Elgen and colleagues (2012) assessed the relationship between neurodevelopmental disability and problems with inattention and hyperactivity at the ages of five to six as assessed by the Inattention-Hyperactivity scale of the Strengths and Difficulties Questionnaire. The authors had three ranks of neurodevelopmental disability ranging from severe to mild. These ranks were based on varying degrees of CP, MR, and visual or hearing impairments. They found that as the degree of neurodevelopmental disability increased scores on the Inattention-Hyperactivity scale increased. In the large national database study by Lindstrom and colleagues, they also assessed the relationship between neurological deficits and attention deficits. They found that children diagnosed with CP were 2.5 times more likely to have used ADHD medication than those without CP.

In sum, of the six studies (Anderson et al., 2011; Baar et al., 2009; Elgen et al., 2012; Huddy et al., 2001; Lindström et al., 2011; Saavalainen et al., 2007) that assessed perinatal risk factors within the PT population of school age children, only one did not find significant associations (Huddy et al., 2001). Within these six studies, five investigated the relationship between GA and attention deficits (Anderson et al., 2011; Baar et al., 2009; Huddy et al., 2001; Lindström et al., 2011; Saavalainen et al., 2007). Three of these studies found that there was an association between GA and attention or hyperactivity within the PT population (Baar et al., 2009; Lindström et al., 2011; Saavalainen et al., 2007) whereas two others found no association (Anderson et al., 2011; Huddy et al., 2001). One study assessed the association between birth weight and outcome and found no association (Anderson et al., 2011). Finally, five of the studies investigated other risk factors that were associated with inattention and hyperactivity (Anderson et al., 2011; Baar et al., 2009; Elgen et al., 2012; Lindström et al., 2011; Saavalainen et al., 2007). Perinatal risk factors associated with inattention and hyperactivity includes neonatal seizures, abnormal EEG, neurodevelopmental disability, Necrotizing Enterocolitis, Cystic Periventricular Leukomalacia, small for gestational age status, low Apgar scores, and Cerebral Palsy.

Methodological Considerations

There are several methodological flaws in the studies reviewed, these flaws are discussed below.

Failure to differentiate between Inattention and Hyperactivity. Most studies reviewed did not differentiate between deficits in attention and hyperactivity. In these studies, symptoms of inattention and hyperactivity were lumped together to form one measure (e.g. attention problems subscale from the CBCL). However, research has consistently shown that these types of symptoms are unique and represent their own construct (Ghanizadeh, 2012). This is a problem within the literature, as several studies reported specific deficits in attention but not hyperactivity (e.g. de Kieviet et al., 2012; Jaekel et al., 2013). The studies in which these symptoms were combined were not adequately describing the particular deficits in this population (e.g. Delobel-Ayoub et al., 2006; Farooqi et al., 2007).

Failure to utilize multiple methods of assessment. Only four of the studies (Anderson et al., 2011; Baar et al., 2009; de Kieviet et al., 2012; Shum et al., 2008) reviewed utilized both behavioral questionnaires and performance measures of attention. The other 13 studies (Caravale et al., 2005; Chu et al., 2012; Delobel-Ayoub et al., 2006; Elgen et al., 2012; Espy et al., 1999; Farooqi et al., 2007; Heinonen et al., 2010; Huddy et al., 2001; Jaekel et al., 2013; Johnson et al., 2010; Lindström et al., 2011; Perricone et al., 2013; Saavalainen et al., 2007) only used one method to assess attention or hyperactivity deficits in their PT sample. This is problematic as it is unreliable to rely on only one method of assessment. Behavioral questionnaires can be impacted by the bias of the rater and performance measures of attention only assess an individual at one time point. To gain a more accurate idea of the attention deficits in this population it is important to use multiple methods of assessment.

Insufficient Exclusionary Criteria. Many studies failed to control for CP, PVL, IVH, or sensory impairments(de Kieviet et al., 2012; Johnson et al., 2010; Lindström et al., 2011). Furthermore, several studies excluded children with an IQ below 70. This is problematic because their samples were not adequate representations of the preterm population (e.g. Anderson et al., 2011; Chu et al., 2012; Ross et al., 1991).

Failure to examine individual differences within the preterm group. Only 8 of the 17 studies reviewed examined differences in attention functioning within the PT group. Although it is important to compare PT children to FT controls, the differences between these groups have been well established. The problem with these analyses is they do not elucidate the reasons why certain children within the PT group have greater deficits than others.

Failure to adjust for risk factors in studies examining attention correlates within the preterm population. Many of the studies that examined perinatal risk factors for attention deficits within the PT group did not adjust for gestational age, intrauterine growth rate, or other perinatal complications (Baar et al., 2009; Farooqi et al., 2007; Huddy et al., 2001).

Failure to use Hospital or Health-Center Matched Groups. Only four of the studies that had FT control groups used hospital or health-center matched groups. (Farooqi et al., 2007; Jaekel et al., 2013; Perricone et al., 2013; Saavalainen et al., 2007). The other studies used community or school matched control groups (e.g. Anderson et al., 2011; Elgen et al., 2012; Shum et al., 2008) . Community or school control groups are problematic as they are unable to control for various perinatal complications or other background factors that may be influencing the child’s performance.

Failure to adjust for socioeconomic status. Several of the studies reviewed failed to account for socioeconomic status within their sample (e.g. Elgen et al., 2012; Farooqi et al., 2007; Shum et al., 2008). This background factor needs to be taken into account because has a large impact on the outcome of the individual.

Use of birth-weight instead of gestational age cut-off. Many of the studies used birth weight cutoffs instead of gestational age (e.g. Elgen et al., 2012; Jaekel et al., 2013; Shum et al., 2008). This is problematic as it leads to overrepresentation of children born SGA. Several studies have shown that individuals born small for gestational age have deficits in attention (Heinonen et al., 2010; Lindström et al., 2011). Therefore, the studies that rely on birth weight cutoffs are actually confounded by the effect of SGA on attention outcome.

Hypotheses and Rationale

As reviewed, PT children appear to have deficits in attention compared to FT controls. Yet, few of the studies reviewed investigated variations in attention within the PT group. For the studies that did analyze these within group differences, most of them only focused on degree of prematurity or IUGR. It is important to investigate all of the individual differences within this group to identify the specific factors that impact this population. These factors, whether they are biological or medical can greatly impact the behavioral outcome of the children. Thus the current study will focus on various biological and medical variables that may impact attention deficits within VP children.

1. It is hypothesized that children with a greater degree of prematurity will receive higher ratings of attention problems on the CBCL and ADHD Rating Scale IV even after controlling for intrauterine growth rate. Yet, it is expected that there will be no relation between degree of prematurity and parent ratings of hyperactivity on the ADHD Rating

Scale IV. In addition, it is hypothesized that degree of prematurity will be associated with all performance measures of attention , with a greater degree of immaturity leading to worse performance on these measures after controlling for intrauterine growth rate.

2. In addition to prematurity, it is hypothesized that intrauterine growth rate will be associated with all measures of attention. Intrauterine growth rate will be expressed as a Z score based on GA and gender of the child (Kramer et al., 2001). Three recent studies found that VP children born SGA had higher rates of ADHD symptoms than children born AGA (Halmøy et al., 2012; Heinonen et al., 2010; Strang-Karlsson et al., 2008). Whereas two other studies found that being SGA or IUGR had no effect on diagnosis of ADHD (Lindström et al., 2011; Sommerfelt et al., 1993). Out of these five studies, only three conducted within groups analyses, with two of these studies finding that intrauterine growth rate had no impact on ADHD symptoms (Lindström et al., 2011; Sommerfelt et al., 1993). The current study seeks to clarify the effect of intrauterine growth rate on attention deficits in this population. Unique from the other studies, the present study will be investigating intrauterine growth rate as a continuous variable instead of dichotomizing the groups as small for gestational age or appropriate for gestational age.
3. As described, there are numerous medical risk factors that can contribute to the behavioral and cognitive outcome of PT children. To investigate this increased risk, the present study will investigate the relationship between total medical complications and attention deficits. It is expected that a greater amount of medical complications at birth will lead to higher ratings of inattention and hyperactivity on the ADHD Rating Scale IV and higher scores on the attention problems subscale of the CBCL. In addition, it is hypothesized that increased medical risk will be associated with poorer performance on

all performance measures of attention even after controlling for degree of prematurity.

CHAPTER 2: METHOD

Participants

One-hundred subjects were recruited for the current segment of this study. The children were recruited as a part of a larger investigation titled Neuropsychological Outcome in Preschool and School Aged Children with Perinatal Complications and with Various Degrees of Exposure to Prenatal Steroids, approved by both William Beaumont Hospital (WBH) and Wayne State University (WSU) internal review boards. The parents of children born before 34 weeks gestation who were born and treated in the Neonatal Intensive Care Unit (NICU) at William Beaumont Hospital (Royal Oak, Michigan) between 2007 and 2010, were contacted to determine interest in participating. The inclusion and exclusion criteria for the study are provided below.

Inclusion Criteria. Participants for this segment of the study were recruited from a cohort of VP infants (<34 weeks of completed gestation) who were born and treated in the NICU at William Beaumont Hospital in Royal Oak, Michigan. Participants included children who were born between 2007 and 2010, who were between the ages of 3 and 4 years (adjusted for prematurity) at the time of recruitment. Approximately 20-25% of families contacted agreed to take part in the study.

General Exclusion Criteria. Infants were excluded from this segment of the Steroid Study under the following circumstances: presence of major congenital anomalies (e.g., spina bifida), chromosomal disorders, children with perinatal neonatal meningitis, periventricular leukomalacia, and children who required mechanical ventilation at discharge from the NICU. Infants were also excluded if they were transported to Beaumont from a different hospital (i.e., “outborn”). It has been reported that during transport from one hospital to another, infants may receive less than optimal treatment (Lee et al., 2003).

Two cases with possible drug abuse and one case with a grade three intracranial hemorrhage were included in the sample. The data were analyzed with and without these cases.

Sample characteristics. In total, 100 participants were recruited for the study. Two participants were eliminated as they were unable to complete any testing and their parents failed to complete any ratings of their behavior, resulting in a final sample of 98 infants. Participants were divided into two groups based on gestational age at birth. The lower gestational age group consisted of children born < 30 weeks gestation (*M* = 28.40, *SD* = 1.94, range = 23.4 – 30.0) and the higher gestational age group consists of children born > 30 weeks of gestation (*M* = 32.36, *SD* = .88, range = 30.3 – 33.9).

The demographic and socio-familial characteristics of each group are presented in Table 4. As the table shows no significant group differences were observed in racial or gender distributions, adjusted age at testing, relative frequency of multiple gestation, maternal and paternal years of education, maternal VIQ (as measured by the WAIS-IV Information, Vocabulary, and Similarities subtests), and socioeconomic (SES) rank (Hollingshead, 1975).

The antenatal, perinatal, and neonatal complications by gestational age group are depicted in Table 4. As the table shows, the groups did not differ significantly in overall *antenatal* risk, including relative frequency of placental abruption, maternal diabetes, hypertension, abnormal vaginal bleeding, or premature membrane rupture. However, there was a significant difference in occurrence of chorioamnionitis, as this condition occurred more frequently in the lower gestational age $\chi^2(1, N = 97) = 5.152$, $p = .023$. Additionally, there were no significant group differences in maternal age or intrauterine growth, as indexed by the intrauterine growth *z*-score. The intrauterine growth *z*-score was calculated according to norms published by Kramer et al. (2001),(period). Computation involved calculating the deviation of an infant's birth weight from the mean weight of his or her normative group, as determined by both gestational age at birth and sex.

With respect to *perinatal* risk factors, as expected, the lower gestational age group had significantly lower weight, $t(95) = -9.252$, $p < .001$, shorter length, $t(95) = 7.613$, $p < .001$, and smaller head circumference, at birth $t(94) = -7.954$, $p < .001$, than the higher gestational age group (see Table 5). In accord with the classification criteria, the groups differed significantly in gestational age, $t(98) = -13.088$, $p < .001$.

The groups also significantly differed in 1 minute Apgar scores, $t(95) = -2.816$, $p = .006$, and 5 minute Apgar scores, $t(95) = -3.809$, $p < .001$, with the lower gestational age having lower Apgar scores than the higher gestational age group. The groups did not differ significantly in the relative frequency of abnormal presentation, need for cesarean section, use of forceps, need for general anesthesia during delivery, or in the presence of a nuchal cord.

In terms of *neonatal* risk factors, Table 5 shows that the lower gestational age group was characterized by significantly more cases of apnea $\chi^2(1, N = 98) = 14.867$, $p < .001$., anemia $\chi^2(1, N = 84) = 9.224$, $p = .002$, intracranial hemorrhage $\chi^2(1, N = 98) = 9.676$, $p = .002$ and, Sepsis (Fisher exact $p = .029$) than the higher gestational age group. The lower gestational age group also had significantly more cases of hyaline membrane disease $\chi^2(1, N = 98) = 20.406$, $p < .001$, retinopathy of prematurity $\chi^2(1, N = 98) = 11.26$, $p = .001$, and patent ductus arteriosus $\chi^2(1, N = 98) = 16.920$, $p < .001$. In contrast, the higher gestational age group exhibited a significantly greater frequency of hyperbilirubinemia $\chi^2(1, N = 97) = 13.664$, $p < .001$. The groups did not differ significantly in the frequency of neonatal complications such as hypermagnesemia, hypotension, meconium aspiration, necrotizing enterocolitis, and thrombocytopenia.

Overall, the lower gestational age group experienced a significantly higher number of neonatal complications, $t(95) = 5.517$, $p < .001$, and total complications, $t(94) = 4.134$, $p < .001$, than the higher gestational age group. The groups were similar on total antenatal and total perinatal complications, however.

Psychological Assessment

General considerations. Each child was evaluated over 1 to 3 sessions depending upon the child's ability to maintain attention and focus during the assessment. Prior to evaluation, the parents signed an informed consent form verifying that they understood the nature of the assessment and agreed to conduct the testing and complete background and rating forms. During the evaluation, the parents completed a background questionnaire designed to obtain information about their child's medical and developmental history as well as current behavioral functioning. Approximately two weeks after the initial child assessment, the mothers or fathers were contacted by phone in order to obtain an evaluation of their verbal intellectual ability and to provide verbal feedback regarding the results of their child's assessment. After feedback was completed, each parent was mailed a typed copy of a report that outlines the results of his or her child's evaluation, including recommendations for further testing as needed.

Intellectual Ability. Intellectual functioning was evaluated using the Wechsler Preschool and Primary Scale of Intelligence-Third Edition (WPPSI-III; Wechsler, 2002). One subtest from the verbal subscale (Information) and one subtest from the performance subscale (Block Design) was administered to each child to obtain an estimate of overall intellectual ability (FSIQ), verbal ability (VIQ) and visual-spatial ability (PIQ). These two subtests were selected because they have the highest correlations with PIQ and VIQ respectively. Reliability and validity properties can be found in Table 2.

Performance measures of attention. Two subtests from the Clinical Evaluation of Language Fundamentals—Preschool, Second Edition (CELF-P2; Wiig, Secord, & Semel, 2004) were used. Recalling Sentences, which requires the child to repeat sentences of increasing length, measured Verbal Working Memory. The Concepts and Following Directions subtest measures focused attention. During this subtest the child was asked to interpret and remember directions of increasing length.

Two subtests from the Woodcock Johnson-III (WJ-III) Tests of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001) were used. Concept Formation measures mental flexibility. Concept Formation has children analyze shapes of different colors and sizes. Children must decide how these shapes differ from each other, or which shape is the “most different.” The Picture Recognition subtest measures visual working memory. In this task children were shown different images and then they selected the images they saw out of an array of possible choices.

To measure inhibition, one subtest from the NEPSY- Second Edition: *A Developmental Neuropsychological Assessment* (NEPSY-II; Korkman, Kirk, & Kemp, 2007) was used. The Statue subtest requires children to hold a pose. They were told that they cannot move, open their eyes, or vocalize. During this time several noises were made from the examiner and the child had to inhibit their response to these stimuli.

Behavioral Questionnaires. Parents filled out two behavioral questionnaires that assess attention problems in preschoolers. The Child Behavior Checklist (CBCL) for Ages 1.5-5 is a

99 item measure that analyzes behavioral, emotional, and social problems in preschool children (T.M Achenbach & Rescorla, 2001). Of interest to the current study were the Attention Problems syndrome scale, the ADHD Problems DSM-oriented scale, and the Externalizing Problems scale.

In addition, the ADHD Rating Scale-IV Preschool Version was used to assess the specific ADHD symptoms present in the sample (McGoey, DuPaul, Haley, & Shelton, 2007). The scale is an 18-item questionnaire that is split into symptoms of inattention and hyperactivity/impulsivity. These symptom scales are combined to a total score. Refer to Table 2 for psychometric properties of both behavioral questionnaires. This measure was added after the study began. Sixty-six of the participants had already been assessed when this measure was added. Therefore, this questionnaire was sent out in the mail to these participants who had already been assessed. In total, 29 participants completed this questionnaire and sent it back via mail or completed the measure over the phone.

Statistical Analyses: General Considerations. Simultaneous multiple regression analyses were used to analyze the data. Several procedures were used in order to identify demographic and perinatal variables that may contribute significant variance to the measured outcomes and subsequently, to determine additional predictors, i.e., “covariates” to include in the analyses. Group differences on demographic variables and medical complications were investigated using t-tests and chi-square analyses. As previously discussed, the two groups (based on gestational age) did not vary significantly on any of the demographic variables (see Table 4). In regard to medical complications, significant group differences were identified for several variables (see Table 5).

SES, sex, multiple gestation, and adjusted age were chosen as covariates to adjust for outcome variance associated with sociodemographic factors. Thus, altogether four socio-demographic factors were included in our regression models. SES was chosen because it represents a combination of both maternal and paternal factors, including both education and occupation, and because it is often found to predict outcome (Raz et al., 2010). Because parental education is a component of SES, and to reduce multicollinearity, neither maternal nor paternal education were entered as covariates. Additionally, multiple gestation was selected as a covariate, as previous studies have shown that multiples exhibit poorer neuropsychological outcomes (Rutter, Thorpe, Greenwood, Northstone, & Golding, 2003). In addition to the socio-demographic variables, several medical risk factors were also added to our prediction models, namely, gestational age, intrauterine growth z score, and total number of complications. Because days on oxygen and birth weight were highly correlated with gestational age ($r(96) = -.832$, $p < .001$; $r(96) = .842$, $p < .001$) and total complications ($r(96) = .634$, $p <.001$; $r(96) = -.490$, $p < .001$) they were not entered as a covariates. These covariates, along with gestational age, total complications, and growth rate were entered simultaneously as predictors in all multiple regression analyses.

Correlations between all other demographic/medical variables and outcome were negligible with no individual variable reaching significance. For example, there were insignificant correlations between hypertension and externalizing problems ($r(86) = -.076$, $p = .484$) as well as hypertension and inhibition as measured by the Statue subtest ($r(72) = .091$, $p = .442$). In addition, race was not significantly correlated with any outcome measure (e.g. externalizing problems $r(94) = -.034$, $p = .746$ or inhibition as measured by the Statue subtest $r(79) = .006$, $p = .955$).

The independent variables of interest were gestational age (treated as a continuous variable), intrauterine growth rate (*z*-score), sex, total number complications, multiplicity, socioeconomic status (SES) and adjusted age at testing. The dependent variables were five scores on performance measures of attention, and six scores from behavioral questionnaires. A separate multiple regression analysis was run for each outcome measure, and included a set of predictors determined to be appropriate for that particular outcome measure. Visual inspection of the predictor variables revealed an insignificant proportion of missing data; only two cases were missing data essential in order to be included in our regression model. Because we considered this number of cases as negligible, it was decided not to impute the missing values. Gestational age was found to be significantly negatively skewed, hence the variable was transformed using the reflect and square root function. Both the days on oxygen variable and total complications variable were found to be significantly positively skewed, therefore these variables were transformed using the square root function. The square root function was used as it increases power and it alters the data to better meet the assumptions underlying the regression analyses (Dunlap, Burke, & Greer, 1995). The transformed gestational age and total complications variables were entered into all regression analyses in place of the original variables.

CHAPTER 3: RESULTS

Table 6 presents the results of the multiple regression analyses for each outcome measure. For each regression, one outcome measure was entered into the model, along with a set of several predictor variables and covariates as discussed previously. It should be noted that all outcome measures' scores are based upon the child's age, adjusted for prematurity.

All analyses were run with and without children of multiple-gestation to determine if the impact of the predictor variables were only isolated to singletons, as children born to multiple-gestation often have fewer behavioral problems (Vandenoord, Koot, Boomsma, Verhulst, & Orlebeke, 1995) than those born as a singleton. In addition, all analyses were run with and without children with maternal alcohol/drug abuse, a severe intracranial hemorrhage (grades 3 or 4), or children diagnosed with periventricular leukomalacia. The rationale for doing both these analyses was to determine if differential effects would be found when these cases were removed and to determine the impact of gestational and growth rate in cases without severe disabilities.

Behavioral Questionnaires.

Child Behavior Checklist 1.5-5

Ninety-six participants were included the analysis of behavior ratings on the Child Behavior Checklist (Achenbach & Rescorla, 2001) as two did not complete the forms. As Table 6 shows gestational age, growth rate, and total complications were not significantly related to variance in ratings of Attention Problems [$F(1,96) = .38$, *ns*; $F(1,96) = .68$, *ns;* $F(1,96) = .24$, *ns*]. Similarly, as shown in Table 6 the predictor variables were not related behavior ratings on the Attention Deficit/Hyperactivity Disorder Scale. Specifically, gestational age [$F(1,96) = .38$, *ns*], growth rate [$F(1,96) = .49$, ns], and total complications [$F(1,96) = .240$, *ns*] did not predict a significant amount of variance in the scale. However, multiple gestation was a significant predictor of ratings on this scale [*F*(1,96) = 4.228, *p* = .043], with twins unexpectedly rated as having significantly fewer ADHD symptoms than singletons. As Table 6 shows analysis of the Externalizing Problems index of the CBCL 1.5-5 indicated that neither gestational age nor growth rate was a significant predictor [*F*(1,96) = 1.158, *ns*; *F*(1,96) = .439, *ns*]. Total complications score was significantly associated with ratings of externalizing problems [*F*(1,96) = 4.981, *p* = .028]. Surprisingly, children with more complications were rated as having fewer externalizing problems.

ADHD Rating Scale IV- Preschool Version

Analyses on the ADHD Rating Scale IV- Preschool Version (McGoey et al., 2007) included 62 participants. As Table 6 shows gestational age, growth rate, and total complications did not significantly relate to ratings on the Inattention Scale [*F*(1,62) = .216, *ns*; *F*(1,62) = .490, *ns; F*(1,62) = .453, *ns*]. Similarly gestational age [*F*(1,62) = .829, *ns*], growth rate [*F*(1,62) = 1.037, *ns*], and total complications [*F*(1,62) = 1.171 = .284, *ns*] did not predict a significant amount of variance on the Hyperactivity subscale . In addition, Gestational age, growth rate, and total complications all failed to account for a significant amount of variance on the Total ADHD Symptom Scale [*F*(1,62) = .590, *ns*; *F*(1,62) = .774, *ns*; *F*(1,62) = .973, *ns*].

Performance Measures.

NEPSY

Eighty-one participants were included in the analyses of scores on the Statue subtest from the NEPSY-II, as seventeen of the children were uncooperative during the task. As shown in Table 6 gestational age, growth rate, and total complications were not significantly related to performance [*F*(1,81) = .17, *ns*; *F*(1,81) = .01, *ns*; *F*(1,81) = .03, *ns*]. However, sex was significantly related to variance in the Statue subtest scores, with females outperforming males on this measure of inhibition [$F(1,81) = 4.45$, $p = .038$].

Woodcock Johnson III

There were 82 participants included in the analyses of the Picture Recognition subtest from the Woodcock Johnson-III, as 16 of the participants either had difficulties with understanding the directions or cooperating with task demands. As Table 6 shows gestational age, growth rate, and total complications were not significantly related to outcome on this measure [$F(1,82) = .144$, *ns*; $F(1,82) = .197$, *ns;* $F(1,82) = .163$, *ns*]. The analyses on the Concept Formation subtest from the Woodcock Johnson-III included 75 subjects, as 23 of the subjects had difficulties understanding the directions or difficulties with cooperation. Gestational age [$F(1,75) = .826$, *ns*], growth rate [$F(1,75) = .153$, *ns*], and total complications [$F(1,75) = .355$, *ns*] did not predict a significant amount of variance on this measure of executive functioning (refer to Table 6).

CELF-P2

The Concepts and Following Directions subtest from the CELF-P2 was completed by 93 participants, as five had difficulties cooperating with instructions. As displayed in Table 6 gestational age, growth rate, and total complications not predict a significant amount of variance in this measure of focused attention [$F(1,93) = .428$, *ns*; $F(1,93) = .110$, *ns;* $F(1,93) = .088$, *ns*]. Yet, socioeconomic status did predict a significant amount of variance [$F(1,93) = 9.849$, $p = .002$] with higher socioeconomic status relating to better performance. Similarly, as shown in Table 6 the Recalling Sentences subtest of the CELF-P2, which was completed by 85 participants (13 participants had difficulties cooperating or understanding directions) was directly correlated to socioeconomic status [$F(1,85) = 11.082$, $p < .001$]. However, the three predictor variables gestational age, growth rate, and total complications did not predict a significant amount of variance in this measure of verbal working memory [$F(1,85) = .528$, *ns*; $F(1,85) = .213$, *ns*; $F(1,85) = .080$, *ns*].

The effects of the predictor variables did not change when the analyses were re-run with more exclusive criteria. Specifically, consistent results were found when only assessing singletons and when children with maternal alcohol/drug abuse, a severe intracranial hemorrhage (grades 3 or 4), or children diagnosed with periventricular leukomalacia were excluded (see Table 6)

CHAPTER 4: DISCUSSION

The first hypothesis that children born less mature would exhibit poorer outcomes on direct performance measures and parental ratings of attention was not supported. No significant relationships were found between gestational age and any outcome measure. These negative results are consistent with several studies that failed to show that within the preterm population, degree of prematurity has an impact on attentional outcome (Anderson et al., 2011; Delobel-Ayoub et al., 2006; Heinonen et al., 2010; Huddy et al., 2001; Miller, Bowen, Gibson, Hand, & Ungerer, 2001; Oberklaid, Sewell, Sanson, & Prior, 1991). However, the negative findings are inconsistent with the results from a few studies that did find a significant relationship between attention outcome and gestational age (Baar et al., 2009; Lindström et al., 2011; Saavalainen et al., 2007).

The only investigation that assessed attention problems in a preschool sample also reported negative results, with no relationships observed between gestational age and attentional outcome within the preterm group (Delobel-Ayoub et al., 2006). In the study by Baar and colleagues, the relationship between gestational age and outcome was limited to mothers' ratings of total behavior problems and was not found in teachers' ratings or specific ADHD symptoms. Furthermore, that study used a sample of seven to nine year-old children suggesting that the relationship between gestational age and attentional outcome may not be present until later in life. The only other study to find a significant relationship between gestational age and attentional outcome was conducted by Lindström and colleagues. This study had an extremely large sample size (over one million subjects) and the subjects ranged from six to nineteen years of age. The study examined the relationship between gestational age and use of prescription stimulant medication. The large sample size, different age groups, and different methodology for assessing attention outcome may account for the findings in their study. Our data and the results of several other studies suggests that prematurity (born before 37 weeks of gestation) may lead to problems with attention and hyperactivity, However, within a very preterm-born sample, the findings show that degree of prematurity is not associated with attention outcome.

In regards to Hypothesis 2, it was found that there was no relationship between intrauterine growth rate and any attentional outcome measure. Intrauterine growth rate, an index of the child's weight standardized by gestational age, is thought to reflect the child's antenatal growth adequacy. Restricted growth can result from maternal diabetes, high blood pressure, malnutrition, and placental pathology (Hediger, Scholl, Schall, Miller, & Fischer, 1995). Restricted intrauterine growth often leads to long term consequences such as cardiovascular disease and type II diabetes (Salam, Das, & Bhutta, 2014). This restricted growth is shown to lead to reduced intracranial volume and cerebral cortical gray matter (Tolsa et al., 2004; Yerushalmy-Feler et al., 2014). Within the preterm population, several recent studies have shown that growth restriction may be accounting for some of the deficits in attention and activity level (Halmøy et al., 2012; Heinonen et al., 2010; Lindström et al., 2011). However, there have been inconsistencies in the literature with two other studies failing to document an association between growth restriction and behavioral problems later in life (Delobel-Ayoub et al., 2006; Sommerfelt et al., 1993). The only study that investigated the effect of growth restriction on parent ratings of hyperactivity in a sample of preterm-born preschool children was conducted by Delobel-Ayoub and colleagues, who were unable to document a significant association.

The findings of an inverse relationship between total complications and preschool behavioral outcome was unexpected and contrary to the predicted direction of this association (Hypothesis 3). The data revealed that preschoolers with more complications were more likely to have parents endorse fewer problems subsumed under the Externalizing Behavioral Scale. Of the studies reviewed (see Table 1), there were not any that utilized a combined measure of total complications. However, studies analyzed the relationship between specific complications and behavioral outcome (e.g., Anderson et al., 2011; Baar et al., 2009; Delobel-Ayoub et al., 2006). Specific complications that were associated with attention outcome in these studies included necrotizing enterocolitis, periventricular leukomalacia, and cerebral lesions, all of which had a negative association with attention outcome as measured by parental ratings and performance measures (Anderson et al., 2011; Delobel-Ayoub et al., 2006). However, several other complications showed no link with attention outcome including need for oxygen, phototherapy, and hypoglycemia (Baar et al., 2009). Of these studies, only one utilized a sample of preschool children (Delobel-Ayoub et al., 2006). In the study by Delobel and colleagues, they found that cerebral lesions were associated with high scores on the Total Difficulties Questionnaire. Yet, many of the risk factors that were subsumed under the total number of complications in the present study were not measured in the study by Delobel and colleagues (e.g. maternal hypertension, HELLP syndrome, maternal smoking, sepsis, retinopathy of prematurity).

Close inspection of our data reveals that in children with extremely high scores on total complications (> 10) there are corresponding extremely low scores on the Externalizing Problems scale of the CBCL 1.5-5 (T-score below 50). Children with many complications during birth may in fact act more inhibited and display withdrawal behaviors instead of externalizing behaviors (Guedeney, Marchand-Martin, Cote, & Larroque, 2012). Also, this relationship may be explained by the parent's comfort level with reporting externalizing problems. Weisglas and colleagues (1993) found that parents of preterm children were more likely to report internalizing problems instead of externalizing problems compared to clinician ratings. Therefore, the mother's in the present study may be overprotective especially if there child had a long stay in the hospital accompanied with numerous complications.

Contrary to the original hypotheses, statistical analyses revealed that attentional outcome is related neither to gestational age nor to intrauterine growth rate. Surprisingly, there was an inverse relationship between total number of birth complications and the Externalizing Problems broad band behavioral scale score. Parents of preschoolers with more birth complications endorsed fewer items on the Externalizing Problems scale. Gestational age and growth rate had weak relationships with all outcome measures (both behavioral and performance). Outside of this relationship there were no trends toward significance for any of the predictor variables of interest. Thus, it appears that within the preterm population other factors beyond gestational, growth rate, and neonatal risk must be accounting for variance in attentional outcome.

Amongst the four covariates, gender was associated with a performance measure of inhibition within our VPT sample. Gender predicted performance on the Statue subtest, which requires children to stand completely still and inhibit responses to external stimuli. Specifically, females outperformed males on this test showing greater inhibitory abilities. Of the studies that investigated gender differences within the preterm population, most did not find differences (Botting, Powls, Cooke, & Marlow, 1997; Lund, Vik, Skranes, Brubakk, & Indredavik, 2011; Rickards et al., 2001; Whitfield, Grunau, & Holsti, 1997). The only study that found gender differences utilized a sample of seven to eight-year-old VLBW children (Horwood, Mogridge, & Darlow, 1998). In this study males had higher scores on the Conners 3 Inattention and Hyperactiviy/Impulsivity behavior scales based on both parent and teacher ratings. The lack of gender differences in attention and hyperactivity in all but one of the studies reviewed (Horwood et al., 1998) is surprising given that ADHD is diagnosed at much higher rates in males than females (Gaub & Carlson, 1997). Interestingly, none of the studies that compared preterm males to females utilized a performance measure of inhibition such as the Statue subtest. The lack of differences between males and females in previous studies may be due to caregiver expectations of gendered behaviors, as caregivers deem disinhibition as more typical of boys (Maniadaki, Sonuga-Barke, & Kakouros, 2003). However, when assessing these inhibitory behaviors through a performance measure these biases are limited making the gender differences more evident.

In addition to gender, multiple gestation was associated with scores on the Attention Deficit/ Hyperactivity Disorder scale of the CBCL 1.5-5. Surprisingly, children of multiple gestation had fewer items endorsed on the Attention Deficit/Hyperactivity Disorder scale and fewer items from the Externalizing Problems scale were endorsed by their parents. These results are consistent with reports in the literature that twins are rated as having more adaptive behaviors and fewer problem behaviors than their singleton counterparts (Pulkkinen, Vaalamo, Hietala, Kaprio, & Rose, 2003; Vandenoord et al., 1995).

The final covariate that showed associations with attentional outcome measures was socioeconomic status. Socioeconomic status was strongly correlated with both performance measures on the CELF-P2, specifically Concepts and Following Directions and Recalling Sentences (measures of verbal working memory). This finding is consistent with results in the literature, showing that SES reliably predicts attention outcome in preterm children (Peralta-Carcelen, Bailey, Rector, & Gantz, 2013; Potijk, Kerstjens, Bos, Reijneveld, & de Winter, 2013; Wild, Betancourt, Brodsky, & Hurt, 2013).

There are some methodological concerns for the analyses of the ADHD Rating Scale-IV Preschool Version. These analyses only included the 62 subjects that completed the relevant form. This subsample may have been too small to detect the effect of the predictor variables. Power analysis suggested that a sample size of 77 was required to detect a medium effect size with three predictors, suggesting that the analysis of this measure may have been underpowered. However, no significant effects were found on the CBCL 1.5-5; a measure that contains several items similar to the ADHD Rating Scale-IV. This suggests that even with a larger sample size associations between the predictor variables and the ADHD Rating Scale-IV could not be detected. This assertion is further supported as no trends for associations were found for any of the three predictor variables on this measure.

The results of this study suggest that predicting attentional outcome within a sample of VPT preschoolers is an elusive task. The three predictor variables of interest (gestational age, growth rate, and total complications) accounted for little variance in the outcome measures. Of the predictor variables that showed associations, they were limited to a specific measurement (CBCL Externalizing Problems scale). This suggests that the measurements utilized are tapping into different constructs of attention or that the method of assessment (behavioral questionnaire vs. performance measure) plays a large role in determining how behaviors are interpreted. Future research should attempt to develop assessment measures that are more appropriate for the preschool population to allow for accurate assessment of attention and hyperactivity. In addition, more longitudinal studies are needed to determine how attention and hyperactivity changes over the lifespan in order to determine when appropriate assessment of these behaviors can be conducted.

APPENDIX A

Table 1

Methodological Characteristics and Findings of Prior Research on Inattention and Hyperactivity

Authors & Year	**GA cut-off (weeks)**	**BW (g)**	**EPT, VPT, or MPT**	**N per Group (PT:C)**	**Age at Testing**	**Comparison Group**	**Exclusions**	**Outcome Measures**	**Covariance or Matching**	**Results**
(Jaekel et al., 2013)	<32 (M= 30.5)	<1500g (M=1303)	VPT/ VLBW	281:286	6:3, 8:5,	FT (hospital)	PT: Non-German speaking 18 cases with severe disability included but did not change results	Behavioral Questionnaire: -TRCB (psychologist) -TEAM Index Scale of Attention (psychologist, paediatrician) -AMCIES coding system (psychologist) -CBCL (parent) -Mannheimer Parent Interview (parent)	Attention Continuum: Model 1: Maternal education and family adversity Model 2: + child IQ	**Between Groups:** VLBW/VP children had lower scores across all attention measures independent of data source. -Model 1: no diff -Model 2: Mother AMCIES, CBCL at age 8 dissapear -At age 6 higher dx of inattentive/combined but not hyperactive -At age 8 higher dx of inattentive but not combined/hyperactive -Both ages had more clinically relevant (CBCL) attention problems than FT group
(Chu et al., 2012)	<37 (M = 37.6 ADHD / 38.8 Control)	<2500g (M = 3007 ADHD / 3351 ADHD	MPT	ADHD: 195 Control: 212	6-12 (Retrospective study)	Non-ADHD (community)	-IQ of less than 70 on the WISC-III -mental retardation -congenital anomalies -chromosome anomalies -neurological disorders.	Behavioral Questionnaire: ADHD Rating Scale-IV (psychologist) CGI-S (psychologist)	Model 2: LBBW Model 3: LBBW, gender, age	**Between Groups:** Model 1 (no covariate): Preterm birth was significant predictor of ADHD inattention, hyperactivity, and CGI-S. Model 2: Preterm birth had effect on overall ADHD measure but not individual hyperactivity or inattention measures. Significant effect on CGI-S Model 3: results consistent with model 2
(de Kieviet et al., 2012)	<32 (M= 29.3)	(M = 1241)	VPT	66:66	7-8	FT (classroom)	No exclusions	Performance Measures of Attention: ANT (orienting, alerting, executive function) DS (verbal working memory) Visuospatial Working Memory Behavioral Questionnaire: CBCL (parent) PDBD (parent) TRF (teacher) TDBD (teacher)	No difference in age, SES, sex Indirect pathway: Tau Visuospatial working memory abilities	**Between Groups:** Attention Measures: -Overall ANT measures of orienting, alerting, and executive function not significant -No difference in mu, or sigma, but difference in tau -VP children had deficit in visuospatial working memory but not verbal working memory -Increase in attention problems (parent/teacher ratings) completely mediated by tau and visuospatial working memory abilities Behavior Ratings: -VP children had higher parent and teacher ratings of inattention (CBCL, PDBD, TRF, TDBD). -No difference in hyperactivity/impulsivity

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Johnson et al., 2010)	<26	Not reported	EPT	219:153	11 years	FT (classroom)	None	Behavioral Questionnaires: DAWBA (structured parent interview) CBCL (parent) SDQ (parents and teachers)	Age, sex, ethnicity, cognitive impairment	**Between Groups**: Behavior Rating: EPT children were 4.3 times more likely to have ADHD Greatest risk was for ADHD inattentive subtype, with 62% meeting criteria and the other 38% had combined type After excluding children with cognitive impairment there was no longer an increased risk of ADHD
(Shum et al., 2008)	≤ 27 (M = 26.44)	≤ 1000g (M=838.24)	EPT/ ELBW	45:49	7-9 years	FT (community)	Significant physical or neurological disabilities	Behavioral Questionnaires: ADHD Rating Scale-IV (parent and teacher) Performance Measures of Attention: DSF (attention span) SSF (attention span) NEPSY – Visual Attention subtest (focused attention) TMTB (focused attention) Stroop (selective attention)	Age, Grade	**Between Groups:** Behavioral Rating: -Significant difference in parent ratings of inattention and total ADHD but not hyperactivity -No difference in inattention, hyperactivity, or total ADHD from teacher ratings Attention Measures: -ELBW/EPT lower scores on SSF, Visual Attention subtest of NEPSY, TMT B. No difference in DSF and Stroop. -Tests of attention were significantly associated with parents and teachers ratings on the ADHD-IV Rating Scale
(Farooqi et al., 2007)	<26 (M = 24.6)	M = 765	EPT	86: 86	11 years	FT (hospital matched)	Analyses done with and without: Moderate or disabling CP, sever visual impairment, sensorineural disability, or need for full time special education	Behavioral Questionnaire: CBCL(parent) TRF (teacher)	Age, gender	**Between Groups** EPT group had greater attention problems for both CBCL and TRF Significant effect for total problems on both CBCL and TRF
(Caravale et al., 2005)	30-34 weeks	N/A	VPT	30:30	3-4 years	FT (school matched)	Congenital abnormalities, major neurological signs	Performance Measures of Attention Memory for location (working memory) Leiter international performance scale revised (sustained attention)	Age, sex, parental education level, occupational status, IQ	**Between Groups** Preterm children scored lower on sustained attention task and spatial working memory, even after accounting for IQ

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Perricone et al., 2013)	<35 weeks (M = 34.6)	1500-2500g (M = 2100)	MPT	50:50	56-67 months	FT (hospital matched)	Neurological pathology, sensorial and genetic pathology deficit, malformative syndrome, cognitive deficit, clinically significant learning disorders	<u>Behavioral Questionnaires:</u> IPDDAI Italian Scale (teacher) IPDDAG Italian Scale (parent)	Socioeconomic status, age, sex	**Between Groups** Preterm children had higher parent ratings of hyperactivity/impulsivity and inattention No difference in hyperactivity/impulsivity or inattention based on teacher ratings Significant sex*birth interaction on teacher ratings of inattention. Females born preterm have greater problems with inattention.
(Espy et al., 2003)	28-36.5 weeks (M = 32.4)	730-2475g (M = 1774)	MPT	29:29	2-3 years	FT (School / Community)	No IVH > grade B, PVL, seizures, chronic lung disease, BPD	<u>Performance Measures of Attention:</u> Delayed Alternation (working memory) Spatial Reversal (shifting/flexibility)	Age, sex, maternal education, race	**Between Groups** PT group showed deficits in working memory but not in shifting/flexibility
(Delobel-Ayoub et al., 2006)	22-32 weeks	N/A	VPT	1228: 447	3 years	FT (community sample)	Blindness, deafness, severe CP, multiple births	<u>Behavioral Questionnaire:</u> SDQ (parent)	Gender, maternal age at birth, birth order, maternal education, marital status of the mother, hospitalization during the last year, neurodevelopmental delay, and health of the child	**Between Groups** Significant difference in hyperactivity between PT group and controls **Within Groups** No significant difference between 24-28 week GA children on hyperactivity in comparison to the 29-30 or 31-32 week GA groups. No effect of IUGR. Total behavior problems related to cerebral lesions, hospitalization > 13 weeks in NICU, children intubated for > 10 days, neurodevelopmental delay, and poor health.

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Heinonen et al., 2010)	<37 (M=34)	< -2 SDs below mean BW (M= 2282)	MPT	656:172	56 months	FT (longitudinal study)	Congenital malformations, chromosomal abnormalities, mendelian disorders potentially affecting growth	Behavioral Questionnaires: Conners' Hyperactivity Index-parent version (parent)	Model 1: Sex, pre- and neonatal complications, child's general reasoning Model 2: Model 1 + multiple pregnancy, mother's smoking during pregnancy, parental education, maternal age, maternal height, maternal body mass index at the end of pregnancy and change in weight during the pregnancy Model 3: Adjusted for Model 2+ child's general reasoning at 56 months old	**Between Groups:** Behavior Rating: No difference in ADHD symptoms or diagnosis (controlled for sex) **Within Groups:** Behavior Rating: GA not associated with ADHD symptoms (controlled for sex) SGA status and lower birth weight SD score were significantly, and independently of gestational age, associated with higher ADHD symptoms
(Saavalainen et al., 2007)	23-32 weeks (M = 30)	M = 1440 g	VPT	30:40	5 and 9 years	FT (hospital)	CP, mental retardation	Performance Measures of Attention: DSF (working memory) DSB (working memory) Letter-Number Sequencing (working memory) Arithmetic (working memory) SSF (spatial working memory) SSB (spatial working memory) Coding (processing speed) Mental Control subtest (processing speed)	Age, sex, mother and father educational and socioeconomic status	**Between Groups** Significant difference in SSB even after controlling verbal IQ and processing speed (coding) No difference in any other working memory tasks **Within Groups** GA significantly explained length of SSB. GA not significantly associated with any other working memory task Neonatal seizures and abnormal EEG had significant impact on SSF, Arithmetic, and Coding Need for ventilator assistance and IUGR were associated with shorter SSB

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Elgen et al., 2012)	<28 weeks	<1000 g	EPT/ ELBW	255: 1119	5-6 years	FT (community health check-up)	Neurodevelopmental disability for some analyses	<u>Behavioral Questionnaire:</u> SDQ (parent)	Age	**Between Groups** Children born ELBW / EPT had higher rates of hyperactivity than controls **Within Groups** Increasing degree of neurodevelopmental disability increased odds of hyperactivity and inattention problem
(Anderson et al., 2011)	<28 (M= 26.5)	<1000g (M = 833)	EPT/ ELBW	189: 173	8	FT / NBW (community)	Excluded for analyses, did not change results: Moderate to severe CP, Deafness, Blindness, IQ<70	<u>Performance Measures of Attention</u> TEA-Ch: Sky Search subtest (selective attention) TEA-Ch: The Score! Subtest (sustained attention) Forward DS (Attention encoding) TEA-Ch: Opposite Worlds and Inhibit scale from BRIEF (inhibitory control) Tea-Ch: Creature Counting and Shift scale from BRIEF (shifting attention) Tea-Ch: Sky Search Dual Task (divided attention) <u>Behavioral Questionnaire:</u> CADS-P (parent) BRIEF (parent)	Expected date of birth, gender, mother's country of birth (English-speaking or not) and health insurance status (private health insurance or not)	**Between Groups:** <u>Attention Measure:</u> EP/ELBW scored lower on the following tasks: -selective attention -sustained attention -attention encoding -shifting attention -divided attention. No difference in task of inhibition <u>Behavior Rating:</u> On parental report questionnaires EP/ELBW higher on : -inhibition -shifting attention -inattentive symptoms -hyperactive/impulsive symptoms -ADHD Index **Within Groups:** Children born prior to 26 weeks GA or born below 750g performed equivalently to other children in preterm group across all attention and behavioral domains NEC and cystic PVL predicted selective attention deficits. Neonatal risk factors did not predict any other attention deficit

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Lindström et al., 2011)	23-28 29-32 33-34 35-36 37-38 39-41 42 or more	Not reported	EPT VPT MPT	1,180,616	6-19 years	None	Malformation at birth, birth weight above 3SD or less than -6SD	Purchase of at least 1 prescription stimulant	Model 1: gender, age, country of residence. Model 2: + birth order, maternal age, maternal education, single parenthood, public welfare, maternal smoking, maternal and paternal psychiatric/addictive disorder Model 3: + low Apgar score, SGA	**Within Groups:** OR for ADHD medication were 2.1 for 23-28 weeks GA in Model 3. OR reduced as GA increased for each group Separate regression done for mothers who had term and pre-term children, found same results as well as a within-mother-between-pregnancy analysis which replicated the results. Effect of GA on ADHD similar for boys and girls. Being SGA or having low Apgar score had moderate effect on risk of ADHD medication. They did not modify effect of GA on ADHD. Having CP increased OR of ADHD meds by 2.5
(Huddy et al., 2001)	32-35 weeks	N/A	MPT	117: none	7 years	None	CP, visual impairment, sensorineural hearing loss, and severe developmental delay	<u>Behavioral Questionnaires:</u> SDQ (parent and teacher)	Age	**Within Groups** Parent / Teacher ratings of hyperactivity not related to gestational age

Table 1 (continued)

Authors & Year	GA cut-off (weeks)	BW (g)	EPT, VPT, or MPT	N per Group (PT:C)	Age at Testing	Comparison Group	Exclusions	Outcome Measures	Covariance or Matching	Results
(Baar et al., 2009)	32-36 weeks (M = 34.7)	1340–4130 g (M = 2425)	MPT	377: 182	7-9 years	FT (school matched)	Dysmaturity, congenital malformations, no NICU admittance needed,	Behavioral Questionnaires: CBCL(parent) TRF (teacher) ADHD Symptom Questionnaire (parent and teacher) Performance Measures of Attention: Bourdon-Vos test (sustained selective attention)	Age, Maternal education	**Between Groups** Behavior Rating: Mothers rated their children as having more attention problems, hyperactivity, and overall ADHD symptoms. They also rated more internalizing and total problems in their MPT children. Father ratings yielded no difference in ADHD symptoms or CBCL internalizing/externalizing problems. Teacher ratings yielded deficits in attention but not hyperactivity and not overall ADHD symptoms. Teachers also rated MPT group as having greater internalizing and total problems on CBCL. Attention Measure: Preterm children showed deficit in sustained attention, as they took longer to complete the task. **Within Groups:** Comparison of 32-33 weeks vs. 34-36 weeks yielded no differences except for mothers ratings of behavior problems, where 32-33 weeks had greater problems. No effect of need for oxygen, phototherapy, or hypoglycemia on any of the outcome measures.

Note: GA=Gestational Age, BW=Birth weight, PT=Preterm, C=Control, EPT=Extremely Preterm, VPT=Very Preterm, MPT=Moderately Preterm, FT=Full Term, UC=unclear, LBW= Low Birth Weight, VLBW = Very Low Birth Weight, ELBW =

Table 1 (continued)

Extremely Low Birth Weight, TRCB = Teacher's Rating of Child Behavior, TEAM Index Scale of Attn = Consensus rating of entire diagnostic team, AMCIES = Assessment of Mother–Child Interaction with the Etch-a-Sketch , CBCL = Child Behavior Checklist, CGI-S = Clinical Global Impression Severity, PDBD = Parent Disruptive Behavior Disorders rating scale, TRF = Teacher Report Form, TDBD = Teacher Disruptive Behavior Disorders rating scale, ANT = Attention Network Test, DS = Digit Span, mu = extremely slow responses, sigma = fluctuations in processing speed, tau = proportion of extremely slow responses assessing laps of attention, ICD-10 = International Statistical Classification of Disease and Related Health Problems (10th Version) , SGA= Small for Gestational Age, NBW = Normal Birth Weight, TEA-Ch = Test of Everyday Attention for Children, BRIEF = Behavioral Rating Inventory of Executive Function, CADS-P = Conners' ADHD/DSM-IV Scales, NEC = Necrotizing Enterocolitis, PVL = Periventricular Leukomalacia, CRSR = Conners' Rating Scale Revised-Long Form, SSF= Spatial Span Forward, VA = Visual attention, TMTB = Trail making test B, NSMDA = Neurosensory Motor Developmental Assessment, DAWBA = Development and Well Being Assessment, SDQ = Strengths and Difficulties Questionnaire, , CPRS = Conners' Rating Scales Parent Version, Stroop = Stroop Color Word Test, DSF = Digit Span Forward, NBW = Normal Birth Weight, IPDDAI = Attention Deficit Hyperactivity Disorder Early Detection for Teachers, IPDDAG = Attention Deficit Hyperactivity Disorder Early Detection for Parents, Bronchopulimary dyplasia: BPD, LBBW = Low birth body weight (<2500 g).

Table 2

Psychometric Properties of Performance Measures of Attention

	Internal Consistency 3 years Old	**Internal Consistency** 4 years old	**Test-Retest Reliability** 3 years old	**Test-Retest Reliability** 4 years old
WPPSI-III				
Block Design	Average for all ages: .84		2:6-3:11: .9	4:0-5:5: .5
Information	Average for all ages: .88		2:6-3:11: .3	4:0-5:5: .9
FSIQ (prorated)	.713	Not Available	.919	Not Available
CELF-P2				
Recalling Sentences	3:0-3:5: .88 3:6-3:11: .87	4:0-4:5: .91 4:6-4:11: .90	.92	.89
Concepts and Following Directions	3:0-3:5: .85 3:6-3:11: .84	4:0-4:5: .85 4:6-4:11: .84	.84	.82
WJ-III				
Concept Formation	Not Available	Not Available	.86	.94
Picture Recognition	Not Available	Not Available	.82	.80
NEPSY-II				
Statue	.93	.93	Not Available	Not Available

Table 3

Psychometric Properties of Behavioral Questionnaires

	Internal Consistency 3-5 years	**Test-Retest Reliability** 3-5 years
ADHD Rating Scale IV Preschool Version-Parent		
Total Score	.92	.87
Inattention	.88	.85
Hyperactivity/Impulsivity	.85	.80
CBCL 1.5-5		
ADHD Problems	Not Available	.74
Total Problems	Not Available	.90

Table 4
Group Comparison of Demographic and Sociofamilial Characteristics

	Gestational Age	
Characteristics	< 30 weeks n = 48	>30 weeks n= 50
Adjusted age (mos.)[a]	44.02 (± 3.19)	44.64 (± 3.88)
Gender (M:F)[b]	22:25	19:31
Multiples	17	17
Race (W:O)[c]	34:14	37:13
SES[d]	46.04 (± 11.89)	48.61 (± 8.27)
Maternal VIQ[e]	99.44 (± 10.11)	102.83 (± 10.67)
Mother's education (yrs.)	15.58 (± 2.11)	15.97 (± 1.38)
Father's education (yrs.)	15.02 (± 1.93)	15.04 (± 2.28)

Note. All differences n.s.
Frequencies are reported for discrete data, means and standard deviations for continuous data. Group differences examined via *t* test (continuous data) or 2 X 2 χ^2 with Yates correction (discrete data).
a Adjusted age at first testing session
b M=male, F=female
c W=White, O = Other
d Hollingshead's (1975) Four Factor Index of Social Status.
e Prorated parental IQ based on three subtests (Vocabulary, Similarities, and Information) of the Wechsler Adult Intelligence Scale-IV (Wechsler, 2008); Testing was completed on the biological mothers in 81 out of 98 cases.

Table 5
Antenatal Perinatal and Neonatal Factors by Group[a]

	Gestational Age	
Characteristics	< 30 weeks n = 48	>30 weeks n= 50
<u>Antenatal Factors</u>		
Abruption of the placenta	6	2
Chorioamnionitis*	17	8
Maternal diabetes[b]	3	5
HELLP syndrome[c]	5	3
Maternal Hypertension	17	23
Intrauterine growth (z-score)[d]	-.1960 (± .69)	-.3950 (± .76)
Premature rupture of membrane[e]	13	11
Oligohydramnios	3	1
Smoking during pregnancy	1	3
Abnormal vaginal bleeding	7	6
Total antenatal complications[f]	1.49 (± .72)	1.30 (± .86)
<u>Perinatal Factors</u>		
Abnormal presentation[h]	18	18
Birth weight (g)***	1125.58 (± 314.88, 524-1725)	1702.88 (± 299.60, 1077-2297)
Birth length (cm)***	36.83 (± 4.10, 22.00-42.5)	42.50 (± 3.20, 33.02- 48.30)
Birth head circumference (cm)***	26.17(± 2.55, 19.30-30.25)	29.47 (± 1.33, 27.20-32.00)
Cesarean section	36	39
Forceps	1	0
General anesthesia	3	6
Gestational age (weeks)[i]***	28.40 (± 1.94)	32.37 (± .88)

Table 5 continued

Nuchal cord	9	13
1 minute apgar**	6.15 (± 1.71, 2-9)	7.16 (± 1.82, 2-9)
5 minute apgar***	7.81 (± 1.17, 4-9)	8.56 (± .73, 6-9)
Total perinatal complications[j]	1.40 (± .88)	1.52 (± .93)
<u>Neonatal Factors</u>		
Anemia[k]**	20	8
Apnea***	40	23
Hyaline membrane disease[l]***	44	25
Hyperbilirubinemia[m]***	1	15
Hypermagnesmia	4	2
Hypotension[n]	1	0
Intracranial hemorrhage[o]**	16	4
Meconium aspiration	3	2
Necrotizing enterocolitis[p]	3	0
Patent ductus arteriosus[q]***	18	2
Retinopathy of prematurity**	12	1
Sepsis[r]*	7	1
Thrombocytopenia	5	2
Total neonatal complications[s]	2.79 (± 1.69)	1.24 (± 1.00)
Total complications	5.70 (± 2.26)	4.06 (± 1.58)

*$p < .05$, **$p < .01$, ***$p < .001$

[a] All comparisons between <30 weeks and >30 weeks Gestational Age groups.
[b] Includes both gestational diabetes and diabetes mellitus.
[c] Hemolysis, elevated liver enzymes and low platelets.
[d] A *z*-score expressing the deviation of an infant's birth weight from the mean weight of his/her gestational age group, at delivery, according to norms published by Kramer et al. (2001).
[e] Time from spontaneous or artificial rupture of membranes to delivery greater than 12 hours.

Table 5 continued

[f] Total antenatal complications includes placental abruption, chorioamnionitis, maternal diabetes, HELLP syndrome, maternal hypertension, membranes ruptured >12 hours, oligohydramnios, smoking during pregnancy, abnormal vaginal bleeding.
[g] Includes various atypical presentations such as breech or transverse.
[i] As determined by obstetrician; > 95% of cases were corroborated by antenatal ultrasound.
[j] Total perinatal complications include abnormal presentation, C- section, forceps, general anesthesia, and nuchal cord.
[k] Hematocrit < 40 %.
[l] Based on a chest roentgenogram and clinical evaluation.
[m] Peak bilirubin ≥ 12 mg/dl
[n] Requiring treatment
[o] Documented on the basis of cranial ultrasound
[p] Documented by radiographic changes, positive stool guiacs and abdominal distention.
[q] Diagnosed by clinical manifestations and echocardiographic information.
[r] Established by positive blood culture.
[s] Total neonatal complications includes anemia at birth, apnea, hyaline membrane disease, hyperbilirubinemia, hypermagnesmia, hypotension, intracranial hemorrhage, meconium aspiration, necrotizing enterocolitis, patent ductus arteriosus, retinopathy of prematurity, sepsis, and thrombocytopenia.

Table 6
Summary of Simultaneous Multiple Regression Analyses

		Total Sample			Selective Sample		
Index	Source	F	*df*	*p*	F	*df*	*p*
Behavioral Questionnaires Attention Problems (CBCL1.5-5)	Gestational age	.787	1,96	.377	.819	1,93	.368
	Growth rate	.684	1,96	.411	.626	1,93	.431
	Total complications	.240	1,96	.626	.128	1,93	.721
	Sex	1.923	1,96	.169	2.453	1,93	.121
	Socioeconomic	.977	1,96	.326	1.531	1,93	.219
	Multiple gestation	2.606	1,96	.110	3.307	1,93	.073
	Adjusted age	.073	1,96	.788	.819	1,93	.368
Attention Deficit/ Hyperactivity Disorder Scale (CBCL1.5-5)	Gestational age	.377	1,96	.541	.319	1,93	.573
	Growth rate	.485	1,96	.488	.682	1,93	.411
	Total complications	.912	1,96	.342	.760	1,93	.386
	Sex	.954	1,96	.331	.984	1,93	.324
	Socioeconomic	2.476	1,96	.119	2.191	1,93	.143
	Multiple gestation	4.228	1,96	.043	4.568	1,93	.035
	Adjusted age	.029	1,96	.865	.196	1,93	.659
Externalizing Problems (CBCL1.5-5)	Gestational age	1.158	1,96	.285	1.128	1,93	.291
	Growth rate	.439	1,96	.510	.596	1,93	.442
	Total complications	4.981	1,96	.028	4.311	1,93	.041
	Sex	.674	1,96	.414	.835	1,93	.363
	Socioeconomic	1.016	1,96	.316	1.088	1,93	.300
	Multiple gestation	3.125	1,96	.081	3.632	1,93	.060
	Adjusted age	.999	1,96	.320	.530	1,93	.469

Table 6 continued

Index	Source	Total Sample F	*df*	*p*	Selective Sample F	*df*	*P*
Total Score	Gestational age	.590	1,62	.446	1.212	1,60	.276
(ADHD Rating Scale IV Preschool Version)	Growth rate	.774	1,62	.383	2.431	1,60	.125
	Total complications	.973	1,62	.328	2.206	1,60	.144
	Sex	.581	1,62	.449	.379	1,60	.541
	Socioeconomic	2.051	1,62	.158	.878	1,60	.353
	Multiple gestation	.433	1,62	.513	.267	1,60	.608
	Adjusted age	.067	1,62	.797	.636	1,60	.429
Inattention score	Gestational age	.216	1,62	.644	.594	1,60	.444
(ADHD Rating Scale IV Preschool Version)	Growth rate	.490	1,62	.487	1.866	1,60	.178
	Total complications	.453	1,62	.482	1.146	1,60	.289
	Sex	.288	1,62	.593	.090	1,60	.765
	Socioeconomic	1.304	1,62	.258	.298	1,60	.587
	Multiple gestation	.784	1,62	.380	.522	1,60	.473
	Adjusted age	.004	1,62	.950	.137	1,60	.713
Hyperactivity Score	Gestational age	.829	1,62	.367	1.436	1,60	.236
(ADHD Rating Scale IV Preschool Version)	Growth rate	1.037	1,62	.369	2.183	1,60	.146
	Total complications	1.171	1,62	.284	2.546	1,60	.117
	Sex	.676	1,62	.414	.570	1,60	.454
	Socioeconomic	2.176	1,62	.146	1.232	1,60	.272
	Multiple gestation	.151	1,62	.699	.078	1,60	.781
	Adjusted age	.293	1,62	.632	1.032	1,60	.315

Table 6 continued

		Total Sample			Selective Sample		
Index	Source	F	*df*	*p*	F	*df*	*p*
Performance Measures	Gestational age	.165	1,80	.685	.176	1,79	.676
Statue (NEPSY-II)	Growth rate	.002	1,80	.966	.007	1,79	.931
	Total complications	.030	1,80	.863	.004	1,79	.947
	Sex	4.205	1,80	.044	4.018	1,79	.049
	Socioeconomic	.030	1,80	.864	.065	1,79	.799
	Multiple gestation	.535	1,80	.467	.483	1,79	.489
	Adjusted age	1.382	1,80	.244	1.578	1,79	.213
Picture Recognition (WJ-III)	Gestational age	.144	1,82	.705	.280	1,80	.598
	Growth rate	1.693	1,82	.197	1.163	1,80	.284
	Total complications	.163	1,82	.688	.428	1,80	.515
	Sex	.639	1,82	.427	.646	1,80	.424
	Socioeconomic	2.618	1,82	.110	1.884	1,80	.174
	Multiple gestation	.558	1,82	.457	NA	1,80	NA
	Adjusted age	.088	1,82	.768	.035	1,80	.852
Concept Formation (WJ-III)	Gestational age	.049	1,75	.826	.014	1,73	.908
	Growth rate	2.093	1,75	.153	1.718	1,73	.195
	Total complications	.867	1,75	.355	1.627	1,73	.207
	Sex	.305	1,75	.583	.649	1,73	.423
	Socioeconomic	.555	1,75	.459	.813	1,73	.371
	Multiple gestation	.101	1,75	.752	.022	1,73	.882
	Adjusted age	1.300	1,75	.258	1.773	1,73	.188

Table 6 continued

Index	Source	Total Sample F	*df*	*p*	Selective Sample F	*df*	*P*
Concepts and Following Directions (CELF-P2)	Gestational age	.428	1,93	.515	.630	1,90	.430
	Growth rate	.110	1,93	.741	.000	1,90	.990
	Total complications	.088	1,93	.767	.465	1,90	.497
	Sex	.102	1,93	.750	.159	1,90	.691
	Socioeconomic	9.849	1,93	.002	8.118	1,90	.006
	Multiple gestation	.472	1,93	.494	.428	1,90	.515
	Adjusted age	1.019	1,93	.316	1.328	1,90	.253
Recalling Sentences (CELF-P2)	Gestational age	.528	1,85	.470	.758	1,83	.387
	Growth rate	.213	1,85	.646	.077	1,83	.783
	Total complications	.080	1,85	.779	.417	1,83	.520
	Sex	1.552	1,85	.217	1.252	1,83	.267
	Socioeconomic	11.082	1,85	.001	10.802	1,83	.002
	Multiple gestation	1.080	1,85	.302	1.214	1,83	.274
	Adjusted age	.027	1,85	.870	.002	1,83	.964

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ABSTRACT

INATTENTION AND HYPERACTIVITY AMONG PRESCHOOL AGE CHILDREN BORN PREMATURELY

by

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Advisor: Dr. Sarah Raz

Major: Psychology (clinical)

Degree: Master of Arts

A large body of literature shows that compared to children born at term, preterm-children are at increased risk for difficulties with inattention and hyperactivity. Less consistency exists, however, in the limited body of research exploring the contribution of early biological risk to behavioral disinhibition within the population of children born prematurely. Therefore, our goal was to examine perinatal variables that may influence activity level and hyperactivity among preterm preschoolers.

One-hundred (23.4 - 33.9 weeks gestation) preschoolers (3-4 years) participated in the study. Direct measures of inattention and hyperactivity as well as parental ratings were used to evaluate behavior. We used simultaneous linear regression analyses with gestational age, perinatal complications, and growth rate z-score (birth weight standardized by gestational age) as predictors of interest. Socioeconomic status, sex, multiple gestation, and age at testing were our "covariates."

Surprisingly, we found that within our preterm sample, total number of complications was inversely related to the CBCL Externalizing Problems scale score. Sex, but not perinatal

medical status, was significantly related to performance on the NEPSY-II Statue subtest, with males displaying reduced ability for motor inhibition. Preschoolers with a greater number of complications obtained lower Externalizing Problems scale scores, suggesting a link between increased perinatal risk and reduced behavioral initiation. The reduced motor inhibition in boys, however, is consistent with the expected male outcome disadvantage documented in the prematurity literature.

AUTOBIOGRAPHICAL STATEMENT

I began my studies at Drake University, where I became interested in researching developmental disabilities. There I joined a project conducted by Dr. Maria Valdovinos that focused on understanding the behavior of a mouse model of Fragile X Syndrome. In addition, while at Drake University I administered neuropsychological assessments to individuals with a wide array of neurological disorders. I chose to continue my studies at Wayne State University, with a focus in developmental neuropsychology. Currently I work alongside Dr. Sarah Raz, where our research focuses on understanding the relationship between risk factors at birth and cognitive outcomes of children.