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A Longitudinal Analysis of Executive Functions, Learning-Related Skills, and Mathematics Achievement

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Education

by

David Shin Lee

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DEDICATION

To

My family, friends, and wonderful wife

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My journey through graduate school would not have been possible without the love and support of many people. First, I would like to express my sincerest gratitude and appreciation to Dr. Penelope Collins, who was my academic advisor, mentor, teacher, cheerleader, and dissertation chair. Her patient support, thoughtful feedback, wealth of knowledge, and supportive suggestions were critical throughout my graduate school experience. I would also like to thank Dr. Susanne Jaeggi for her time, energy and support. I want thank Dr. Jaeggi for serving on my dissertation committee, mentoring me, teaching me, motivating me, and allowing me to work on various projects with her. I also want to thank Dr. Deborah Vandell for serving on my dissertation committee and allowing me to use her data on this dissertation. Dr. Vandell wisdom, professionalism, and care for students are incomparable.

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ABSTRACT OF THE DISSERTATION

A Longitudinal Analysis of Executive Functions, Learning-Related Skills, and Mathematics Achievement

By

David Shin Lee

Doctor of Philosophy in Education

University of California, Irvine, 2016

Professor Penelope Collins, Chair

The transition to kindergarten is a critical milestone for many children. Children who enter kindergarten ill-prepared may experience early academic and social difficulties that persist into their elementary school years. This dissertation examines the relationship between learning-related skills, executive functioning, and math achievement between the preschool grade and fifth grade. The purpose of this study is to identify the early executive functioning skills and classroom learning-related skills that predict academic success. I also examine the stability of one important executive functioning skill, sustained attention, between preschool and elementary school and the effects persistent problems with sustained attention through elementary school. Data were drawn from the National Institute of Child Health and Human Development (NICHD) Study of Early Childcare and Youth Development (SECCYD), a longitudinal dataset collected across the United States.

The results suggest that among three learning-related social skills, teacher ratings of attention problems in the classroom in first grade was the strongest predictor of concurrent and later math performance, even when controlling for individual executive functioning

skills, gender, income, and maternal education. Next, sustained attention skills at 54 month - as measured by the Continuous Performance Task- was the strongest predictor, among the three executive functioning skills, of classroom attention problems and classroom work habits through elementary school.

This study also found that sustained attention skills relatively stable between 54 months and fourth grade. Analysis of trajectories suggests that students with persistently low attention control had weaker work habits and more attention problems as they progress through fifth grade. In fact, the gap in work habits skills between those with persistently low sustained attention skills and those with average attention skills increases between first and fifth grade. Finally, teacher-student relationship in kindergarten partially mediated the relationship between low sustained attention skills at 54 months and later attention problems in first and third grade. The significance of early skills, behaviors, and classroom experiences are highlighted in this study.

CHAPTER ONE
INTRODUCTION

The recent educational emphasis on higher academic standards, greater high school graduation rates, and improvements in college preparation is trickling down to the elementary school level. Most notably, attempts to raise academic standards have resulted in the creation of national Common Core State Standards for Kindergarten students. The pressure placed on Kindergarten teachers to raise academic standards and performance drew greater attention to the gaps and variations in children's ability as they enter formal schooling. Children who enter formal schooling with inadequate academic, cognitive, or social skills may lag behind their peers and have difficulty catching up to the increasing academic, social, and behavioral demands of formal schooling (e.g., Magnuson, Meyers, Ruhm, & Waldfogel, 2004; Mashburn & Pianta, 2006). Unfortunately, the transition into kindergarten is difficulty for many students. In one study, teachers report that over half of their students entered kindergarten with general problems related to transition and readiness for formal schooling, including skills such as taking turns, staying on task, following directions, and controlling impulses (Rimm-Kaufman, Pianta, & Cox, 2000).

According to Rimm-Kaufman & Pianta's (2000) ecological and dynamic model of transition, the kindergarten classroom context is different from preschool and home environment because of the greater emphasis on formal instruction and learning standards, behavioral expectations, and academic achievement. Children unprepared for these demands begin schooling already lagging behind their peers in achievement and the gaps between these students and their peers are persistent and difficult to narrow (Lee, Brooks-Gunn, Schnur, & Liaw, 1990; Magnuson et al, 2004). Consequently, research on early childhood

education and school readiness continues to be emphasized and promoted (Seifert & Metz, 2016; Welchons & McIntyre, 2015).

Although definitions of school readiness may vary, academic and social skills tend to be emphasized in most states (Howes et al., 2008). The Office of Head Start (OHS, 2012 & 2015) recommends a holistic approach to development, describing a comprehensive school readiness that includes skills such as approaches to learning, self-regulation, social and emotional development, language and communication skills, cognitive skills, and perceptual/motor development.

Despite the extensive examination of school readiness factors, several questions still exist. First, much of the early childhood research distinguishes between early academic skills such as number sense, and social skills such as peer relation and self-control (Graziano et al., 2016; Ziv, 2013). Consequently, many early childhood educators may benefit from guidance on how to weigh the relative importance of social and behavioral skills as well as academic skills as children enter kindergarten. For example, on one hand, children with poor foundational academic knowledge and skills such as phonemic awareness and number sense may struggle in the classroom (e.g., Jordan, Kaplan, Olah, & Locuniak, 2006). Alternatively, children's ability to fulfill the social demands of a classroom, such as not disrupting the class, following directions and taking turns are more of a priority for many kindergarten teachers than basic domain-specific academic skills (Lin, Lawrence, & Gorrell, 2003). According to teacher reports, many children enter Kindergarten with inadequate basic social-behavioral skills such as following directions and working independently, which negatively impact school success (Rimm-Kaufman et al., 2000). Furthermore, classroom engagement between first and third grade have been associated with

academic success in middle school (Ladd & Dinella, 2009). Indeed, children who have difficulty with classroom engagement are at greater risk for learning-related social problems such as classroom engagement (Rimm-Kaufman et al., 2010). Children with learning-related social problems exhibit difficulties engaging in and completing many school-related tasks. Other important learning-related skills associated with academic achievement include independence, responsibility self-regulation, and cooperation (McClelland & Morrison, 2003). Finally, individual differences in cognitive skills such as executive functioning skills (e.g., Bull & Scerif, 2007; Valiente et al., 2008) have been associated with school success. Better understanding of how these skills contribute to school success can help early childhood educators and teacher best prepare children for formal schooling.

Secondly, many studies on the relationship between individual skills and academic performance have been cross sectional (e.g., Martin, Razza, & Brooks-Dunn, 2012). Less is known about the importance of timing and growth of certain skills and how it is associated with academic success. Longitudinal analysis spanning the preschool and elementary school years can provide a clearer picture for prevention and intervention policies.

Finally, extant research has examined the impact of contextual factors to children's early success. Schools and classrooms are situated within a social context that include several factors such as positive relationships with teachers and child-centered learning environments, that may contribute to success in early elementary school (e.g., Liew, Chen & Hughes, 2010; Rimm-Kaufman et al., 2015; Williford et al., 2013). Research on early childhood education should consider the influence of contextual factors such as socials skills, peer influences teacher practices, and teacher-student relationship on variety of individual skills that children possess as they enter kindergarten.

The Present Study

The early elementary school years are a possible "window of opportunity" in which students can develop learning-related behaviors that can lead to positive long-term academic outcomes (Alexander, Entwisle & Dauber, 1993). The purpose of this dissertation is to examine the interactive effects of a collection of individual-level executive functioning skills and learning-related social skills-which McClelland and colleagues (2006) refer to as learning-related social skills-that are important for early academic success in the school setting. Several different learning related skills such as attention, self-regulation, behavioral self-regulation social competence, and social and emotional skills have been found to be critical for academic success (Blair, 2010; Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003; NICHD Early Child Care Research Network, 2003). At the heart of learning-related skills appears to be the importance of individual differences in executive functioning (McClelland, Acock, & Morrison, 2006). Therefore we examine three important executive functioning skills in this dissertation – attention control as measured by the continuous performance task, attention shifting/flexibility as measured by the Stroop task (Diamond et al., 2010), and delay of gratification task measured by a version of the classic marshmallow task (Mischel, Shoda, & Rodriquez, 1989).

Whereas considerable evidence indicate that many of the domain-specific risks for school failure (Duncan et al., 2007; Vaughn & Fuchs, 2003), less is known about the impact of persistence difficulties of executive functioning skills, on long-term academic and learning-related behaviors. Additionally, what types of protective factors may alleviate the difficulties associated with persistent attention problems throughout elementary school? This dissertation examines the longitudinal relationship between executive

functioning, learning-related social skills, and academic outcomes and addresses the following research questions:

1. What is the relationship between specific learning-related skills and math performance in first and third grade?
2. What early executive functioning skills at 54 month predict later learning-related social skills in first and third grade?
3. Do classroom-level factors such as teacher practices and student-teacher relationships in kindergarten moderate the relationship between early self-control skills and learning-related skills?
4. Are sustained attention skills stable from early childhood into fourth grade? Do children with persistent difficulties sustained attention have different outcomes in academic achievement, learning-related skills? How do children with persistent difficulties in attention or inhibitory control differ from those whose initial difficulties at preschool are later resolved?

Significance

This dissertation contributes to the existing research in four broad. First, I build on prior studies by examining the relationship between learning-related social skills and math achievement through third grade. This study seeks to clarify and establish the importance of learning-related skills early in elementary school. Secondly, little is known about the pathway to which test of cognitive abilities lead to academic performance. I examine the relationship between executive functioning skills at 54 months and learning-related social skills in first, third and fifth grade in order to find a possible mechanism between cognitive skills and academic performance. Third, I explore the effects of persistent attention

problems through early elementary school and potential classroom-level protective factors that may help improve the outcomes of those with early or persistent difficulties. Finally, I use a large, longitudinal dataset to examine the effects of the timing of attention problems.

CHAPTER 2

LITERATURE REVIEW

To situate this study in the context of early learning and school readiness, this chapter provides an overview of learning-related skills, executive functioning, and classroom-level factors to early academic success. Given the importance of early experiences on school readiness, an abundance of studies have addressed the importance of preschool factors that predict long-term academic success (e.g., Becker et al., 2014; Duncan et al, 2007; Viterbori et al., 2015). Over the last couple decades, researchers from several different universities have focused their efforts on investigating important early childhood factors using a large, nationally representative, longitudinal dataset sponsored by the National Institute Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development (SECCYD). Results from studies by the NICHD research network emphasize the importance of family-level factors such as early maternal sensitivity, parenting, and stimulation (Belsky, Fearon, & Bell, 2007; Gazelle & Spangler, 2007); external factors such as preschool quality and income (Belsky et al. 2007; Mistry et al., 2004); and individual-level factors such as self control, attention, and emotional regulation (e.g., Campbell & Stauffenberg, 2009). This dissertation builds on the NICHD research network studies to examine the co-relationship between executive functioning skills at the individual-level, classroom-level factors, and classroom learning skills during the preschool through elementary school years.

Three theoretical principles guide this dissertation. First, I work under the framework that early school readiness skills are important long-term school success. Second, I argue for the importance of learning-related social skills and executive

functioning skills in early childhood and for subsequent academic success. Finally, I draw from research on the importance of classroom-level factors such as teacher-student relationships, teacher instructional characteristics, and peer influences on learning behaviors and academic performance.

According to the Ecological and Dynamic model of transition (Rimm-Kaufman & Pianta, 2000), the transition to formal schooling is a big change for many children due to the increased demands in academic performance and behavioral self-regulation as they enter kindergarten. Consequently, successful transition between preschool and kindergarten requires a dynamic interaction between the teacher, peers, neighborhood, and family (see Figure 2.1). The knowledge and skills children possess and demonstrate as they enter kindergarten is an important predictor for later academic achievement (e.g., Blair & Razza, 2007; Bull & Scerif, 2010; Bull et al., 2011; Duncan et al., 2007; Poniz et al., 2009; Valiente et al., 2008). An array of factors such as income, stress, maternal education, self-control, and individual differences in cognitive abilities such as intelligence and executive functioning have received the most attention in the school readiness literature. Another area that continues to garner a great deal of research attention is the importance of observable classroom behaviors that promote learning – often referred to as learning-related social skills (McClelland & Morrison, 2003). Learning-related social skills and other classroom-level factors (the peers and teacher effects in the model of transition) is the focus of this study.

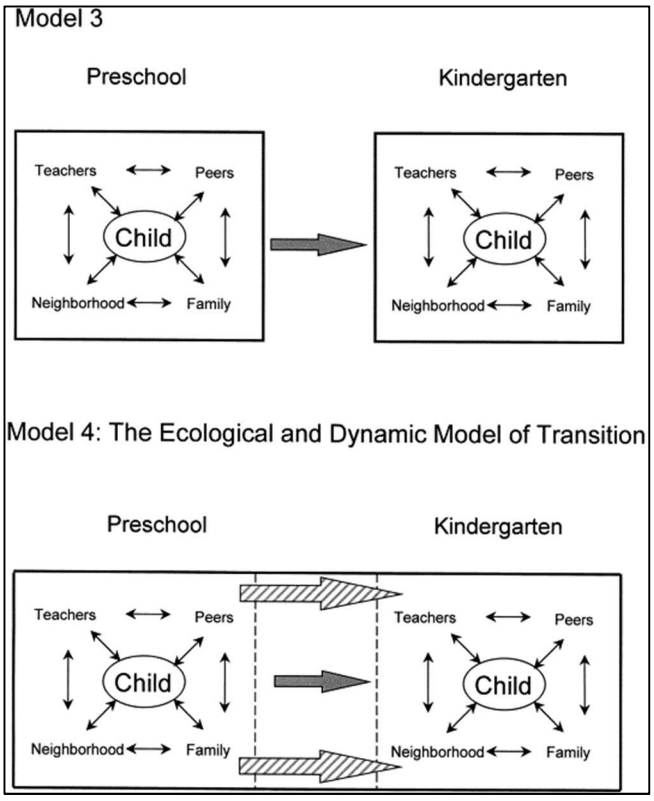


Figure 2.1. The Ecological and Dynamic Model of Transition. From Rimm-Kaufman & Pianta (2000)

Learning-Related Skills and Academic Achievement

In addition to cognitive and academic skills, an array of learning-related classroom behaviors are important for children's academic success (e.g., Fredricks et al., 2004; Rimm-Kaufman, 2015). Although learning-related behaviors have been defined in a variety of ways, most studies have either focused on general social behaviors or have differentiated two different social behaviors: learning-related social skills and interpersonal skills (Cerda, Im, & Hughes, 2014; Cooper & Farran, 1988 & 1991; Putwain, Sander, & Larkin; 2013). While general social skills, such as interpersonal skills, may be important for learning, social skills that are more closely related to learning, such as engagement on academic tasks, uniquely predict academic performance (Cooper & Farran, 1998; McClelland et al., 2000). Further, learning-related social skills such as initiating tasks, and behavioral regulation

contribute to student learning beyond more general cognitive skills and intelligence (McClelland et al., 2000; von Suchodeoletz et al., 2009). For example, the learning-related social skills of self-discipline in the classroom accounted for more than twice as much as the variance as IQ when predicting academic school grades and school attendance in middle school (Duckworth & Seligman, 2005).

For the purpose of this study, we refer to the collection of classroom behaviors directly associated with academic learning as "learning-related skills (McClelland et al, 2000)". Learning-related skills reflect a set of integrated behaviors important for academic success, including self-regulation and social competence in an academic environment. Self-regulation skills include the ability to monitor and adapt one's own thinking and behaviors in order to accomplish a goal such as an academic task (Dinsmore et al., 2008; Fox & Riconscente, 2008). While social competence skills include behaviors such as responsibility, independence, and cooperation with others (Morgan et al., 2011; Razza, Martin, & Brooks-Dunn, 2015), learning-related skills also comprise of a cognitive component, including skills such as attention and emotional control (e.g., NICHD ECCRN, 2003); listening to instructions and compliance with teacher demands (Foukls & Morrow, 1989); involvement in the classroom and classroom rules (Bronson, Hauser-Cram, & Warfield, 1995); and mastery behaviors, such as organization, behavioral regulation, and self-direction. Although learning-related skills stem from a cognitive root, these skills are a social manifestation of these cognitive processes, making them readily observable (McClelland, Acock, & Morrison, 2006). However, because they are a manifestation of cognitive processes, the precise sources of these behaviors are difficult to narrow down. Three observable learning-

related skills are discussed in the following sections: classroom engagement, attention problems, and work habits.

Classroom Engagement. Engagement in the classroom requires a combination of behavioral, emotional, and cognitive skills (Reshley & Christensen, 2012). Behavioral engagement refers to the active participation in academic and social activities, whereas emotional engagement includes the affective responses to other people and the activities at school. Cognitive engagement refers to students' attention and effort in learning academic material and demonstrating skills. Observable behavioral engagement is considered particularly important for academic success in elementary school and middle school (Buhs & Ladd, 2001; Reyes et al., 2012; Valiente et al., 2010). Students that are engaged in the classroom exhibit active participation, effort, and persistence on academic tasks (Fredricks et al., 2004). For example, engaged students are seen writing notes, asking and answering questions, reading aloud, and talking about academics (e.g., Greenwood, 1996).

Because students who are academically engaged are more likely to inhibit some behaviors and activate attention to learning tasks, they are afforded more opportunities to respond to and attempt tasks, which result in greater learning and higher academic performance (e.g., Blair & Razza, 2007). Indeed, young children's engagement in the classroom is a strong predictor of academic performance (Singh, Granville, & Dika, 2002; NICHD Network, 2004; Ladd & Dinella, 2009). Kindergarten children who show greater classroom engagement also demonstrate steeper gains in academic achievement compared to their disengaged peers (McClelland et al., 2006). In fact, observable indicators of classroom engagement such as persistence on tasks, attention to teachers, and participation on group activities predicts academic performance beyond prior achievement in low-

functioning students (Hughes, Luo, & Loyd, 2008). In contrast, students who struggle academically tend to be disengaged, often failing to take advantage of academic engagement opportunities given to them (Thurlow, Yesseldyke, Graden & Algozzine, 1984). Finally, classroom engagement skills are also considered to be strong mediators between students' knowledge or skills and their academic performance, as students may underperform despite adequate knowledge if they are not engaged on the tasks (Bohlman & Downer, 2016). Classroom engagement is associated with another important learning-related behavior – attention.

Attention. The ability to attend relevant aspects of a task is an important precursor to or a sub-component of learning-related behaviors. In order to engage in a learning task, a student must first devote sufficient levels of attention to that task. The level of observed attention to the learning tasks is predictive of performance on academic tasks in elementary school children (e.g., Duncan et al., 2007; Fredricks et al., 2004; Hughes & Kwok, 2007; Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009; Reyes, et al., 2012). Further, the ability to control and regulate attention during the preschool years appear to be predictor early literacy and mathematics achievement in Kindergarten, particularly among children from low-income families (Blair & Razza, 2007; Duncan et al., 2007; von Suchodoletz et al., 2013). Effective attention skills are also a precursor to another important learning-related skill-classroom work habits.

Work Habits. Children's work habits encompass a broad array of skills, such as working independently, time management, and the organization of work material. These types of work habits have been found to be predictive of academic success (Zimmerman & Kitsantas, 2014). Fantuzzo and colleagues (2007) found that persistence, motivation, and

positive attitudes toward learning in preschool were strong predictors of subsequent Kindergarten academic performance.

The Development of Learning-Related Skills

To better understand the complexity and importance of learning-related skills, it is important to understand the development of these skills during early childhood and elementary school. The preschool ages between three and five years of age has garnered a great deal of interests for educational researchers for two main reasons. First, the preschool years are a formative time, preparing children for school entry. Numerous studies have highlighted the importance of a variety of early learning-related skills for future academic performance and social outcomes (e.g, Duncan & Magnuson, 2011). Second, the preschool years is of special interest because of the rapid neurological development that occurs during this stage, particularly, in the prefrontal cortex, which-among other areas of the brain- is associated with the self-regulation skills such as executive functioning (e.g., Zelazo & Frye 1998).

Early Childhood/Preschool Years. During the preschool years, children's learning-related skills may be manifested as emotional school engagement, with children developing an interest for learning and learning-related activities. At this age, children are typically engaged in tasks that bring them positive emotions such as joy, pleasure, or interest (e.g., Couse & Chen, 2010; Flecher & Reese, 2005). Children's interest in the classroom activities help direct students attention to a given stimulus and encourages participation to the task, which in turn is associated with academic performance in elementary school (Alexander et al., 1993; Flecher & Reese, 2005; Ladd & Dinella, 2009).

Another way to conceptualize children's early learning-related skills is related to their future-oriented behaviors (Atance & Jackson, 2009). As children prepare for formal schooling, they begin for formulate the idea of planning and beyond the present. For example, children begin to understand that the only way they would get want they want is to engage in an undesirable activity in the present. Using a Mental Time Travel (MTT) protocol for studying children's future oriented skills, Busby and Suddendorf (2005) found significant improvements between he ages of three and five. As children progress through the preschool ages, are better able to plan and follow through with the plans.

Elementary School Years. As children progress into first grade, their classroom learning-related social skills such as the ability to plan, evaluate, and self-regulate learning increase and becomes a strong predictor of subsequent academic performance (e.g., Normandeau & Guay, 1998). The growth in learning-related social skills coincide with the increasing difficulties of academic tasks and classroom demands. As children progress through elementary and middle school, they are expected to participate in activities and complete tasks that they don't find interesting. As a result, the ability to engage in effective learning-related social skills requires a more complex combination of various cognitive and social skills that tap into higher levels of self-control and discipline is required to be successful in school (Marks, 2000).

Executive Functioning and Learning-Related Skills

Learning-related behaviors in the classroom may be a function of several different factors. In the following sections, we highlight three possible contributors: executive functions, social influences, and classroom influences.

Many learning-related skills are grounded in individual differences in cognitive skills associated with the self-control or self-regulation of thinking. More specifically, executive functioning skills have been discussed as a contributing factor to learning-related skills. Successful engagement on learning tasks requires the willingness and ability to exert adequate levels of effortful control of attention and persistence on the academic task at hand (e.g., Pagaani, Fitzpatrick, & Parent, 2012). This includes the ability to focus attention on the relevant aspect of a task and resist the temptations of distractions and other possibility more interesting environmental stimuli and sustain appropriate levels of attention until the completion of the task. The theoretical concept of attention and the modulation or effortful control of attention is more broadly described as executive functions (EF).

One of the challenges that emerged in the review of research is that the construct of EF is broad and characterized by both unity and diversity (Miyake et al., 2000; Weibe et al., 2011). Although the definition of EF tends to vary by the discipline and perspective of the researcher, many common elements such as the ability to modulate or control attention, inhibitory control, and working memory, are present in most definitions (e.g., Rothbart, Sheese, & Posner, 2007; Miyake et al., 2000). Stronger executive functioning skills are associated with greater attentional and inhibitory control, which is often manifested as higher level of persistence, vigilance, and performance on academic tasks (Putnam & Rothbart, 2006).

Different EF skills such as attention modulation, inhibitory control, and processing speed during preschool have been associated with later academic achievement (Blair & Razza, 2007; Fuchs et al., 2005; Geary et al., 2007). A recent study of British elementary school students by found that a collection of executive functioning skills - including

inhibitory control, attention control, perceptual sensitivity, and low intensity pleasure -was associated with observed classroom engagement during the first year of school (Yang & Lamb, 2014).

Skills within the executive functioning network are given much attention due to their importance for self-regulation of behaviors, including the ability to maintain and control attention (Kaplan & Berman, 2010). Children's ability to monitor and manage attention plays an important role in the regulation of these behaviors. For example, during a given task, children focus their attention on their own performance in order to adapt their actions as needed and control their behaviors while resisting behaviors that are counterproductive for their goal.

Recent studies have attempted to untangle the importance of different EF skills of success in different academic and behavioral skills. For example, attentional control-the ability to activate, shift, and sustain adequate attention-appear to be the underlying factor that supports higher-level cognitive skills (Kaplan & Berman, 2010). Alternatively, inhibitory control appears to be important in early academic achievement and social skills (Blair & Razza, 2007; De Weerdt, Desoete, & Roeyers, 2013). Indeed, in children as young as preschool, EF skills such as inhibitory control and working memory have found to be distinct from attention tasks, as measured by the Continuous Performance Task (Allen et al., 2015). This dissertation focuses on three areas of EF: sustained attention, attention shifting or attention control, and delay of gratification.

According to a simple information processing model of cognition (Atkinson & Shiffrin, 1968), attention is a gatekeeper or bottleneck that controls what is consciously in our short-term memory at a given moment, thereby allows us to focus on specific aspects of

our world and consciously process information. The degree of effort required to control and sustain attention is malleable and improves developmentally throughout early childhood (Kaplan & Berman, 2010; Moors & De Houwer, 2006; Zelazo, 1998). Successful attention control involves the complementary skill of inhibitory control, the ability to prevent irrelevant information or responses from disrupting performance (e.g., Zelazo et al., 2004). In other words, to successfully attend to and complete a task, children must simultaneously attend to relevant information while filtering out irrelevant information and temptations that may distract us from completing that task. Children are often faced with this challenge when required tasks become more difficult or uninteresting, creating a desire to quit and stop (Willingham, 2009).

The management and control of attention and inhibitory control is considered a self-regulatory process that controls an individual's ability to modulate both thinking and behaviors. Similar to the central executive component in Baddeley and Hitch's (1974) model of working memory, the executive attention network is responsible for the modulation of attention in order to manage information in both long-term memory such as the rules or parameters for task, and the information in short-term memory. For example, when a student is required to complete a homework assignment but would rather watch a television program, his or her attention must shift from the desire to watch television, towards the important aspects of the homework assignment. Further, the student needs to sustain adequate attention to the task at hand until it is completed while preventing the desires to do other, more enjoyable activities from controlling attention and behaviors. In this sense, the executive attention network is important for regulating one's emotions and behaviors on goal-directed behaviors (Rothbart, Sheese, & Posner, 2007 Reuda, Postner;

Rothbart, 2005). This network develops rapidly during the preschool and early elementary school ages (Reuda et al., 2004).

Sustained Attention. Sustained attention refers to activating and sustaining attention to relevant information in order to complete a goal. Sustain attention is associated with success on many academic skills (Sarter et al., 2003; Choudhury & Gorman, 2000) and behavioral regulation skills (Eisenberg et al, 2005; NICHD ECCRN, 2003). In the classroom, adequate sustained attention is required to follow directions from the teacher, selecting, focus on relevant information of a task, and persisting on the task in the midst of distractions (e.g., Rothbart & Posner, 2005; Zelazo & Muller, 2002). It is a contributing a factor in the ability to form, plan, and complete goal-directed tasks (Ruff & Rothbart, 1996). One potential mechanism that explains the relationship between EF and academic skills is to conceptualize learning-related skills as a mediator – executive functioning skills improve learning-related skills, which in turn improve academic performance. First, sustained attention is associated with persistence and diligence and is therefore considered an important aspect of self-regulation, social-emotional functioning, and academic performance (McClelland et al., 2010). For example, results from a large-scale, longitudinal dataset indicated that attention skills in Kindergarten, as assessed by teacher observation ratings of behaviors, is a strong predictor of the trajectory or growth in classroom engagement from 1st grade to 6th grade (Pagani, Fitzpatrick, & Parent, 2012).

Secondly, classroom engagement skills are associated with higher academic performance. An early study of classroom engagement found that high-achievement students are engaged in academic-related tasks approximately 75% of the time, whereas the

lower-achieving students were observed to be engaged approximately 51% of the time (Frederick, 1977).

Thirdly, there is also a strong relationship between sustained attention and academic performance. For example, a longitudinal study of 430 children found that parents' ratings of children's ability to sustain attention for a long duration, or attention span-persistence, predicted math and reading achievement, even when controlling for math skills at age seven (McClelland et al., 2013). Additionally, children with longer sustained attention spans in preschool were 48.7% more likely to complete college by age 25 (McClelland et al., 2013). Furthermore, the persistence aspect of attention is important when students have to marshal the perseverance through difficult, complex tasks (Andersson & Bergman, 2011).

Difficulties with sustained attention during early elementary school can result in future difficulties in mathematics, reading and writing into the adolescent ages (Daley & Birchwood, 2010; Rodriguez et al., 2007). Attention problems in preschool classroom are also associated with increasing likelihood of disruptive behaviors (Campbell, 1994). One survey study found that inattention is more detrimental on academic achievement in elementary school compared to problems related to hyperactivity (Buamgaertel, Wolraich, & Deitrich, 1995). Children with deficit with inattention are four to five times more likely to be placed in special education services and use more supplemental services in the school setting (LeFever, Villers, Morrow, & Vaughn, 2002; Jensen & Kenny, 2004). Also, the quality of sustained attention skills interacted with intelligence to predict academic performance in adolescence suggesting that attention skills may be more important for those with lower intellectually abilities (Steinmayr, Ziegler, & Trauble, 2010).

Although a strong association exists between sustained attention and school success, less is known about the dynamics between these skills. For example, do early deficits in sustained attention persists into later childhood and adolescence or do these skills develop differentially into childhood? How does the growth of attention skills interact with classroom behaviors and learning?

Attentional Control and Shifting. Attentional control is the ability to modulate and, shift, attention as needed. Attentional control consists of a variety of processes and consists of different networks that serve different functions. These networks are identified by the different aspects of the brain that is being activated during a given tasks. One neurocognitive model of attention recognizes three different attention functions based on brain networks that are activated during different tasks: (1) activating and sustaining attention, (2) orienting attention and selecting the source of stimulation, and (3) regulating thoughts, emotions, and action (Posner & Peterson, 1990). This last function is related to what Posner and colleagues (1997) refer to as the executive attention network that involves the anterior cingulate and lateral prefrontal cortex areas of the brain and is responsible for attention control when goals and demands conflict with desires and preferences (Botwinick et al., 2001; Rothbart, Sheese, & Posner, 2007). In a large study using six longitudinal datasets, Duncan and colleagues (2007) found that math abilities, reading skills, and attention skills when children enter kindergarten are the strongest predictors of math and reading achievement through 3rd grade. (Campbell & von Stauffenberg, 2009; Sonuga-Barke, Dalen, & Remington, 2003). One possible explanation for this relationship may be that young children with attention control problems are more likely to a lack of persistence on challenging academic tasks (Brown, 2009).

One prerequisite for the attentional control is inhibitory control. Inhibitory control is an aspect of attentional control that refers to the ability to refrain from responding impulsively to prepotent or unprompted stimuli. Inhibitory control is considered to be part of the executive attention network. Problems with inattention may also impede children's ability to process and determine effective strategies during an academic learning task (Blair & Razza, 2007). Relatedly, shifting refers to an individuals' ability to flexibly focus attention to different aspects of a task by filtering out the task-irrelevant aspects (Anderson, 2002). The Stroop task (Stroop, 1935) is an example of a commonly used measure that demonstrates the construct of attention shifting and inhibitory control. In the original Stroop task, participants are shown several color words that are printed in a different ink color, so the word "red" may be printed in blue ink. Individuals must name the ink color rather than reading the word. Thus the stroop task requires individuals to inhibit the typical response of reading, then shift their attention to relevant features of the stimulus, the ink color. For young nonreaders, the day/night task may be used as a measure of attention shifting and inhibitory control (Gerstadt, Hong, & Diamond, 1995), whereby children were asked to say the opposite of what is shown in a target picture.

Inhibitory control is often required in the classroom environment, as children must resist temptations in order to engage in and complete tasks that are not of their choosing. They must ignore distractions and irrelevant information. Indeed, children's inhibitory control in the primary grades has been associated with adaptive skills in the classroom such as "working hard" and "behaving well" as assessed by the classroom teacher (Vuontela et al., 2013). Furthermore, preschoolers' performance on cognitive measures of inhibitory control has been associated with emergent math and reading skills (Epsy et al., 2004; Fuches

& McNeal, 2013; McClelland, et al., 2007). The contributions of inhibitory control to school achievement may be direct, but it may also be indirect, contributing to the self-regulation, which in turn impacts academic performance (Monette, Bigras, & Guay, 2011).

Similarly, attention shifting is important for classroom success, particularly in transitioning between activities, working on multi-step tasks, and refocusing attention back to work after an interruption or distraction. The ability to shift attention in early elementary school is associated with fewer externalizing problems (e.g., Eisenberg et al., 2000) more pro-social classroom behaviors (Wilson, 2003), better self-regulation skills (Valiente et al., 2010), and higher academic achievement (Kieffer, Vukovich, & Berry, 2013) independent of other executive functioning skills such and other cognitive skills such as intellectual skills (Bull et al. 2011).

Inhibitory control skills play a role in academic performance both directly and indirectly. Inhibitory control may be considered a supplementary skill to sustained attention and is often more detrimental than problems in sustained attention (Rodriguez et al., 2007). Young children's ability to control behavioral responses, including inhibiting natural responses in associated with math performance. For example, preschool-aged children's performance on the Head-to-Toes, which requires children to inhibit the natural responses and instead perform an opposite task, is associated with performance on emergent reading and math tasks (McClelland et al., 2007). In another study, researched found that performance on a cognitive measure of inhibitory control-the continuous performance task-is associated with math performance in preschool, independent of language skills and other executive functioning skills (Epsy et al., 2004).

Inhibitory control may also indirectly impact academic skills. A study of preschool-aged children found that inhibitory control skills may moderate the relationship between number sense skills (approximate number system acuity) and math performance (Fuchs & McNeal, 2013). The relationship between inhibitory control and academic achievement may be mediated through other observable behaviors. In studies of executive functioning and academic achievement, working memory seems to be the strongest direct main or direct predictor of academic achievement. Inhibitory control appears to help control or regulate behaviors, which in turn impacts academic performance (Monette, Bigras, & Guay, 2011).

Delay of Gratification. Another EF skill associated with learning-related behavior is the delay of gratification or the ability to postpone immediate pleasures in order to complete the task at hand. One popular way to measure delay of gratification in children is with the use of the Marshmallow task (Mischel, Shoda, & Peake 1988), in which children are given the choice of eating a marshmallow or waiting for the examiner to return and have two marshmallows. Performance on this task is associated with both individual differences in other EF skills, such as observed attention and inhibitory control, future-oriented planning skills, as well as intelligence as measured by memory and vocabulary (Atance & Jackson, 2009; Duckworth, Tsukayama, & Kirby, 2013). Children with difficulty in delaying gratification tend to spend less time on academic tasks and have weaker academic achievement than their peers who are more skilled at delaying gratification (Brock, Rimm-Kaufman, & Wanless, 2014).

Although performance on the delay of gratification task is thought to reflect deficient inhibitory control and executive functioning (Duckworth et al., 2013), others have argued that performance may reflect children's understanding of the task and their expectations

about the results (Mischel & Staub, 1965). A child who has experienced neglect or broken promises may be more skeptical of the task and fail, not due to a lack of self-control, but due to a lack of faith or foresight. For example, preschool-aged children waited longer in the Marshmallow task for the experimenter to return when the conditions were reliable rather than unreliable (Kidd et al., 2013). Although several factors may contribute to delay of gratification performance, EF is still a likely contributor to success on this task (Carlson, 2005)

The Development of Executive Functioning Skills During Early Childhood

The preschool period is a time marked by rapid development in children's executive functioning skills and prefrontal cortex of the brain (Anderson, 2008; Braken, Jones, Rothbart, & Posner, 2003; Garon et al., 2008). Indeed, neuropsychological studies have found that the rate of development of executive attention skills is related to the maturation of frontal lobe areas of brain (e.g., Miyake et al., 2000). Although complex EF skills continue to develop into adolescence, the most rapid growth happens during early childhood into elementary school ages (Best, Miller, & Naglieri, 2011). Because different types of EF skills may development at different rates, the following sections discuss each of the skills separately. This topic is of interest because the individual differences in the timing and rates in which children's attention and inhibitory control skills develop may impact school readiness and performance in school (McClelland et al, 2007; NICHD Network, 2003).

The Development of Sustained Attention and Inhibitory Control. The development of the executive attention network corresponds with the development of and frontal lobes of the brain (Zelazo, 2008). The childhood years between the ages for three and seven have been identified as a period of rapid growth in the executive attention network (Davidson,

Amso, Anderson & Diamond, 2006; Williams et al., 1999). Between the ages of two and four, children develop the ability to override inappropriate responses during conflict tasks (Gerardi-Caulton, 2000).

Although attention and inhibitory control skills work in conjunction, they develop independently and at different times throughout childhood. Attentional control processes such as sustained attention are precursors to behavioral inhibitory control processes (Friedman et al., 2007). Indeed, young infants demonstrate selective attention skills long before inhibitory control as evidenced by their preference to focus on novel or interesting stimuli through the preferential looking task paradigm (Markant, Cicchetti, Hetzel, & Thomas, 2014; Mayer & Dobson, 1982). Inhibitory control skills begin to be apparent as young children begin to understand rules, expectations, and consequences. These rules or expectations are first verbally stated as a reminder, and then becomes more internalized as inner speech as the child develops both language skills and cognitive maturity (Vygotsky, 1964). The first sign of toddlers' inhibitory control is the compliance to other's instructions. When toddlers are obedient, they are resisting the impulse to do as they please and completing a different goal. In line with other types of EF skills, the most rapid development of basic inhibitory control appears to occur during the preschool year. In a study of the accuracy and response time on the day/night task in children between that ages of 3.5 to 11 years, the greatest improvement on the day night task seen between the ages of 3.5 to five (Simpson & Riggs, 2005). Between the ages of three and four years old, children begin to find success on tasks that introduce conflict (Gerardi-Coulton, 2000). By the time children reach the age of four they are able to inhibit natural responses and respond in ways that conflict or are incongruent with the given stimulus.

The rates and trajectories of the development of attention are still debated in extant literature. Some studies suggest that the development of sustained attention, measured by the Continuous Performance Task (CPT), seems to develop most rapidly between the ages of four to six (Levy, 1980), while other studies using the same measure of sustained attention found that the greatest growth occurs between ages eight to 10, followed by a slower increase between ages of 10 and 13 (Rebok et al., 1997; Lin, Hsiao, & Chen, 1999). Studies using the CPT with children ages six to 16, was found to be non-linear (Greenberg & Waldman, 1993; Lin, Hsiao, & Chen, 1999), with another study using a novel selective reaching task found that inhibitory control skill develop rapidly between the ages of six to eight and then plateaus at about age 10 (Klimkeit et al., 2004). Furthermore, researchers using a Go-No-Go tasks found that children demonstrate substantial growth in inhibitory control between the ages of six and eight followed by a leveling of performance between the ages of 10 to 12 (Becker, Isaac, & Hynd, 1987). The time require to stop an unwanted to unprompted prepotent response appears to develops rapidly in childhood and is stable through early adolescence and adulthood (Williams et al, 1999).

The development of attention and inhibitory control also depend on the complexity of the task that requires attention. For example, studies using the Dimensional Change Card Sort Task suggests that the age in which the child is able to modulate one's own attention is dependent on the number of rules or restrictions that need to be simultaneously managed (Diamond, Carlson, & Beck, 2005; Zelazo, 2006). Research using the CPT with young children and adolescents also found a nonlinear relationship with age where the number of false alarms decreases rapidly between the ages of six and 9 and beings to level off at about age 10 (Lin, Hsiao, & Chen, 1999).

Persistent Problems with Sustained Attention and Inhibitory Control

Difficulties in inhibitory control are a risk factor for learning and social-emotional difficulties among elementary school-aged children (Gilmore et al., 2013; Liew, 2013; Lubin et al., 2013). Poor inhibitory control, which is associated with difficulties in impulsivity, results in limited behavioral regulation and greater externalizing problems (Choe, Olsen, &Y Sameroff, 2014; Kim et al, 2012). Indeed, improvements in impulsivity is associated with lower rates of internalizing problems such as anxiety and depression (Eisenberg et al., 2009).

Although attentional skills develop rapidly through the preschool years and may be predictive of long-term academic success, not all young children with attention problems follow the same developmental trajectory through childhood and adolescence (Hetchtman, 2000; Pagani, Fitzpatrick, & Parent, 2012). Young children with inattention and impulsivity difficulties typically follow one of three developmental trajectories (Hechtman, 2000). Approximately one quarter of children with ADHD later function comparably to their age-matched control peers. However, most children continue to experience challenges related to ADHD in adulthood, with over half still presenting symptoms as young adults and fewer than one quarter developing severe emotional and behavioral problems in adulthood.

The timing of when children are behind or "catch-up" to peers may also be important. This would provide insight on the timing of interventions and prevention efforts of attention problems during early childhood. For example, children whose attention problems were unresolved by second grade experienced greater academic difficulties in reading and math through fifth grade compared to their peers whose attention problems were resolved by the end of first grade (Rabiner, Carrig, & Dodge, 2013). Similarly,

children whose attention problems diminished tend to have improved classroom engagement throughout elementary school (Pagani, Fitzpatrick, & Parent, 2012).

Social Factors to Learning Related Behaviors

We adopt a transactional model of development when conceptualizing the development of learning-related skills, where children's individual development in different domains results of an interaction between child's individual characteristics and their social environments (Sameroff & Mackenzie, 2003). The social, instructional, and organizational climate of the schools may influence student engagement (e.g., Eccles et al., 1998). Environmental factors may be lead to differences in engagement within an individual student in any given day (Fuligni et al., 2012; Vitiello et al., 2012). The experience of attending formal schooling may impact children's cognitive skills such as executive functioning (Diamond, 2000) and cognitive flexibility (Yeniad et al., 2014) for different reasons. For example, although students with deficits in attention and inhibitory control perform lower on reading and math compared to their counterparts, placement into special education program strongly predicted the academic growth trajectories in elementary school (Bussing et al., 2012). This suggests that the type of classroom and program in schools may be a moderator in the relationship between inhibitory control and academic performance.

Broadly speaking, students' perceptions of and relationships with their teachers and with peers are important factors to school success in early elementary school (Vitiello et al., 2012). In fact, one study found that students' self-regulation mediate the relationship between positive emotions about the classroom environment and academic achievement (Mega, Ronconi, & De Beni, 2014). In the next section, we review research on how peers

and teachers impact children's learning-related behaviors in preschool and elementary school.

Teachers and Learning-Related Behaviors. It should come to no surprise that teachers are extremely influential in children's learning in the classroom setting. Teachers are a source of support and guidance in children's social, cognitive, and academic development during the elementary school years and may spend more time working with children than any other adult. Preschool and Kindergarten teachers are often children's first encounter with a classroom teacher (Rimm-Kaufman & Pianta, 2000). These early experiences are critical for setting the stage for their interactions with future teachers. Consequently, the relationship between the teacher and student can influence children's development. Elementary school-aged children who engage in positive and warm interactions with teachers tend to perform stronger academically. Indeed a positive relationship with teachers has been found to contribute to academic engagement and achievement not just concurrently, (Graziano et al., 2007), but also in the subsequent year, which in turn, contributes to reading and math performance three years later (Hughes, Lujo, Kwok, & Loyd, 2008). In contrast, students who perceived their teachers to be over-controlling and detached to their students were more likely to be off task (Hambre et al., 2008). Teacher sensitivity also helps children with different social skills and temperament engage in academic tasks (Rimm-Kaufman et al., 2002). Further, supportive teachers may better support students with low effortful control skills on academic performance in early elementary school (Liew, Chen, & Hughes, 2010).

Teacher-student relationship may also have a moderating effect on academic performance. A recent study by Blair and colleagues (2016) found that students from low-

income families and those with low math abilities during preschool showed vast improvements in mathematics when they experienced positive student-teacher relationships during Kindergarten. On the contrary, students with low math abilities during preschool and poor student teacher relationship showed poor math performance in kindergarten. Student-teacher relationships in preschool also moderated the relationship between early EF skills and externalizing problems such as the hyperactivity and impulsivity (Gaziano, et al., 2016).

Teachers may also help improve children's engagement in tasks by creating an environment ideal for optimal cognitive functioning. For example, reducing potential stressful situations may improve student performance. Children who experience stressful situations, as indicated by increases in cortisol levels, demonstrate a decrease in cognitive functioning (Blair et al., 2011) and that a moderate level of stress is optimal for cognition (e.g., Arnsten, 2009). In fact, the level of cortisol measured in young children moderated the effects of high-quality preschools on cognitive functioning, where children with low-levels of cortisol showed increases in executive functioning as a result of preschool experience (Berry et al., 2014). This study employed a composite of several attention and working memory measures as a composite for executive functioning, therefore, less is known about the contributions of individual executive functioning skills such as sustained attention and impulse control. Furthermore, providing opportunities for student choice in activities, to the extent feasible, have also been shown to improve young children's levels of attention and engagement on tasks (DiCarlo, Baumgartener, Ota, & Geary, 2016).

Teachers can also help support children's engagement and learning by creating a supportive and organized environment. High-quality elementary school classrooms are characterized by high levels of teacher support and organized management that use

proactive approaches to discipline, predictable routines, clear expectations, and hands-on child-centered activities with appropriate amount of scaffolding (Hambre & Pinata, 2007). Teachers that used effective classroom management strategies and organized routines in instructional learning format were more likely to report higher levels of inhibitory control skills in children (Hambre et al., 2014). A study in preschool classrooms found that children with most engaged with the task and with peers when they were given a greater amount of choice in the activity (Vitiello et al., 2012). This positive relationship extended into elementary schools and was also found in children with low levels of self-regulation skills upon school entry (Rimm-Kaufman, et al., 2009). The benefit of high-quality teachers may also be relevant in at the preschool classroom (e.g, Early et al., 2007; Peisner-Feinberg et al., 2001). Some of the core principles of a successful program such as the Abecedarian programs include the emphasis on structured and predictable classrooms, encouragement from teachers, and stable support from the teacher (Ramey, Sparling, & Ramey, 2011). Positive teacher practices may also be important in Kindergarten where many children first experience the classroom. In fact, a study in a Kindergarten classroom found that a classroom quality composite that includes emotional support, classroom organization, and instructional support, predicted later reading mediated through classroom behavioral engagement (Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). This suggests that a supportive and well-structured classroom environment may increase student engagement, which ultimately supports academic performance.

Peers and Learning-Related Behaviors. Peers and social interactions in the school setting also play a role in learning-related behaviors. Peers are a source of emotional reassurance, safety, and support (Hartup, 1993) leading children to change their behaviors to

be consistent with those of their peers. For example, when peers increase in their classroom engagement over time, one's engagement in classroom activities also tend to increase in a similar manner, even when controlling for teacher-level factors (Kinderman, 2007). Further, first grade children tend to show higher levels of classroom engagement when they are in larger groups (Lan et al., 2009). Studies have also demonstrated a positive relationship between children's sense of belonging and perception of social ties and their subsequent engagement in the classroom (e.g., Wentzel, 1997; Capella et al., 2013). This relationship, however, does not provide insight on the underlying mechanisms or influences on how a network of peers' level of engagement changes.

Children with impaired inhibitory control and sustained attention are more likely to have social problems and be rejected by peers (Bacchini, Affuso, & Trotta, 2008; Schacht, & Barkley, 2010). For example, the externalizing behavior problems associated with ADHD such as impulsivity become less accepted by peers as the child gets older (e.g. Rubin, 1993), which may lead to social isolation and disengagement from school. The persistence of attention problems into adolescents may increase the likelihood of having friendships with peers who are considered deviant (Barkely, 2006) which may lead to further behavior problems. Consequently, persistent challenges with inattention and impulsivity may become exponentially more of a problem when as young children become older.

Despite difficulties with sustained attention and inhibitory control, young children may succeed in the classroom when provided with the proper support, guidance, material, and instruction. Studies suggest that the classroom quality of the classroom environment is associated not only with students' level of aggression toward others and peer relations, but also their ability to adequately focus on academic tasks (Barth et al., 2004). These

classroom factors may be even more important for students at-risk for learning academic difficulties (Hambre & Pianta, 2005). Classroom-level support factors can be considered from three perspectives: emotional, organizational, and instructional (e.g., Hamre, Pianta, Mashburn, & Downer, 2007). Teachers who effectively use organizational and instructional strategies create a classroom environment that promotes engagement and student achievement. Tasks are uninteresting can be detrimental to students' growth and learning (Curby, Rimm-Kaufmann, and Poniz, 2009).

CHAPTER THREE
DATA & METHODS

Participant Sample

The data for this dissertation are drawn from the Study of Early Child Care and Youth Development (SECCYD) from the National Institute of Child and Human Development (NICHD Early Child Care Network, 1994). The SECCYD is a nationally-representative dataset collected over four phases in ten sites across the United States: Little Rock, AR; Irvine, CA; Lawrence, KS; Boston, MA; Philadelphia, PA; Pittsburgh, PA; Charlottesville, VA; Morgantown, NC; Seattle, WA; and Madison, WI. The total number of participants in the initial wave of data was 1,364, which represents 52% of the original recruited sample. Data collection for the NICHD SECCYD began in 1991 and then continued at multiple later time points. A comparison of the sample with the United States census data in 1991 indicated that the SECCCYD sample were generally better educated, more likely to receive public assistance, and consisted of less Hispanic participants (NICHD Early Child Care Research Network, 2001). This dissertation draws data from the following six data-collection time points: 54 months, kindergarten, 1st grade, 3rd, grade, 4th grade, and 5th grade.

Handling of Missing Data

For a variety of reasons, data were missing on several of the key variables in this study. Only 26% of the sample included data on all they key variables at every time point. In order to address potential problems of missing data, a Markov Chain Monte Carlo (MCMC) multiple imputation method was utilized for multiple variables. A summary of demographic statistics is found on Table 3.1.

Table 3.1
Demographic Information of Sample (N=702)

	Percent/Mean	Range	Standard Deviation
Male	53%	--	--
White	78%	--	--
Hispanic	14%	--	--
Maternal Education (in yrs).	14.39 yrs.	7-21	2.56
Income-Needs Ratio	3.59	0.9-20.2	2.74

Note: Maternal education is the number of years mother attended school. The income-needs ratio is an average between the years when the child was born to 54 months of age.

Measures

Learning-Related Social Skills.

Three learning-related social skills were included in our analysis: observed classroom engagement, classroom work habits, and observed concentration problems in the classroom. The following instruments were used to measure each learning-related skills.

Classroom Engagement was operationalized with the *Classroom Observation System* (COS) (Pianta et al., 2008) in 1st, 3rd, and 5th grade. Researchers observed target children in time interval cycles of where they observed participants for 30 seconds and recorded data for 30 seconds in each cycle. Each participant was observed for 10 segments with eight observations cycles in each segment. Among other behaviors, students' engagement during academic tasks were coded as positive/neutral, highly positive, or negative. For this analysis, the proportion of time the student was observed as being highly positively engaged is used as a measure of observed engagement.

Work Habits. Students' work habits in 1st, 3rd, and 5th grades were rated by classroom teachers using the *Mock Report Card (MRC;* Vandell & Pierce, 1998). The MRC consists of 37-items, each based on a 5-point Likert-Scale ranging from 1= "below grade level" to 5="excellent." A composite scale of six items, including questions about child's

ability to follow classroom procedures, work independently, work neatly/carefully, use time wisely, complete work promptly, and keep material organized, was used to create the Work Habits subscale (please see Appendix A for the items). This scale had a maximum possible score of 30 and yielded high internal consistency with a Cronbach's alpha of .95.

Classroom Attention Problems. The Inattention Problems composite of the *Teacher Report Form* (Achenbach, 1991) was used as a norm-referenced rating scale of children's attention problems. Teachers rated children's behaviors on a scale of 1 to 3, with higher scores reflecting greater attention problems. The 20 items of the Inattention Problems composite are presented in Appendix A. The score was the standardized T-score that has mean of 50 and a standard deviation of 10. Higher T-scores indicate greater observed attention problems in the classroom.

Executive Functioning Measures

Three tasks were used to assess different areas of executive functioning- The Continuous Performance Task, Delay of Gratification Task, and the Stroop Task.

Sustained Attention. The *Continuous Performance Task* (CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1965) was given at 54 months, first grade, and fourth grade as a measure of sustained attention. This is a lab-administered, direct measure of sustained attention that is often used to assess children with attention-deficit hyperactivity disorder (Hooks, Milich, & Lorch, 1994; Lin, Hsiao, & Chen, 1999). In this computer-administered task, children were required to quickly press a button only in response to target stimuli. Target stimuli were presented randomly within each of the 22 presented blocks of stimuli. This task taps students' ability to not only initiate action and activate attention as needed, but also resist or inhibit pressing the button when non-target stimuli are presented. Omission

errors, or misses, occurred when participants failed to respond when the target was presented and reflects difficulties activating and sustaining attention. Commission errors, or false alarms, occurred when participants responded to non-target items and are thought to reflect failures in inhibitory control. Measures of both initiating and impulsivity derived from the CPT had an adequate test-retest reliability (r = .65 to .74) (Halperin et al. 1991). For this dissertation, we calculated and used a d' score that accounts for both omission and commission errors. The d' value for each participant was calculated by subtracting the z-score of the false alarm rate from the z-score of the hit rate (MacMillan & Creelman, 2004).

Attention Shifting. The *Children's Stroop Task* (Gerstadt, Hong, & Diamond, 1994) was administered when children were 54 months old. In this task, participants were shown 18 cards with pictures of either a night scene or a day scene. When they were shown the picture of the night scene, they were to say "day" and when they were shown the picture of the day scene, they were to say "night", thus tapping into their ability to inhibit natural responses and respond in a conflicting manner. Of particular interest were the 10 trials in which the cards switched from night scenes to day scenes, or from day scenes to night scenes. The score was the number of correct responses, with the maximum possible score being 10.

Delay of Gratification. The ability to delay gratification was assessed at 54 months by a version of the Mischel & Ebbesen's (1970) Marshmallow task. In this task, children first selected candy, animal crackers, or pretzels as their preferred food. They were shown a large quantity and small quantity of their selected food, and the examiner confirmed that the large quantity is more desirable. Children were told they could eat the small quantity of food immediately, or if they waited until the examiner returned to the room, they could have a

greater quantity. The number of minutes waited the child waited until eating the food or the summoning of the examiner was recorded. Children who waited the full seven minutes for the examiner to return before eating the treat were coded as passing the task, while those who did not were coded as failing the task. A variable that indicated pass or fail on this task is primarily used this dissertation.

Mathematics Achievement

The Applied Problems subtest of the *Woodcock-Johnson Tests of Achievement-Third Edition (WJ-R,* Woodcock & Johnson, 1989) was administered *at* 54 month, first grade, & third grade, and fifth grade as a standardized, norm-referenced measure of math achievement. Two scores were sued in this analysis: the standard scores, which reflect children's performance relative to their peers, and the weighed scores (W-scores) which reflects achievement based on the difficulty of the items. The Applied problems subtest has Cronbach alpha coefficients ranging from .81 and .83 and test-retest reliabilities ranging from .80 to .87 across 54 months through 5^{th} grade (Woodcock & Johnson, 1989).

Memory

The Memory for Sentences subtest of the *Woodcock-Johnson Tests of Cognitive Abilities (WJ-R,* Woodcock & Johnson, 1989) was administered *at* 54 month as a standardized, norm-referenced measure of rote memory. On this task, children were verbally given sentenced and asked repeat what they heard. Children were scored on the accuracy of their memory for sentences. Standard scores, which reflect children's performance relative to their peers, were used in this analysis.

Vocabulary

The Picture Vocabulary subtest of the *Woodcock-Johnson Tests of Cognitive Abilities-Revised (WJ-R,* Woodcock & Johnson, 1989) was administered *at* 54 month as a standardized, norm-referenced measure of receptive vocabulary. On this task, children were shown a variety of pictures and one word for each trial. The task was to identify which picture accurately depicted the word that they heard. Standard scores, which reflect children's performance relative to their peers, were used in this analysis. The picture vocabulary yielded a Cronbach alpha coefficient of .84 (Woodcock & Johnson, 1989).

Preschool and Kindergarten Classroom-Level Variables

To examine the possible moderation and mediation effects on preschool skills, several, kindergarten classroom-level variables were included in this analysis.

Classroom Practices Inventory. The *Classroom Practices Inventory* (CPI; Hyson, Hirsh-Pasek, & Rescorla, 1990) measures the level of organization and stimulation observed in the preschool classroom. The CPI is a 23-item observation measure that evaluates the emotional climate, peer interactions, and child-focused instructions in the preschool classroom. The CPI is based observation cycles on six different interval points and yielded an internal reliability coefficient of .96 and an inter-rater reliability coefficient of .86 (see Appendix A). The overall CPI composite score is used in this dissertation.

Teacher-Student Relationship. The Student Teacher Relationship Scale (STRS) measures teachers' perceptions of the quality of their relationships with their students using a 15-item rating scale completed by the teacher, shown in Appendix A. In this analysis, we used the composite score that addresses the perceived conflict and closeness with each student. The maximum score was 35, with higher scores reflecting better relationships with

students. This scale has a high internal-reliability coefficient of .91 (Pianta & Steinberg, 1992).

Social Skills. Teachers rated children's social skills in Kindergarten using the Social Skills Rating System (SSRS; Pianta, 1992). The SSRS is a 39-item rating scale that as three broad social subscales: cooperation, assertion, and self-control. A sample of the items are presented in Appendix A. Each item was scored on a three-point scale rating from "never" to "very often." The maximum score was 60, with higher scores indicating stronger social skills. The social skills total score yielded internal consistency reliability coefficient of .93 (Gresham & Elliott, 1990).

Family-Level Covariates.

Income-Needs Ratio. The income-to-needs ratio was used as one of two measures of socioeconomic status. The income-to-needs ratio is calculated by dividing the total family income by the poverty threshold for a family of the same size using figures from the U.S. Census Bureau in 1991. A ratio less than one indicates poverty status and ratios five and above indicate relative affluence. We used the mean income-to-needs ratio for each child between the ages of one month to 54 month.

Maternal Education. Because maternal education is a predictor of children's biological and psychological development (e.g., Walker et al., 2011), we included the number years of education the mother has completed as a covariate and an additional indicator of socioeconomic status.

A summary of the data collection schedule is found on Table 3.2.

Table 3.2
Data Collection Schedule

Grade **Variables**	**54 Months**	**Kindergarten**	**First Grade**	**Third Grade**	**Fourth Grade**	**Fifth Grade**
Executive Functions	CPT Delay of Gratification Stroop Task		CPT		CPT	
Learning-Related Skills			Classroom Observation Engagement Attention Problems	Classroom Observation Engagement Attention Problems		Classroom Observation Engagement Attention Problems
Covariates	Mathematics Memory Vocabulary	Social Skills Teacher-Student Relationship Classroom Practices/ Environment	Mathematics	Mathematics		Mathematics

CHAPTER FOUR:
RESULTS

Descriptive Results

Descriptive statistics of the analytic sample at the five different time points are presented on Table 4.1. Overall, children tended to be more engaged than not in the classroom. The Classroom Observation System (COS) results revealed that children were observed as being actively engaged between 52% and 67% of the time. Repeated-measures ANOVA analysis comparing active engagement at the three time points suggested that engagement in first grade was significantly lower than at third and fifth grade, $F(2, 353) = 56.76$, $p<.001$. The results of the Teacher Report Form of attention problems are based on standardized T-scores with higher scores indicating higher levels of attention problems in the classroom. Repeated ANOVA results indicated that teachers' ratings of observed attention problems were moderately different across the three grades, with overall ratings being the lowest in first grade, $F(2,352) =6.31$, $p<.01$. Grade comparisons of performance on the CPT suggest that children at 54 months exhibited higher levels of omissions errors and commissions errors, compared to first and fourth graders. Direct comparisons of CPT omission and commission errors were not possible because of the different number of target and total items and the three different time points. Results of a repeated-measures ANOVA analysis across the three time points suggest that children's d' scores on the CPT between 54 months, first grade, and fourth grade were not significantly different ($p=.21$). Next, observed work habits were stable across the three time points, with no significant differences between the three grades ($p=.19$).

On the delay of gratification task, 20% of the analytical sample failed by either eating the smaller treat or calling for the examiner before the seven-minute time limit.

Finally, the WJ-R is presented as Standard Scores on the Applied Math, Memory for Sentences, and Picture Vocabulary subtests of the Woodcock Johnson Psychoeducational Battery-Revised (WJ-R), where a score of 100 is considered average when compared to others at their age level. Performance on the vocabulary and memory tasks was considered average, whereas performance on the math subtest was on the average to high average range when compared to the national norms.

Table 4.1
Descriptive Statistics of Classroom Engagement, EF Skills, and Applied Mathematics by Grade

	54 month	First Grade	Third Grade	Fourth Grade	Fifth Grade
% Active Engagement	--	58%	52%	--	67%
SD	--	16.6%	15.0%	--	13.2%
Range	--	12-100%	0-97.4%	--	18.8-95.0%
Work Habits (Max=30)	--	23.04	21.12	--	21.91
SD	--	6.14	5.96	--	5.61
Range	--	6-30	6-30	--	8-30
Attention Problems	--	53.91	54.94	--	54.14
SD	--	4.34	6.54	--	5.08
Range	--	50-79	50-94	--	50-89
CPT Omission Errs	8.28	1.85	--	3.23	--
SD	7.63	2.89	--	3.79	--
Range	0-43	0-24	--	0-26	--
CPT Commission Errs	9.54	4.42	--	6.74	--
SD	14.44	8.29	--	10.89	--
Range	0-113	0-91	--	0-136.00	--
Delay Gratification: %Fail	20%	--	--	--	--
Stroop Switch	7.27				
SD	2.61				
Range	0-10				
WJ-Memory SS	91.76	--	--	--	--
SD	18.39	--	--	--	--
Range	29-160	--	--	--	--
WJ- Picture Vocabulary SS	102.90	--	--	--	--
SD	15.09	--	--	--	--
Range	29-163	--	--	--	--
WJ- Applied Math SS	102.58	110.81	118.44	--	114.81
SD	15.11	17.14	12.72	--	14.47
Range	41-153	46-160	71-144	--	60-160

Note: Means or percentages reported. SD=Standard Deviation. Engagement and Active is based on the proportion engaged as measured by the Classroom Observation system. SD and ranges for engagement are given in percentages. Work Habits are the total raw score of teacher ratings on the Mock Report Card. TRF is the Teacher Report Form and is the teacher ratings of attention problems reported as T-Scores with a maximum score of 100. The WJ-Memory is the Memory of Sentence subtest. Standard Scores for WJ Memory and Picture Vocabulary are reported. Mean Standard Scores on the Woodcock-Johnson Applied Math standard scores are reported.

Correlations Among Key Measures

In order to examine the relationship and stability of executive functioning and learning-related behavior measures, we calculated pairwise correlations of the work habits,

observed engagement, observed attention problems, sustained attention skills, delay of gratification, and attention shifting skills (see Table 4.2). The correlations between the teacher ratings of work habits skills between first to fifth grades yielded moderate correlations coefficients ranging between .31 and .60. The correlations among observed classroom engagement across the grades were lower than those of work habits with coefficients ranging from .02 to .22 suggesting less consistency between the grades first to fifth grade. The teacher ratings of attention problems were moderately correlated with coefficient ranging from .44 and .48 and relatively stable between first grade, third grade and fifth grade.

Next, we examined the relationship between the three learning-related skills at first, third, and fifth grade. While the correlations between the three measures were low in first grade, ranging from .05 to -.14, the correlations between the measures increased throughout the grades. Specifically, the correlations between work habits and attention problems were the high in third and fifth grades, r=.73

Next, we examined the relationship among the executive functioning (EF) variables. The correlation between CPT at 54 month and time waited on the delay of gratification task was moderate yielding a coefficient of -.30.

Finally, we compared the relationship among the learning-related behaviors and EF across the grades. The relationship between work habits in the classroom and EF skills were relatively low to moderate. The correlations between work habits and CPT in third and fifth grades ranged from .23 to .32. The classroom engagement variables at the three time points and EF variables resulted in low correlations with coefficients ranging from .01 to .27. Finally, the relationships between inattention problems in the classroom and EF skills

ranged from -.21 to -.29, reflecting moderate correlations. The relationships among the variables are further examined in the following sections using regression analysis.

Table 4.2

Pairwise Correlations between Variables (N=702)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Work Habits 1st	-												
2. Work Habits 3rd	0.31*	-											
3. Work Habits 5th	0.32*	0.60*	-										
4. Engagement 1st	0.02	0.05	0.02	-									
5. Engagement 3rd	0.10	0.29*	0.17	0.13	-								
6. Engagement 5th	0.12	0.28*	0.33*	0.02	0.22*	-							
7. Attn. Probs. 1st	-0.14*	-0.49*	-0.47*	-0.01	-0.21*	-0.20*	-						
8. Attn. Probs. 3rd	-0.23*	-0.73*	-0.48*	-0.02	-0.22*	-0.24*	0.48*	-					
9. Attn. Probs. 5th	-0.26*	-0.52*	-0.73*	-0.02	-0.17*	-0.29*	0.44*	0.48*	-				
10. CPT 54 Mo.	0.17*	0.33*	0.28*	0.05	0.14	0.13	-0.25*	-0.23*	-0.29*	-			
11. CPT 1st	0.12*	0.30*	0.27*	0.07	0.15*	0.15*	-0.25*	-0.25*	-0.26*	0.29*	-		
12. CPT 4th	0.14*	0.32*	0.25*	0.01	0.11	0.27*	-0.21*	-0.22*	-0.25*	0.27*	0.45*	-	
13. DOG -54 mo.	0.15*	0.25*	0.23*	0.06	0.09	0.09	-0.23*	-0.24*	-0.24*	0.30*	0.14*	0.19*	-
14. Stoop Switch – 54	0.05	0.11*	0.05	0.02	0.04	0.05	-0.12	-0.06	-0.05	0.14*	0.11*	0.13*	0.12*

Note: * p<.05 Work habits are teacher ratings. Engagement is based an observation of classroom engagement. Attention problems are based on teacher ratings and the CPT is the d' score on the Continuous Performance Task. DOG is the number of seconds waited on the delay of gratification task and Stoop is performance on switch trials of the attention-shifting task.

Research Question 1: Which learning-related skills and executive functions predict Math performance?

The first set of regression analysis aimed to identify specific executive function skills at 54 months and learning-related skills in first grade that predict math performance in first and third grade. To account for any differences between the ten data-collection sites, each pair of models was estimated and their standard errors were clustered by the data collection site for each of the three dependent variables: engagement, work habits, and classroom attention problems. A step-wise regression model was used in order to examine the variance explained by prior math, the EF variables, and the learning-related skills. The following equations represent the different regression models where the MATH outcomes were measured at first grade and third grade:

(1) $MATH_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \varepsilon$

(2) $MATH_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \beta_6 MATH54 + \varepsilon$

(3) $MATH_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \beta_6 MATH54 + \beta_7 ENGAGE + \beta_8 ATTNPROBS + \beta_9 WORKHABITS + \varepsilon$

(4) $MATH_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \beta_6 MATH54 + \beta_7 ENGAGE + \beta_8 ATTNPROBS + \beta_9 WORKHABITS + \beta_{10} CPT + \beta_{11} DOG + \beta_{12} STROOP + \varepsilon$

The first model examines the relationship between mathematics in first and third grade and all the covariates – gender, income, maternal education, memory at 54 months,

and vocabulary at 54 months. In the second model, math at 54 months was added to the first model in order to estimate the role of prior math on later math performance. In Model 3, each of the learning–related skills were included in the analysis. Finally, in Model 4, the three executive functioning variables - sustained attention, delay of gratification, and attention shifting- were added to the regression model. The same four models were estimated twice, once with first grade math as the dependent variable and the second with third grade math as the dependent variable. All the regression analyses were adjusted using Bonferroni corrections to provide a more conservative estimate of significance and reduce the likelihood of Type I errors.

The results of the regression analyses are summarized on Table 4.3. The results of Model 1 suggest that males performed .24 standard deviations higher than females on mathematics in first grade. Memory and vocabulary skills at 54 months also appeared to be important factors mathematics performance in first grade. When we controlled for prior mathematics at 54 months in model 2, it accounted for approximately 14% of the variance in first grade math performance, even when controlling for gender, memory, vocabulary and other covariates. The results of the third regression model indicated that teacher ratings of attention problems predicted first grade math performance independent of other learning-related skills, prior math, and covariates. A one standard deviation increase in attention problems was associated with a .14 standard deviation decrease in first grade math performance. Finally, EF skills at 54 months only accounted for 1% of the variance in first grade math performance. Although sustained attention at 54 months predicted first grade math performance, its contributions did not remain when controlling for all the covariates and classroom learning-related skills.

Table. 4.3
Step-Wise Linear Regression Results of Individual Factors Predicting First Grade Math Achievement

	(1) Math	(2) Math	(3) Math	(4) Math
Male	0.24***	0.30***	0.30***	0.31***
	(0.06)	(0.07)	(0.05)	(0.06)
Income-Needs	0.04	0.02	0.02	0.02
	(0.06)	(0.01)	(0.01)	(0.01)
Maternal Education	0.05*	0.02	0.02	0.02
	(0.02)	(0.02)	(0.04)	(0.01)
WJ Memory – 54 months	0.28***	0.16***	0.15***	0.13***
	(0.02)	(0.03)	(0.03)	(0.03)
WJ Vocabulary – 54 months	0.23***	0.10	0.09*	0.09*
	(0.04)	(0.04)	(0.04)	(0.04)
WJ- Math 54 months		0.48***	0.47***	0.44***
		(0.04)	(0.04)	(0.04)
Engagement –First Grade			0.03	0.02
			(0.03)	(0.03)
Work Habits–First Grade			0.00	0.00
			(0.04)	(0.03)
Atten. Problems-First Grade			-0.15***	-0.13***
			(0.03)	(0.06)
CPT d' 54 Months				0.24
				(0.13)
DOG Fail 54 Month				0.00
				(0.01)
Stroop Switch at 54 months				0.00
				(0.01)
Constant	-1.81***	-0.62***	-0.53	-0.68**
	(0.05)	(0.06)	(0.04)	(0.04)
N	702	702	702	702
R^2	0.29	0.43	0.44	0.45
ΔR^2	--	0.14	0.01	0.01

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Standardized coefficients presented. Standard errors in parentheses. Maternal Education is in years. Engagement is an observation of engagement during academic tasks, while the Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary.

Next, I used the same regression models to examine the predictors of third grade mathematics achievement. The results of the linear regression analysis suggested that the pattern was similar to the first grade outcomes. Males continued to outperform females in mathematics by .22 standard deviations, even when controlling for all EF variables, learning-related skills and child-level covariates (See Table 4.4). Additionally, vocabulary skills at 54 months moderately predicted third grade math performance, independent of covariates and prior math performance. Math skills at 54 months accounted for approximately 10 % of the variance in third grade math performance. Learning-related skills accounted for three percent of the variance, with attention problems being the strongest predictor. A one standard deviation increase in attention problems ratings was associated with .15 standard deviation lower math scores in third grade.

Table. 4.4
Step-Wise Linear Regression Results of Individual Factors Predicting Third Grade Math Achievement

	(1)	(2)	(3)	(4)
	Math	Math	Math	Math
Male	0.15*	0.20***	0.21***	0.22***
	(0.06)	(0.06)	(0.06)	(0.06)
Income-Needs	0.03	0.02	0.02	0.02
	(0.01)	(0.01)	(0.01)	(0.01)
Maternal Education	0.04*	0.02	0.01	0.01
	(0.02)	(0.01)	(0.01)	(0.01)
WJ Memory – 54 months	0.20***	0.10*	0.09*	0.09
	(0.03)	(0.03)	(0.03)	(0.03)
WJ Vocabulary – 54 months	0.27***	0.16***	0.15***	0.14*
	(0.04)	(0.03)	(0.03)	(0.03)
WJ- Math 54 months		0.39***	0.37***	0.38***
		(0.04)	(0.04)	(0.04)
Engagement –First Grade			0.03	0.03
			(0.03)	(0.03)
Work Habits–First Grade			0.04	0.04
			(0.03)	(0.03)
Atten. Probs.-First Grade			-0.15***	-0.15***
			(0.03)	(0.03)
CPT d' 54 Months				0.01
				(0.13)
DOG Fail 54 Month				0.06
				(0.06)
Stroop Switch at 54 months				0.02
				(0.01)
Constant	-1.77***	-0.45***	-0.37	-0.52**
	(0.21)	(0.20)	(0.20)	(0.23)
N	679	679	679	679
R^2	0.27	0.37	0.40	0.40
ΔR^2	--	0.10	0.03	0.00

Note:* *p<.05, ** p<.01, *** p<.001*
Standardized coefficients presented. Standard errors in parentheses. Maternal Education is in years. Engagement is an observation of engagement during academic tasks, while the Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary.

The teacher ratings of attention problems and work habits appeared to have non-normal distribution based on quintile analysis of normality (see Figure 4.2 for Attention Problems). As a result, we created a dichotomous variable using (Grimm et al., 2010) classification using T-scores. High attention problems were considered students with T-scores greater than 60. We also created a dummy variable for work habits, with scores greater than one standard deviation above the mean being considered to have high work habits.

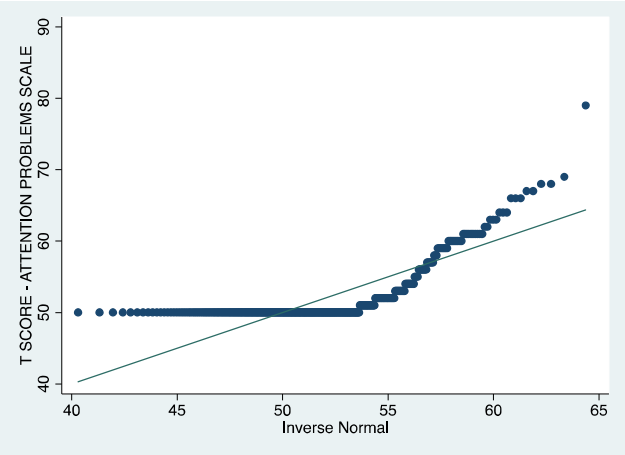


Figure 4.1. *Quintile analysis of Normal Distribution for Teacher Ratings of Attention Problems*

The results from this analysis resulted in similar findings with high attention problems the first grade classroom being associated with .55 standard deviation lower scores in math in first grade and .32 standard deviations lower in third grade (Table 4.5).

Table. 4.5

Regression Results of Individual Factors Predicting First Grade & Third Grade Math Achievement Using Dummy Variables for Work Habits and Attention Problems

	First Grade			Third Grade		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	Math	Math	Math	Math	Math
Engagement –First Grade	0.02		0.01	0.02		0.02
	(0.04)		(0.03)	(0.04)		(0.04)
High Work Habits–First	-0.08		-0.04	0.08		0.06
	(0.10)		(0.09)	(0.04)		(0.04)
High Attention Probs.-First	-0.55***		-0.28**	-0.32***		-0.14*
	(0.07)		(0.08)	(0.06)		(0.05)
CPT d' 54 Months		0.22***	0.00		0.19***	0.07
		(0.05)	(0.05)		(0.06)	(0.05)
CPT d' First Grade		0.01	0.02		0.03	0.00
		(0.05)	(0.04)		(0.04)	(0.05)
Stroop-Switch 54 Months		0.02	-0.03		0.04	0.03
		(0.05)	(0.09)		(0.04)	(0.03)
DOG Fail 54 Month		-0.16*	-0.03		-0.16	-0.11
		(0.10)	(0.08)		(0.09)	(0.08)
WJ Memory – 54 months		0.24***	0.13*		0.16***	0.07
		(0.05)	(0.05)		(0.05)	(0.04)
WJ Picture Vocab – 54 months		0.19***	0.07		0.23***	0.12**
		(0.05)	(0.05)		(0.05)	(0.04)
Male			0.27**			0.26**
			(0.08)			(0.08)
Maternal Education			0.03			0.04
			(0.02)			(0.02)
Income-Needs Ratio			-0.02			0.01
			(0.02)			(0.01)
Math-54 Months			0.42***			0.32***
			(0.05)			(0.04)
Constant	0.43	0.25***	-0.63	0.12	0.20	-0.92*
	(0.07)	(0.06)	(0.30)	(0.04)	(0.05)	(0.28)
N	701	701	701	701	701	701
R^2	0.08	0.24	0.43	0.09	0.22	0.38

Note:* *p<.05, ** p<.01, *** p<.001*

Standardized coefficients presented. Standard errors in parentheses. Engagement is an observation of engagement during academic tasks. Work habits and Attention problems are dummy variables. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary. Maternal Education is in years.

Research Question 2: What are the Preschool predictors Learning-Related Skills in First Grade?

In order to examine the relationship between individual executive functioning skills at 54 months and first grade learning-related behaviors, the following pair of linear regression models were estimated for each of the three learning-related skills- engagement, work habits, and attention problems:

(1) $LEARNING_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \varepsilon$

(2) $LEARNING_y = \beta_0 + \beta_1 MALE + \beta_2 INCOME\text{-}NEEDS + \beta_3 MATERNALED + \beta_4 MEMORY + \beta_5 VOCAB + \beta_6 MATH54 + \beta_{10} CPT + \beta_{10} CPT + \beta_{11} DOG + \beta_{12} STROOP + \varepsilon$

To account for any differences between the ten data-collection sites, each pair of models was estimated and clustered by the data collection site for each of the three dependent variables: engagement, work habits, and classroom attention problems. The first model examined how the covariates predicted each of the learning-related skills. The second model added the three EF skills to examine the relationship between each of the EF skills and learning-related skills when controlling for other factors. The two models were conducted twice for each of the three learning-related skills – once for first grade and once for third grade outcomes.

The results of the regression analyses suggest that females have stronger work habits than males by approximately .36 standard deviations, even when controlling for other factors. Second, although the three EF skills accounted for less than two percent of the variance in work habits and classroom engagement, they accounted for about five percent of

the variance in attention problem. In particular, sustained attention at 54 months and first grade was a strong predictor of attention problems in first grade.

Table. 4.6
Linear Regression Results Predicting First Grade Classroom Work Habits and Attention Problems in First Grade

	(1) Work Habits	(2) Work Habits	(3) Attention Problems	(4) Attention Problems
Male	-0.36***	-0.36***	-0.04	-0.09
	(0.08)	(0.08)	(0.07)	(0.07)
Income-Needs	0.04*	0.04	-0.02	-0.01
	(0.02)	(0.02)	(0.01)	(0.01)
Maternal Education	0.05	0.04	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
WJ Memory – 54 months	0.01	0.01	-0.05	-0.03
	(0.05)	(0.05)	(0.04)	(0.04)
WJ Vocabulary – 54 months	0.07	0.06	-0.08	-0.09
	(0.05)	(0.05)	(0.04)	(0.04)
WJ Math 54 Months	0.05	0.00	-0.13**	-0.05
	(0.05)	(0.06)	(0.05)	(0.05)
CPT d' 54 month		0.09		-0.11**
		(0.05)		(0.04)
CPT d' – First Grade		0.03		-0.13**
		(0.05)		(0.04)
DOG Fail – 54 Months		-0.08		0.16*
		(0.09)		(0.07)
Stroop Switch – 54 Months		-0.01		0.01
		(0.04)		(0.03)
Constant	-0.57	-0.53	0.51	0.28
	(0.30)	(0.31)	(0.23)	(0.24)
N	701	701	701	701
R^2	0.10	0.12	0.09	0.14
ΔR^2	--	0.02	---	0.05

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Standard errors in parentheses. Standardized regression coefficients presented. Engagement is an observation of engagement during academic tasks, while the Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary. Maternal Education is in years.

When the same regression models above were analyzed to predict third grade learning-related behaviors, a similar pattern emerges (see Table 4.7). Females continued to out-perform males on work habits in third grade. Sustained attention skills was still a strong predictor of work habits and classroom ratings of attention problems in third grade, accounting for approximately four to five percent of the variance in these behaviors. One standard deviation increase in sustained attention at 54 months was associated with a .14 standard deviation increase in work habits and a .09 standard deviation decrease in attention problems.

Table. 4.7

Linear Regression Results Predicting Third Grade Classroom Work Habits and Attention Problems in Third Grade

	(1) Work Habits	(2) Work Habits	(3) Attention Problems	(4) Attention Problems
Male	-0.37***	-0.31***	0.01	-0.04
	(0.07)	(0.07)	(0.07)	(0.07)
Income-Needs	0.04*	0.03	-0.02	-0.02
	(0.01)	(0.01)	(0.01)	(0.02)
Maternal Education	0.05*	0.04	-0.05**	-0.05*
	(0.02)	(0.02)	(0.02)	(0.02)
WJ Memory – 54 months	0.09*	0.06	-0.05	-0.02
	(0.04)	(0.04)	(0.04)	(0.04)
WJ Vocabulary – 54 months	0.07	0.06	-0.08	-0.08
	(0.04)	(0.04)	(0.04)	(0.04)
WJ Math 54 Months	0.17***	0.08	-0.14**	-0.08
	(0.05)	(0.05)	(0.05)	(0.05)
CPT d' 54 month		0.14**		-0.09*
		(0.04)		(0.04)
CPT d' – First Grade		0.16***		-0.15***
		(0.04)		(0.04)
DOG Fail – 54 Months		-0.13		0.18*
		(0.07)		(0.07)
Stroop Switch – 54 Months		0.02		0.01
		(0.04)		(0.04)
Constant	-0.57	-0.41	0.78	0.60
	(0.24)	(0.28)	(0.25)	(0.26)
N	701	701	679	679
R^2	0.20	0.25	0.12	0.16
ΔR^2	--	0.05	---	0.04

Note: * *p<.05,* ** *p<.01,* *** *p<.001*

Standard errors in parentheses. Standardized regression coefficients presented. Engagement is an observation of engagement during academic tasks, while the Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary. Maternal Education is in years.

We again analyzed the dummy variables for work habits and attention problems and used logistic regression to examine the odds of having high work habits skills or high attention problems in first grade. The results of logistic regressions were similar to that of the linear regression above. Greater sustained attention skills as measured by the d' on the CPT is associated with moderately greater odds of having high work habits in first grade

with a one standard deviation increase in CPT scores associated with a 56% higher odds of having high work habits (see Table 4.8). The results also suggested that males are 61% less likely than females to have high work habits in first grade.

The results of logistic regression models 3 and 4 indicated that performance on the CPT moderately predicted having high work habits in first grade. However, when controlling for child-level factors, sustained attention was no longer a significant predictor.

Table. 4.8
Logistic Regression Results Predicting High First Grade Work Habit and Attention Problems

	(1) High Work Habits	(2) Work Habits w/ controls	(3) High Atten. Probs.	(6) High Atten. Problems w/ controls
CPT d' – 54 Mo.	1.56*	1.42*	0.63*	0.66
	(1.05)	(0.87)	(0.14)	(0.16)
DOG Fail – 54 Mo.	0.67	0.61	1.32	1.16
	(0.17)	(0.17)	(0.33)	(0.29)
Stroop-Switch	0.81	0.77	0.96	1.01
	(0.10)	(0.10)	(0.12)	(0.29)
WJ Memory – 54 months	0.85	0.83	0.88	0.96
	(0.11)	(0.12)	(0.11)	(0.13)
WJ Vocabulary – 54 months	0.90	0.85	0.84	0.92
	(0.12)	(0.12)	(0.11)	(0.13)
Male		0.39***		0.91
		(0.10)		(0.22)
Maternal Ed		1.22*		1.01
		(0.08)		(0.65)
Income-Needs		1.01		0.86*
		(0.08)		(0.05)
WJ Math 54 Mo.		0.85		0.76
		(0.14)		(0.12)
Constant	0.60*	0.06*	0.64	1.03*
	(0.10)	(0.06)	(0.10)	(0.93)
N	702	702	702	702
R^2	0.06	0.10	0.04	0.16
ΔR^2	--	0.04	---	0.07

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Odds Ratios Presented. Standard errors in parentheses. Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary. Maternal Education is in years.

The next analyses examined the predictors of high work habits and attention problems in third grade. The results of the logistic regression analysis suggest that sustained attention skills at 54 months as measured by d' on the CPT moderately predicted having higher attention problems in third grade. One standard deviation increase in performance on the CPT d' was associated with a 35% decrease in the likelihood of having high attention problems.

Table. 4.9
Logistic Regression Results Predicting High Third Grade Work Habits and Attention Problems

	(1) High Work Habits	(2) Work Habits w/ controls	(3) High Atten. Probs.	(6) High Atten. Problems w/ controls
CPT d' – 54 Mo.	1.41*	1.28	0.65*	0.65*
	(0.22)	(0.22)	(0.09)	(0.10)
DOG Fail – 54 Mo.	0.98	1.17	1.78*	1.61
	(0.25)	(0.16)	(0.56)	(0.12)
Stroop-Switch	1.22	0.96	0.96	0.95
	(0.16)	(0.13)	(0.12)	(0.12)
WJ Memory – 54 months	1.19	1.14	0.88	0.89
	(0.16)	(0.16)	(0.12)	(0.13)
WJ Vocabulary – 54 months	1.05	1.00	0.95	1.01
	(0.15)	(0.14)	(0.13)	(0.15)
Male		0.70		0.61
		(0.18)		(0.16)
Maternal Ed		1.02		0.91
		(0.07)		(0.06)
Income-Needs		1.04		0.96
		(0.05)		(0.05)
WJ Math 54 Mo.		1.18		1.07
		(0.19)		(0.17)
Constant	0.39***	0.30	0.39***	2.32
	(0.07)	(0.28)	(0.07)	(2.21)
N	678	678	678	678
R^2	0.03	0.10	0.06	0.08
ΔR^2	--	0.04	---	0.01

Note:* *p<.05, ** p<.01, *** p<.001*
Standard errors in parentheses. Standardized regression coefficients presented. Work Habits and Attention Problems are teaching ratings of classroom behaviors. DOG fail is a dummy variable indicting a failure to bass the delay of gratification task. WJ Memory refers to the rote memory on the Sentence Completion task and WJ Picture vocabulary is a standardized measure of Receptive Vocabulary. Maternal Education is in years.

A Mediation Analysis of Classroom Behaviors and Executive Functioning

The extent to which learning-related social skills in first grade mediated the relationship between executive functioning skills at 54 months and math achievement in third grade is presented in Figure 4.2. The mediation model yielded a Tucker-Lewis Index of .73, which is considered a poor fit, as values over .95 are considered a strong fit. The models also yielded a Root Mean Squares Estimation value of .077 which is considered a

moderate fit with values less than .05 being considered a strong fit (Hooper et al., 2008). Taken together, the results suggest that sustained attention, as measured by performance on the CPT at 54 months, was directly associated with math performance in third grade. However, the relationship between sustained attention at 54 months, and math in third grade was partially mediated by teacher ratings of attention problems in first grade. This suggests that students with greater levels of sustained attention at 54 month of age were less likely to be rated by their first grade teacher as having attention problems. Lower ratings of attention problems in first grade was associated with higher mathematics performance in third grade.

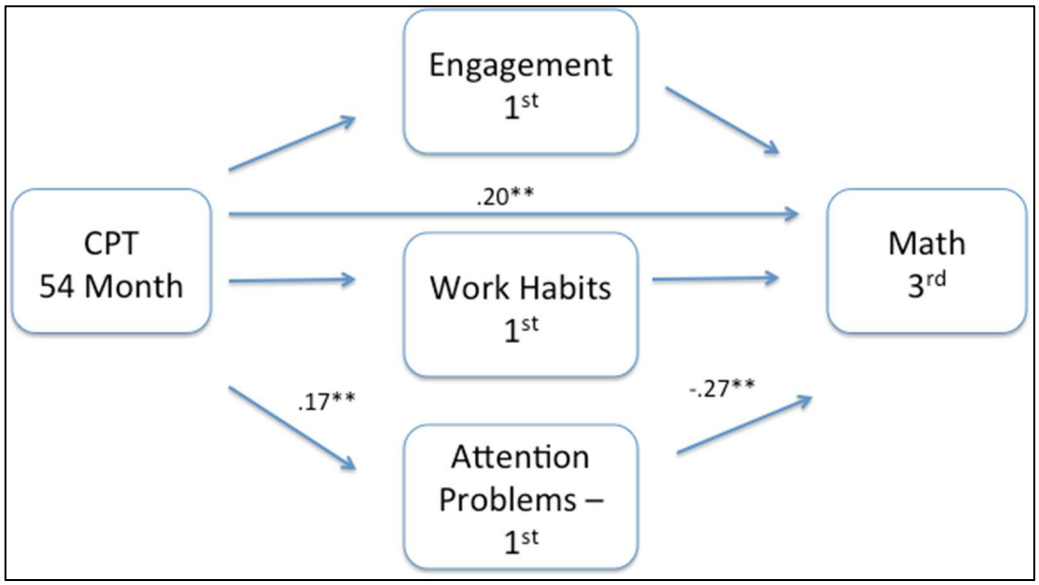


Figure 4.2. First Grade *Classroom Behaviors as Mediators Between CPT at 54 months and Math in Third Grade. Note:* Standardized coefficients presented. Only statistically significant pathways are presented **p<.01

We also examined the extent to which kindergarten factors such as teacher-student relationship and social skills mediated the relationship between CPT at 54 month and classroom learning-related behaviors. Using Barron and Kenny's (1986) mediation model, we tested the correlations between the direct path between EF and learning related social skills and the indirect path examining the path mediated by Kindergarten factors. The results

suggest that teacher-student relationship in Kindergarten did not mediate the relationship between sustained attention at 54 months and first grade attention problems (Figure 4.3). The relationship between the lab-based measure of attention problems, the CPT, and later attention problems in the classroom appeared to be more direct as indicted by Path C.

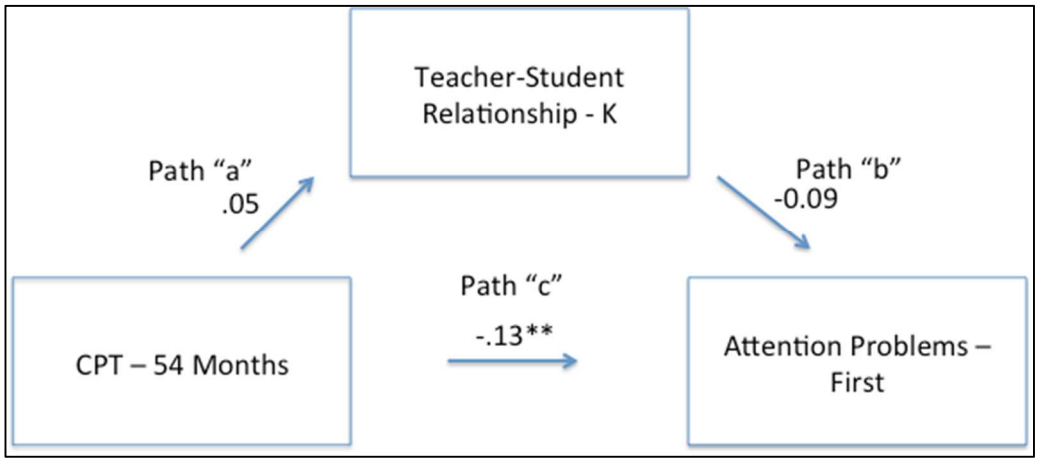


Figure 4.3. Student-Teacher Relationship Mediation Analysis.
** p<.05, ** p<.01, *** p<.001* Standardized coefficients presented. The regression models included individual-level control variables: gender, income, maternal and education.

Figure 4.4 presents relations among sustained attention at 54 months as measured by the CPT d', social skills in kindergarten, and teacher ratings of attention problems in first grade. We found that sustained attention at 54 months significantly predicted social skills in Kindergarten and attention problems in first grade. However, the relationship between CPT at 54 months and attention problems in first grade was partially mediated by children's social skills in kindergarten because the relationship between CPT at 54 months and Attention Problems remained significant, even when controlling for social skills in kindergarten.

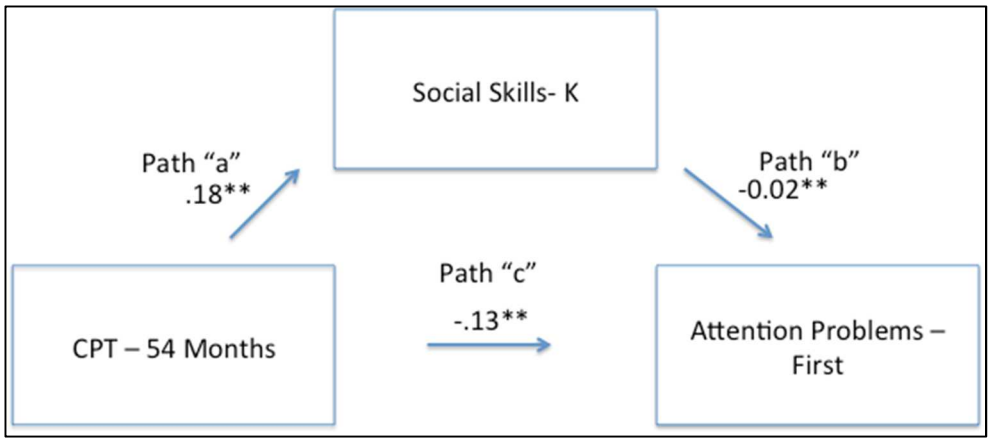


Figure 4.4. Social Skills Mediation Analysis.
Note: :* *p<.05,* ** *p<.01,* *** *p<.001* Standardized coefficients presented. The regression models included individual-level control variables – gender, income, maternal and education.

We calculated a third model to determine whether children's social skills in kindergarten mediates the relationship between CPT at 54 months, and teachers' ratings of attention problems in first grade, which is presented in Figure 4.4. The results suggest that social skills do not mediate the relationship between sustained attention and work habits in first grade.

The results of the mediation analysis between 54 months EF skills and 1st grade attention problems are summarized in Table 4.10. Overall, sustained attention at 54 months appears to be associated with both social skills in kindergarten and classroom attention problems in first grade and social skills partially mediated the relationship between CPT at 54 months and later attention problems.

Table. 4.10
Estimates of Path Models Used to Calculate Mediated Effects of Kindergarten Factors on Attention Problems in First Grade

	(1) Path a Teacher Relationship	(2) Path c Attention Probs.	(3) Path b Attention Prob.	(4) Path a Social Skills	(2) Path c Attn. Probs.	(6) Path b Attn. Probs.
CPT d'	0.05	-0.13**		0.18**	-0.13***	
	(0.10)	(0.10)		(0.05)	(0.04)	
Teacher Relationship			0.09			
			(0.02)			
Social Skills						-0.02**
						(0.00)
Intercept	-0.04	-0.01	-0.11	-0.08	0.01	0.08
	(0.06)	(0.06)	(0.11)	(0.11)	(0.06)	(0.08)
Constant	0.04	0.15	-0.04	-0.86*	0.15	0.53
	(0.07)	(0.11)	(0.05)	(0.38)	(0.11)	(0.27)
N	354	354	354	354	354	354
R^2	0.01	0.08	0.09	0.14	0.08	0.14

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Standard errors in parentheses. Standardized regression coefficients presented. Path "c" is the direct path and path "b" and "c" are the mediated paths.

Research Question 3: Do Kindergarten classroom-level factors protect against the negative effects of sustained attention problems at 54 months?

The next set of analyses investigated the role of preschool and kindergarten school-level factors in buffering the relationship between low sustained attention skills at 54 months and subsequent attention problems in the classroom. More specifically, this set of multiple regression analyses examined predictors of attention problems in first grade, including three preschool/kindergarten classroom-related factors as independent variables: classroom practices in preschool, social skills in kindergarten, and teacher ratings of

student-teacher relationship in kindergarten. Moderation terms for the interaction between sustained attention skills at 54 month and each of the three classroom-level factors in kindergarten and preschool are included in the site-level clustered regression model. The pair of regressions equations include the following:

(1) $ATTNPROBLEMS_y = \beta_0 + \beta_1 CPT + \beta_2 DOG + + \beta_3 STROOP + \beta_4 PREKCLASSROOM + \beta_5 SOCIALSKILLSK_{ij} + \beta_6 TEACHERSTUDENTREL + \varepsilon$

(2) $ATTNPROBLEMS_y = \beta_0 + \beta_1 CPT + \beta_2 DOG + + \beta_3 STROOP + \beta_4 PREKCLASSROOM + \beta_5 SOCIALSKILLSK_{ij} + \beta_6 TEACHERSTUDENTREL + \beta_7 COVARIATES + \beta_8 CPT*PRACTICES + \beta_9 CPT*SOCIAL_{ij} + \beta_{10} CPT*TEACHERREL + \varepsilon$

ATTNPROBLEMS refers to teacher ratings of attention in first grade and is the dependent variable in both models. The CPT, DOG, and STROOP are the three EF variables assessed at 54 months. In model 2, child-level covariates and the interaction variables were included as independent variables. The COVARIATES were math at 54 months, maternal education, gender, and income-needs ratio. Finally, we included three interaction variables in the analysis, calculated as the interaction between performance on the CPT and each of the kindergarten-level factors. In these analyses the kindergarten social skills, and teacher-child relationship variables were treated as a dichotomous variables and was based on a median split. That is, students were considered high in social skills or teacher-child relationships if they were in the top half of the sample, whereas students in the bottom half for both of these variables were considered low.

The results of models 1 and 3, which did not include covariates, suggest that social skills in kindergarten was a moderate predictor of attention problems in first and third grade,

yielding effect sizes of -.14 and -.21 respectively (see Table 4.11). The interaction variables were included in Models 2 and 4 to assess whether the relationship between sustained attention at 54 months and classroom behaviors in first grade is moderated by the preschool classroom environment and/or teacher-child relationships during kindergarten.

Table 4.11
Linear Regression Results Predicting First Grade and Third Grade Attention Problems with Moderation Models

	(1) Attention Probs. First	(2) Attention Probs. w/Interactions First	(3) Attention Probs.- Third	(4) Attention Probs. w/Interactions - Third
CPT d'	-0.12	-0.05	-0.06	-0.01
	(0.05)	(0.06)	(0.07)	(0.06)
DOG Fail 54M	0.19	0.16	0.29*	0.20
	(0.10)	(0.10)	(0.10)	(0.10)
Stroop-Switch	-0.02	-0.04	-0.05	-0.05
	(0.05)	(0.05)	(0.06)	(0.05)
Practices – PreK.	0.01	0.08	0.05	0.10
	(0.05)	(0.05)	(0.06)	(0.05)
Social Skills-K	-0.14*	-0.15*	-0.21**	-0.25***
	(0.05)	(0.05)	(0.06)	(0.06)
Teacher Rel.-K	0.08	-0.02	0.00	-0.03
	(0.05)	(0.06)	(0.05)	(0.06)
Math 54Mo		-0.10		-0.06
		(0.06)		(0.07)
Male		-0.06		-0.28*
		(0.01)		(0.01)
Maternal Ed		-0.04		-0.04
		(0.02)		(0.03)
Income-Needs		-0.01		-0.02
		(0.02)		(0.02)
CPT*Practices		-0.05		0.03
		(0.05)		(0.05)
CPT*Social		0.09		0.04
		(0.05)		(0.05)
CPT*Teacher Rel.		-0.20*		-0.10
		(0.08)		(0.10)
Constant	-0.27***	0.55	-0.25***	0.63
	(0.06)	(0.37)	(0.06)	(0.45)
N	227	227	227	227
R^2	0.16	0.22	0.17	0.24

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Log-Odds ratios presented. Standard errors in parentheses. The interaction term was a combination of performance on the CPT and a dichotomous variable for high positive classroom environment. CPI refers to the classroom environment and Teacher Rel. refers to the teacher ratings of the student-child relationship.

Model 2 revealed a moderate interaction between performance on the CPT and reported teacher-child relationship, contributing to attention problems in first grade. This interaction is illustrated in Figure 4.6, showing that attention problems in first grade were related to student-teacher relationships for students with low sustained attention skills, but not for those with high sustained attention skills. More specifically, students with low sustained attention at 54 months yet had positive relationships with their teachers in Kindergarten exhibited fewer attention problems in first grade, than those who had poor relations with their teachers. The quality of the student teacher relationship in kindergarten was unrelated to attention problems for students with average or higher sustained attention skills. This interaction was limited to attention problems in first grade (Model 2), but not in third grade (Model 4). Similar to the analysis above, a logistical regression was conducted to predict the likelihood of having high attention problems in first and third grade.

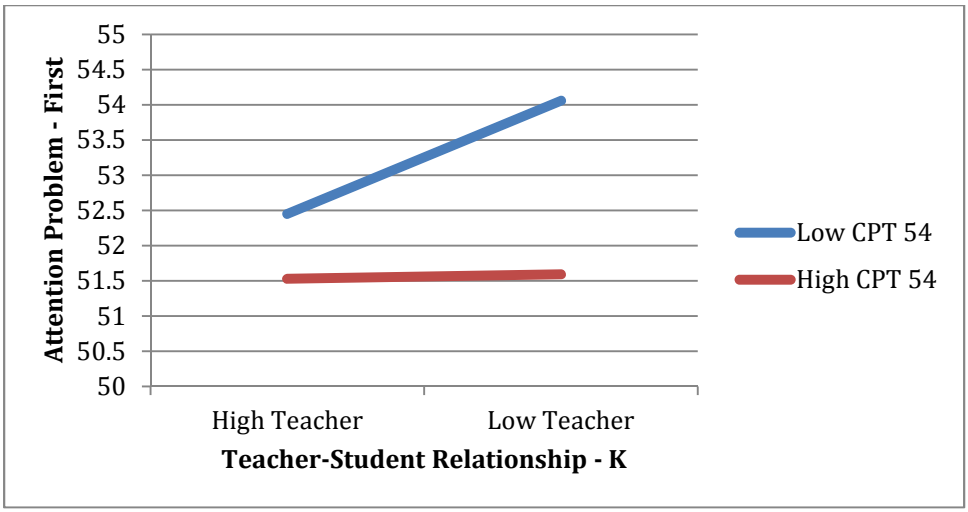
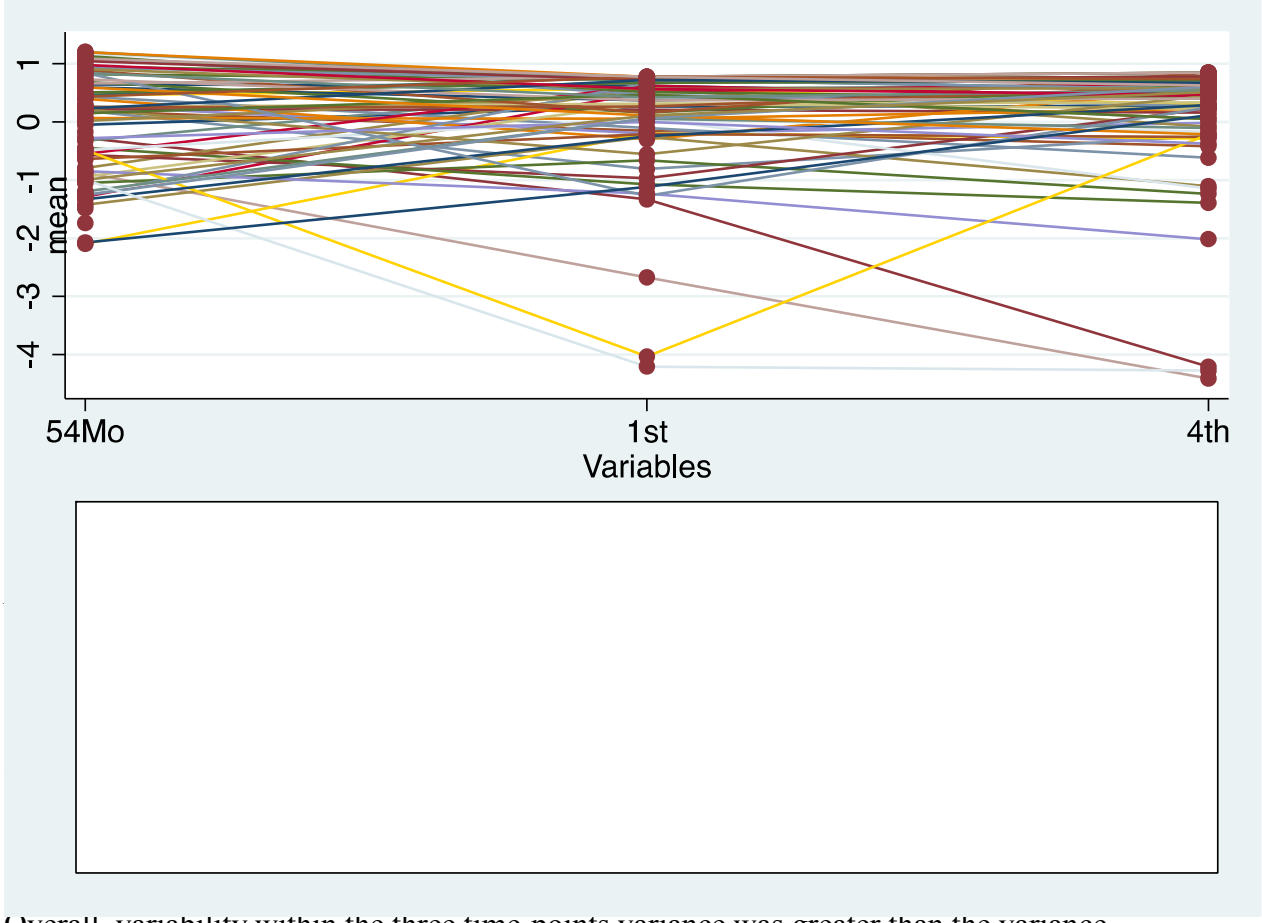


Figure 4.5. *T-Scores on the teacher rating scale of Attention Problems by CPT (Sustained Attention) performance and Student-Teacher Relationships.* High Teacher refers to more positive student teacher relationships. Higher T-Scores indicate greater attention problems.

Research Question 4: How Stable are sustained attention skills through elementary school?

In the next set of analyses, we examined the stability of sustained attention skills from 54 months to fourth grade and the effects of persistent problems with sustained attention through the early elementary school years. First, we investigated a visual display of individual growth trajectories on the CPT (d') for a random sample of 10% of the total analytical sample (see Figure 4.7). The graphical display of growth at three time points indicate relative stability with a greatest change occurring between 54 months and first grade.



Overall, variability within the three time-points variance was greater than the variance between time-points, F(2, 352) = 1.48, *ns*, suggesting that performance on the CPT was relatively consistent between 54 months and 4th grade.

Next, we conducted a different method of examining of the stability by calculating the Cronbach's alpha value using the d' score on the CPT at 54 months, first grade, and fourth grade. The overall alpha value across the three time points was .65, indicating moderate stability. The alpha coefficient when collapsing across 54 months and first grade was the lowest, α = .44, and the combined coefficient when collapsing across first and fourth grades was the highest, α =.77. Finally, the alpha value between 54 months and fourth grade was .51. The results suggest that the performance on the CPT appears to be more stable between first and fourth grade compared to 54 months and first grade.

Finally, I analyzed the stability of sustained attention by estimating the amount of variance explained by using step-wise linear regression. Model 1 examined the predictors of sustained attention at fourth grade and found that males performed significantly lower than females. Furthermore, failing the delay of gratification task was associated with .19 standard deviation lower CPT scores in first grade (see Table 4.12). The CPT at 54 months accounted for only two percent of the variance in CPT score in fourth grade, whereas CPT in first grade accounted for approximately 13% of the variance. This supports prior finding that the association between first grade and fourth grade is stronger than between 54 month and fourth grade, suggesting a bit of leveling off or stability of skills.

Table 4.12
Stepwise Linear Regression Results Examining the Association between prior CPT and CPT in Fourth Grade

	(1) CPT – 4th Grade – Includes all Covariates	(2) CPT – 4th Grade adding CPT at 54 Months	(3) CPT – 4th Grade adding CPT 1st Grade
Male	-0.18*	-0.15*	
	(0.08)	(0.08)	
Delay of Gratification - Fail	-0.19*	-0.18*	-0.17*
	(0.08)	(0.08)	(0.08)
Maternal Ed		0.04*	
		(0.02)	
CPT – 54 Months		0.69***	
		(0.17)	
CPT – 1st Grade			0.38***
			(0.04)
N	679	679	679
R^2	0.09	0.11	0.22
ΔR^2 (compared to Model 1)	--	0.02	0.13

Note: only statistically significant predictors were included. Standardized coefficients presented with standard errors in parenthesis. Model 1 includes all covariates: gender, income-needs, maternal education, memory, vocabulary, math performance at 54 months, Stroop Switch, and Delay of Gratification.

To better understand how developing skills contribute to classroom behavior, we categorized the participants into four groups based on their performance on the CPT at 54 months and in fourth grade. CPT d' scores in the bottom third of the sample were considered low, whereas CPT d' scores were considered average if their performance was in the upper two-thirds of the sample. Children whose CPT d' scores were in the bottom third at both 54 months and fourth grade were categorized as Low Stable, whereas their peers whose CPT d' scores were in the upper two thirds at both 54 months and fourth grade were considered Average Stable. The Low Increasing group consisted of children whose CPT d' scores were in the bottom third at 54 months, but were in the upper two-thirds at fourth grade. In contrast, the Average Decreasing group consisted of children whose CPT d' scores were in the upper two-thirds at 54 months, but their scores were in the bottom third in fourth grade. Reports of students' work habits and attention problems in first and third grade, as a function of trajectory group, are summarized in Table 4.13. The mean d' scores on the CPT also suggest that the d' scores for all the trajectory groups increased between 54 months and fourth grade.

Table 4.13
Description of CPT Trajectory Groups (N=354)

Group	Count	% of Total Sample	Mean CPT d' at 54 Month	Mean CPT d' in Fourth Grade	Work Habits First Grade (max 30)	Work Habits Third Grade (max 30)	Attention Problems First Grade (max 100)	Attention Problems Third Grade (max 100)
Low Stable	21	6%	0.25	0.78	18.71(7.35)	19.95(6.67)	53.33(5.45)	55.05(7.30)
Low Increasing	49	14%	0.30	0.95	22.47(6.20)	21.24(6.07)	53.20(4.80)	54.65(7.19)
Ave Decreasing	45	13%	0.72	0.90	23.56(6.40)	20.31(6.71)	53.07(4.69)	56.11(9.47)
Ave Stable	239	67%	0.79	0.96	24.23(5.78)	24.15(5.40)	51.93(4.04)	52.58(5.41)

Note: Means reported, standard deviation in parenthesis. Low refers to scores that were in the bottom third percentile of the sample. Average refers to scores that were the upper two-third of the sample.

Three different one-way ANCOVAs were calculated to examine whether students in the four different trajectory groups were significantly different on work habits, attention problems, and engagement in the classroom. The results revealed that the trajectory groups different significantly on work habits in first grade, $F(3, 353) = 6.05$, $p<.001$. This difference in performance persisted into 3rd grade as well, where the Low Stable group continued to have significantly lower work habits compared to the three other trajectory group, especially the Average Stable Group, $F(3,353)=9.97$, $p<0001$.

On the other learning-related behaviors, engagement and attention problems, we saw no significant difference between the four trajectory groups. Consistent with the previous regression analyses, the Low stable group has the highest level of attention problems and the lowest scores on work habits while the Average stable group displayed the least attention problems and highest rating on work habits.

Do Students Long-Term Performance on Sustained Attention Predict Learning-Related Behaviors at First and Third Grade?

In the next analysis, we examined the relationship between the different CPT groups on learning-related behaviors in the classroom in first, third, and fifth grades. Based on the regression results above, I focused the Average Stable group and the Low Stable Group, as they displayed the largest difference. Overall, the Average stable group demonstrated greater overall work habits scores at all three grade levels compared to the Low stable group (see Figure 4.7). Results of ANOVA analysis comparing the two groups at the three time points indicated that the Average Stable group exhibited .90 standard deviations higher work habits scores in first grade $F(3,353) = 35.65$ ($p>.001$), .38 standard deviations higher work habits scores in third grade ($p<.10$) and .36 standard deviations higher work habits in fifth grade ($p<.10$).

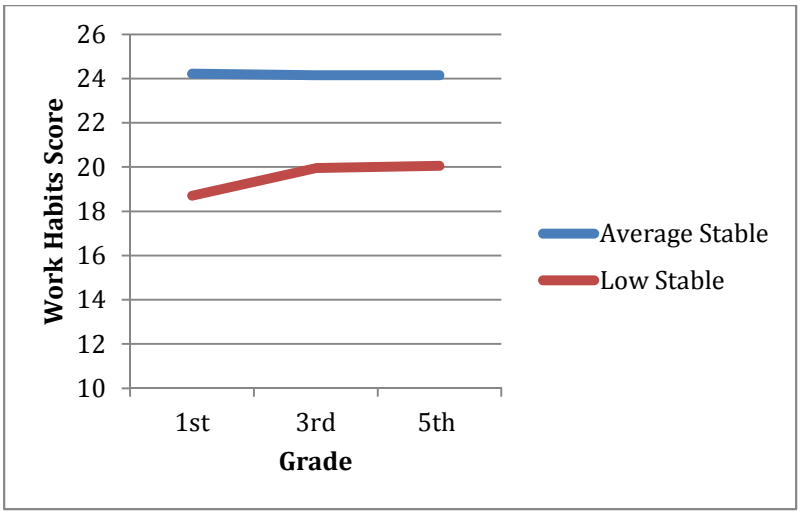


Figure 4.7. *Work Habit Scores for the Average Stable and Low Stable Groups at three time points*

Next, we compared the classroom attention problems of the Average Stable and Low Stable group at first, third, and fifth grade (see Figure 4.9). Again, the Average stable group displayed lower attention problems at all three grades, while the ratings of attention problems for the Low Stable group as whole appeared to increase over the three grade levels. Results of ANOVA analysis comparing the two groups at the three time points indicated that the Low Stable group exhibited .02 standard deviations more attention problems in first grade ($p>.05$, *ns*), .13 standard deviations more attention problems in third grade ($p<.05$) and .55 standard deviations more attention problems in fifth grade ($p<.01$).

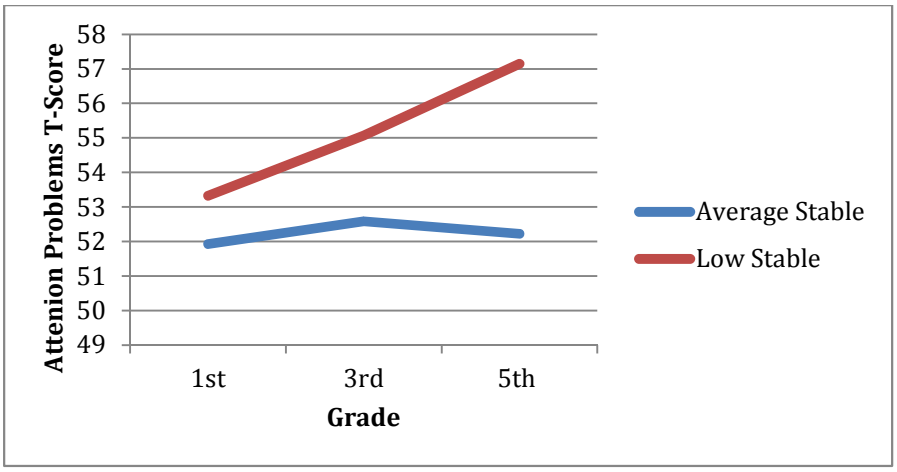


Figure 4.8. *Attention Problems T-Scores for the Average Stable and Low Stable Groups at three time points.*

Next, for each of the grade levels, six linear regression equations were estimated, two for each for the three learning-related skills. We again explored the possible protective effect of early classroom factors in preschool and kindergartens for children with persistent low sustained attention skills. The following two equation models represent the regression models included for each learning-related social skills at each of the grade levels:

(1) $LEARNING_y = \beta_0 + \beta_1 CPTAVEDEC + \beta_2 CPTLOWINC + \beta_3 CPTLOW + \beta_4 DOG + \beta_5 STROOP + \varepsilon$

(2) $LEARNING_y = \beta_0 + \beta_1 CPTAVEDEC_{ij} + \beta_2 CPTLOWINC + \beta_3 CPTLOW + \beta_4 DOG + \beta_5 STROOP + \beta_6 GENDER + \beta_7 MATERNALED + \beta_8 INCOME + \beta_9 PMATH54 + \beta_{10} LOWSTABLE*TEACHERREL + \beta_{11} LOWSTABLE*SOCIALK + \beta_{12} LOWSTABLE*CPI + e$

The LEARNING variables were the dependent variables and included one of the three learning-related behaviors (Engagement, Work Habits, and Engagement) in each of the models. The CPTAVEDEC refers to a dummy variable for placement in the Average

Decreasing trajectory, CPTLOWINC is the Low Increasing trajectory group, and the CPTLOW is the Low Stable group. The Average Stable group was used as the comparison, reference group in each of these models. The results of the six regression models are summarized in Table 4.8. Models 1, 3, and 5 suggest that the Low Stable attention trajectory group demonstrated significantly weaker work habits (shown in Model 3) compared to the Average Stable group. The two other sustained attention trajectory groups, Low Increasing and Average Decreasing, did not differ significantly from the Average Stable group.

The moderator variables were included in Models 2, 4, and 6 to examine how early classroom factors may interact with having persistent sustained attention problems. The moderation analysis suggested that none of the early classroom factors interacted with the persistent attention problem group when predicting learning-related skills in first grade.

Table 4.14

Linear Regression Results with CPT Groups predicting First Grade Learning-Related Behaviors

	Engagement		*Work Habits*		*Attention Problems*	
	(1) EC	(2) Interactions	(3) EC	(4) Interactions	(5) EC	(6) Interactions
CPT Low Stable	-0.10	0.04	-0.90***	-0.69	0.02	2.05
	(0.23)	(0.43)	(0.22)	(0.42)	(1.02)	(1.64)
CPT Low Inc.	-0.11	-0.17	-0.24	0.22	1.01	0.47
	(0.15)	(0.17)	(0.16)	(0.16)	(0.70)	(0.76)
CPT Ave. Dec.	0.01	0.03	-0.11	-0.04	0.93	0.42
	(0.16)	(1.02)	(0.16)	(0.17)	(0.71)	(0.85)
DOG Fail-54	-0.04	-0.02	-0.20	-0.17	1.37**	0.90
	(0.05)	(0.04)	(0.11)	(0.06)	(0.50)	(0.09)
Stroop-Switch-54	0.20	-0.06	0.03	-0.01	-0.11	0.28
	(0.11)	(0.06)	(0.05)	(0.05)	(0.25)	(0.04)
Male		0.14		-0.43***		-0.09
		(0.01)		(0.11)		(0.08)
Maternal Ed		0.03		0.09*		-0.38**
		(0.01)		(0.03)		(0.13)
Income-Needs		-0.04		0.03		-0.07
		(0.02)		(0.02)		(0.10)
Math 54 Month		0.05		0.06		-0.55
		(0.07)		(0.00)		(0.30)
LowStable*teach		-0.46		-0.26		-0.39
		(0.47)		(0.45)		(2.07)
LowStable*social		0.13		-0.43		-0.83
		(0.45)		(0.46)		(2.12)
Low Stable*CPI		0.07		0.32		1.31
		(0.43)		(0.44)		(2.01)
Constant	0.09	-0.10	0.22	1.02*	51.48***	3.89*
	(0.07)	(0.36)	(0.07)	(0.42)	(0.32)	(1.34)
N	354	342	354	354	354	354
R^2	0.17	0.20	0.08	0.19	0.05	0.16

Note: ** p<.05, ** p<.01, *** p<.001*

Standard errors in parentheses. Standardized regression coefficients. The Average Stable group is the reference group. The interaction models included interactions between the Low-Stable CPT group and differ classroom factors (teacher Relationships, social skills, and classroom practices)

We also conducted logistic regression analyses to examine the groups that predict having high work habit skills and high attention problems in first and third grade. The results suggest that the groups did not differ significantly on having high work habits skills.

Models 3 and 4 examined the dichotomous dependent variable of high attention problems characterized by children with T-score 60 or higher. The results of the logistic regression analyses suggested that the four trajectory groups did not significantly differ on predicting high attention problems in either first or third grade.

What are the predictors of students' classification of sustained attention trajectory groups?

Four logistic regression models were calculated to examine the classroom-level and child-level factors associated with classification in the Low Stable, Low Increasing, Average Decreasing or Average Stable groups between 54 months and fourth grade. The following equation reflect logistic regression models that were used in this analyses:

$$CPT\_TRAJECTORY_y = \beta_0 + \beta_1 DOG + \beta_2 STROOP + \beta_3 CLASSROOMK + \beta_4 SOCIALK + \beta_5 TEACHERRELK + \beta_6 COVAR + \varepsilon$$

The dependent variable in each model was one of the four trajectory group, represented by the CPT_TRAJECTORY in the equation above. The findings of the logistic regression suggest that EF skills at 54 months and Kindergarten social factors did not predict the student membership in any of the trajectory groups. However, math skills at 54 months appeared to predict placement into the Average Stable and Low Increasing group. The log-odds of 0.38 indicated that a one standard deviation increase in math is associated with a 62% increase of being the Low Increasing group. A one standard increase in math performance at 54 months was associated with a 145% increase in being in the Average Stable group. Thus, there seems to be a strong association between early math performance and stable, positive, sustained attention skills.

Table 4.15
Logistic Regression Results Predicting CPT trajectory group placement

	(1) Low Stable	(2) Average Decreasing	(3) Low Increasing	(3) Average Stable
DOG Fail-54	2.17	1.37	1.51	0.49
	(1.41)	(0.11)	(0.68)	(0.04)
Stroop-Switch	0.93	0.63	0.92	1.38
	(0.31)	(0.05)	(0.06)	(0.06)
Practices. – Pre-K	1.27	1.04	-1.25	0.81
	(0.01)	(0.01)	(0.01)	(0.01)
Social – K	1.22	1.15	1.08	0.85
	(0.01)	(0.01)	(0.01)	(0.01)
Teacher Relationship - K	0.86	0.86	1.01	1.13
	(0.32)	(0.01)	(0.01)	(0.01)
Male	0.91	1.31	1.18	0.75
	(0.01)	(0.01)	(0.01)	(0.01)
Maternal Ed	0.93	0.75*	1.01	1.17
	(0.91)	(0.91)	(0.91)	(0.91)
Income-Needs	0.86	1.13	0.95	0.96
	(0.15)	(0.01)	(0.01)	(0.01)
Math-54 M	0.72	0.69	0.38***	2.45***
	(0.27)	(0.19)	(0.10)	(0.54)
Constant	1054.71	4211.20	-0.10	23900
	(9357)	(27924)	(0.36)	(0.36)
N	342	342	342	342
R^2	0.08	0.10	0.12	0.17

Note:* *p<.05,* ** *p<.01,* *** *p<.001*
Standardized log-odds presented. Standard errors in parentheses. The DOG is a dummy variable that indicates failing to wait the full seven minutes.

Teacher-Student Relationships on Learning-Related Behaviors for Different Trajectory Groups

In order to examine the relationship between the different trajectories of sustained attention as measured by the CPT and classroom inattention problems as measured by the teacher, moderation models were graphed. Table 4.16 displays the students' scores on the learning-related behavior by trajectory group as a function of their relationships with their teachers. Student-teacher relationships were treated as a categorical variable using a median split. Children with student-teacher relationships ratings that were in the top half of the

sample were rated as high, while students with ratings that were in the bottom half of the sample were rated as Low.

Two-way ANOVA analyses were conducted to examine the interaction between trajectory group and teacher-student relationship on the three classroom learning-behaviors. The results of the ANOVA suggested that there were significant differences in engagement by group or by student teacher relationship. Furthermore, the student-teacher relationship did not moderate the relationship between trajectory group and engagement ($p=0.32$). Analysis of attention problems yielded similar results, with no significance difference between the groups or by student-teacher relationship. As we did above, the main effects and results of the Tukey post-hoc test suggested that there are significant differences between the Low Stable group and the other groups on work habits ($p<01$). However, the student-teacher relationship did not interact with the trajectory groups when predicting work habits in first grade.

Table 4.16
Raw and Standardized Scores on the Learning-Related Skills by CPT Trajectory Group and High or Low Student-Teacher Relationship.

	Engagement (max. 60)		Attention Problems (T-scores)		Work Habits (max. 30)	
	High Student-Teacher Relationship	Low Student-Teacher Relationship	High Student-Teacher Relationship	Low Student-Teacher Relationship	High Student-Teacher Relationship	Low Student-Teacher Relationship
Low Stable	30.44	36.25	53.11	53.50	18.01	19.25
Low Increasing	30.65	35.12	52.13	54.50	21.90	22.90
Average Descending	36.33	34.38	53.04	53.09	25.12	21.76
Average Stable	34.78	34.92	51.52	52.47	24.67	23.65

Note: Means Reported. Engagement is number of cycles observed engaged out of 60, Attention Problems are presented as T-scores with a Mean of 50 and Work Habits are raw scores out of 30 possible points.

I examined the four CPT groups on classroom engagement using Two-Way ANOVA analysis and found that there was no significant interaction between the four CPT groups and teacher-student relationship. The results of the interactions can be found in Figure 4.9 and Table 4.17.

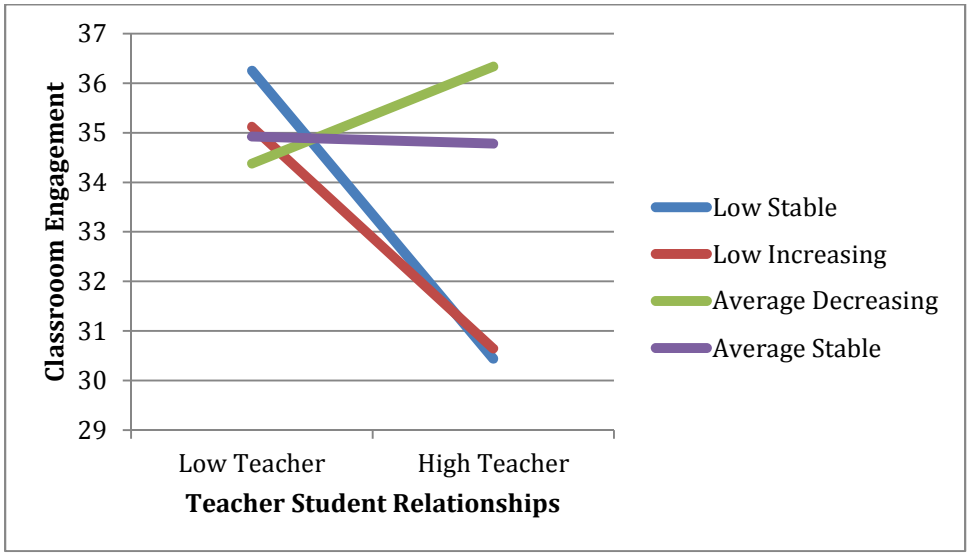


Figure 4.9. Raw scores observed classroom engagement by four CPT trajectory groups and the quality of teacher-child relationship. High teacher refers to positive relationships while low teacher refers to negative relationships.

Table 4.17
The results of a two-way ANOVA Interactions Between CPT Group and Classroom Factors

	Engagement		Attention Problems		Work Habits	
	F	p>F	F	p>F	F	p>F
Model	0.81	.58	1.72	.10	3.42	.00
CPT Group	0.64	.59	1.83	.14	5.97*	.00
Teacher-Rel.	1.64	.20	1.64	.20	0.34	.56
Group*Teach Rel.	1.17	.32	0.44	.72	1.25	.29
Model	5.21	.77	2.69	.01	3.63*	.00
CPT Group	1.90	.58	178	.15	5.68*	.00
Social - K	0.41	.38	8.20*	.00	5.37*	.02
Group*Social - K	3.50	.81	0.77	.54	0.92	.45

Note: Engagement is number of cycles observed engaged out of 60, Attention Problems are presented as T-scores with a Mean of 50 and Work Habits are raw scores out of 30 possible points.

In the final analysis, we examined the importance of the timing of sustained attention skills between 54 months and 5th grade. The results of the cross-lagged structural equation modeling of the relationship between sustained attention and classroom engagement suggest sustained attention skills, as measured by the CPT contributed to work habits equivalently at the 54 months and 1st grade time points (See Figure 4.10). In other words, the sustained attention at 54 month predicted work habits in first grade to the same degree as sustained attention in 1st grade predicted work habits in 3rd grade. CPT at 54 month and first grade appeared to be a bit more associated with subsequent work habits compared to CPT performance in 4th grade predict work habits in 5th grade.

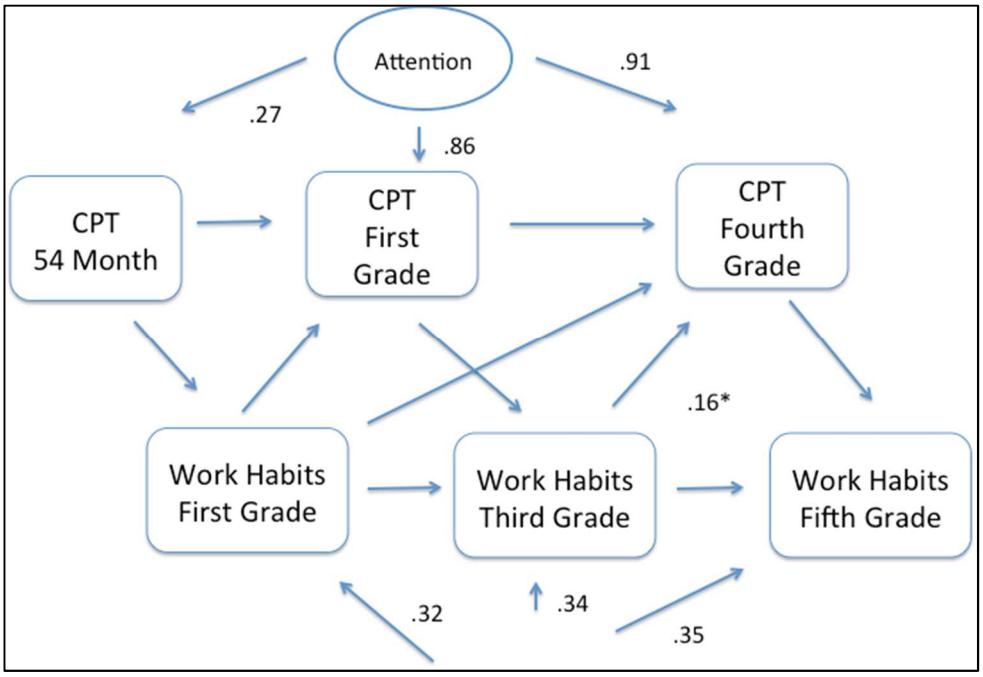


Figure 4.10 State-Trait Longitudinal relationship between Attention (CPT) and Work Habits. Factor Loading and Significant coefficients displayed * $p<.05$.

Similar analyses were conducted with attention problems and engagement instead of work habits. The state-trait model did not converge suggesting a model of poor fit and results that may not be significant for inferential testing.

CHAPTER FIVE
DISCUSSION AND CONCLUSIONS

The purpose of this dissertation was to examine the longitudinal relationship between executive functioning skills, classroom learning-related skills, and math achievement. We also aimed to examine potential school-level moderating effects that may impact the relationship between early executive functioning skills and later classroom learning-related skills.

Correlations Among Learning-Related Behaviors and Executive Functions

The results of correlational analyses of learning-related behaviors at three time points indicated that the three-learning related behaviors were not highly correlated at 54 months. However, as children progress through elementary school the correlations between work habits and attention problems were substantial. It is possible that as children progress through elementary school, the academic demands become more rigorous and take more of the classroom time. As a result, children who have strong attention skills also demonstrate positive academic work habits. In other words, when children are "on-task" they are attentive on academic-related tasks.

Predictors Math and Classroom Learning-Related Behaviors in First and Third Grade.

The results indicated that among the three learning-related behaviors, teacher reports of attention problems in first grade were most predictive of math performance in first grade and third grade. Attention problems in first grade predicted math performance independently of prior math performance, the three EF skills, gender, and rote memory at 54 months. This is consistent with prior studies that suggest that attention problems in the classroom may inhibit the initiation and completion of classroom tasks and is important for academic

success (Hofmann, Schmeichel, & Baddeley, 2012; Pagani, Fitzpatrick, & Parent, 2012). Although some studies found similar correlations between teacher-reported engagement and researcher-observed engagement (e.g., Cadima et al., 2015), this was not the case in our sample as teacher observations and reports of attention problems were more predictive of mathematics success than observed engagement. Considering the high correlation between work habits and attention problems, it appears that from a teacher's view having strong attention problems may appear similar to having good work habits. However, displaying high levels of attention problems seems detrimental academic performance independent of the level of cognitive skills and prior math skills. Based on our study, the observed behaviors of the child may not necessary reflect his or her work habits on academic tasks. A researcher observing a child that appears to be on task at the surface may not actually be fully engaged in the material. Furthermore, compared to a researcher making brief observations, teachers spend more time with the students have a better understanding of their behaviors.

Cognitive skills such as rote memory attention and vocabulary at 54 months predicted early math performance. We found that lab-based, direct measures of cognition are important for early math skills, supporting the value of "cool" cognitive skills in predicting real-world performance. This is consistent with other studies that found relationships between cognitive skills and math early math performance (e.g., Allen et al., 2007; Blair & Razza, 2007; Miller et al., 2015; Sarver et al., 2012). In all, a combination of behaviors, domain-general cognitive skills, and domain specific academic skills contribute in predicting math performance in early elementary school.

Interestingly, vocabulary at 54 months predicted math performance in third grade, but not first grade, even when controlling for prior math abilities and other EF skills. One explanation is that as math skills become more advanced, language skills become more important. For example, third grade math may include more word problems compared to first grade problems leading to challenges for those with difficulties in either math or language skills (Fuchs, Fuchs, & Prentice, 2004).

In the second analysis, I examined the predictors of learning-related behavior and found that a lab-based measure of sustained attention at 54 months predicted work habits and attention problems in first grad independent of other factors. While Toplak and colleagues (2012) found that most performance-based measures of EF such as the CPT, measure different constructs, we found one possible link between lab-based skills at 54 months and observable classroom-based skills. This supports the value of lab-based measures in predicting meaningful behavioral outcomes that are observable. Additionally, the three lab-based EF tasks emphasized in this study appear to tap into different skills, with sustained attention being the strongest factor math learning and classroom behaviors.

This also supports theories of attention and sustained attention resource models on self-regulation of behaviors in a real-life setting, where limitations in cognitive skills may directly impact functional performance (Carver & Scheier, 2012; Hofmann, Schmeichel, & Baddeley, 2012). Children display individual differences in the a amount of cognitive resources available to allocate during a given task, which in turn may impact their ability to effectively complete tasks. Those with fewer cognitive resources are unable to inhibit unwarranted responses and active attention as needed in the classroom.

I also found that sustained attention, more so than delay of gratification or attention shifting was predictive of classroom learning-related behaviors. First, this highlights the importance of cool executive functions such as the performance on the CPT on observable behaviors (Zelazo & Carlson, 2012). As opposed to "cool" EF, hot EF skills have an emotional component that may increase motivation. In our study, we found that tasks unattached to emotions such as the CPT reflect important skills in the classroom, both with behavior such as attention problems and work habits, as well as academic performance. Comparing the contributions of attention shifting and delay of gratification, it appears that the patience, activation of attention, persistence on a tedious task is captured by the CPT task (Conners et al., 2003). Although, we found low correlations between our EF measures, some studies suggest that ability to activate and sustain attention as well as inhibit is often considered to stem from a single, stable factor (Friedman & Miyaki, 2016; Lee, Bull, & Ho, 2013), which in our sample, may have been better captured with the CPT rather than the delay of gratification task or the Stroop task.

Learning-Related Behaviors as Moderator and Mediators

The results of a mediation analyses of three time points indicated that sustained attention as measured by performance on the CPT at 54 months was directly associated with math in third grade. However, the relationship between sustained attention at 54 months and math in first grade was partially mediated by teacher ratings of attention problems in first grade. This suggests that students with greater levels of sustained attention at 54 month of age were less likely to be rated by their third grade teacher as having attention problems. Less attention problems in first grade was associated with subsequent higher mathematics performance in third grade. The directionality of this relationship is a bit unclear. It seems

that sustained attention, observed attention problems, and math performance are correlated and that classroom behaviors are a manifestation of cognitive skills.

Kindergarten Classroom Factors

When examining the possible mediating role of kindergarten classroom factors, we found that the relationship between children's sustained attention at 54 months and attention problems in first grade was partially mediated by children's social skills in kindergarten. Children with higher sustained attention skills demonstrated greater social skills in kindergarten, which led to lower levels of attention problems in first grade. Although this was only partially mediated, it emphasizes the importance of early sustained-attention skills, even for a higher performing group of students in our sample.

We also examined the impact classroom factors in Kindergarten on learning related behaviors in first grade and found that children with lower social skills in Kindergarten demonstrated greater levels of attention problems in first grade and third grade. Children with social skills difficulties appear to continue to demonstrate behavioral difficulties into the 1st grade classroom. It is important for Kindergarten teachers to address the development of social skills that may facilitation learning and the completion of academic-related tasks. Social skill problems may be associated with a lack of self-control or impulse control and that may translate into academic attention problems as children progress through early elementary school (e.g., Bulotsky-Shearer, 2011). Considering the homogeneity of this population, this provides some support for the Transactional model of development (Sameroff & Mackenzie, 2003) which suggested that academic performance and classroom behaviors are a result of a complex mix of individual factors such as sustained attention skills, and environmental factors, such as socialization and student teacher-relationships

regardless of the background factors. Preschool and kindergarten teacher might take a more holistic approach to early child development.

We also found that having positive teacher-child interactions in Kindergarten may help children with low sustained attention skills at 54 months display lower levels of attention problems as they enter into first grade. This was our first evidence for the importance of teacher factors on attention problems and is consistent with recent findings by Blair and colleagues (2016) but expands it by finding a similar effect in a group of higher-functioning higher-SES group of children. This also builds on studies that found the importance of preschool teacher-student interactions and extends the importance into kindergarten teacher relationships (Searle et al., 2013; Williford et al., 2013). A teacher's warmth and responsiveness to the student may impact students' perception of the teacher, and responsiveness to learning-related tasks by reduce conflict and resistance (e.g, Liew, Chen & Hughes, 2010; Schmitt, Pentimonit, & Justice, 2012). Because both the teacher-student relationship and the attention problems are rated by teachers, we can infer that having a positive relationship with teachers may lead result in higher level of cooperation with teacher demands, even if it does not impact work habits or academic skills.

The Stability of Sustained Attention

Children's sustained attention was moderately stable between 54 months and 4th grade. When comparing the three time points, performance was more consistent between 1st and 4th grade compared to the performance between 54 month and 1st grade suggesting that greater change or development may occur between the preschool and early elementary school time point and then somewhat stabilizes as children progress into upper elementary school (McClelland et al., 2007; Zelazo & Carlson, 2012). Also, it is possible that

measurement at the 54-month time point was unreliable, which is weakening the correlation between the first two time points. Future studies with more than three measurement point of the CPT would help clarify the stability of sustained attention skills over a longer period of time. While the d' scores appeared to be relatively stable over this time period, interventions directly related to improving attention and self-regulation during the preschool an kindergarten maybe a worthwhile endeavor for early childhood and kindergarten educators (e.g., Diamond & Lee, 2011; Zelazo & Carlson, 2012).

Persistent Attention Problems may be Problematic

After assigning our sample into different groups based on sustained attention between 54 months and fourth grade, we found that the groups differed significantly on work habits with the Low Stable group displaying the lowest work habits in first grade, third grade, and fifth grade, particular when compared to the Average stable group. Indeed, the gap between the two groups on attention problems increased as the students entered fifth grade. Students who have consistently low sustained attention skills appear to also have lower work habits skills. Strong work habits in the classroom are reflected by high levels of self-control and self-regulation of learning behaviors. These self-regulation skills in the classroom appear to have a cognitive basis and be relatively stable through the first few years of elementary school. Contrary to our hypotheses, we did not find that any of the Kindergarten level factors moderated the relationship between trajectory groups and work habits. So unfortunately, work habit problems exhibited by students with persistent attention problems through early elementary school may not be alleviated by strong teacher-student relationships or social skills in Kindergarten. Based on these findings and prior findings (e.g., Blair & Razza, 2007; Cadima et al., 2015; Duncan et al., 2007), results support the

notion of addressing children's sustained attention skills and other EF skills (e.g., prior to kindergarten entry) to improve their attention skills and avoid academic and learning-related problems.

As math skills are associated with sustained attention skills at 54 month, early childhood programs should focus their efforts on concurrently developing both self-regulation skills such as attention control, as well as early academic skills. Furthermore, kindergarten teachers are often the first formal instructors for many children and may lay the groundwork for academic and social success in the classroom. Teachers that report positive relationship with students believe that their students can rely on them when they need help and don't engagement in many relational conflicts. Therefore, students with positive teacher relationship may not hesitate to seek out teachers for assistance rather than avoid them. Students with attention problems may benefit from possible help the teacher might provide.

Limitations

Although the current dissertation found significant relationships between sustained attention, classroom factors, and learning, some limitations must be considered. First, the relationships found this study are not causal but only correlational. Secondly, the analytical sample was generally higher functioning, wealthier, and ethnically homogeneous. The results of this study may only generalize to a small portion of the children in the United States. Similar studies with a more diverse sample of students my provide information predictors of learning-related social skills. Furthermore, trajectory groups were created based on relative performance based on the sample rather than normative data on a larger scale, the results from the different trajectory group must be interpreted with caution. For example, even the group that was consistently low on the CPT had and average d' score of

0.7 by the time they were in fourth grade, where a d' closer to zero demonstrates poorer stimulus discrimination or attention activation and control.

Next, because the CPT tasks of sustained attention were designed differently at each time point, we used (d') to measure of CPT when analyzing growth trajectories. While d' is sensitive to commission and omission errors, the number of omission errors may vary based on the number of critical and non-critical items. The version of the CPT used in this study was a more "passive" CPT where the child only responds when asked to do so and is different than the traditional CPT task where the child consistently responds to every trial item and changes or shifts his or her response to a target item (Conners et al., 2003). This "active" version CPT task may be a more valid measure of sustained attention control and future distinguish those with low and high abilities. Future studies should use measures of EF that are sensitive to growth and change at multiple time points. Next, a comprehensive examination of the relation between EF skills would need to include measures of working memory, an important factor in both academic performance and behavioral self-regulation (e.g., Hofmann et al. 2008; Swanson et al., 2008). Working memory has also been associated with attention skills (e.g., Gathercole et al., 2008). Future studies could examine growth trajectories of working memory and how these skills impact classroom learning-related skills.

Conclusions

Taken together, the development of academic skills and learning-related skills appear to stem from a complex combination of individual differences in cognitive abilities, academic knowledge, classroom factors, and classroom behaviors. These findings suggest that early intervention and prevention seems to be critical. More specifically, preschool

attention and math skills are important for learning-related behaviors in early elementary school. They not only predict other academic skills, but also are associated with important self-regulation skills. Furthermore, early kindergarten experience also appears to have a small buffering effect for those with low attention skills at school entry. While early attention problems may not improve drastically during elementary school, children with low attention skills at preschool may find it beneficial to have teachers that are more patience and willing to develop a relationship built on trust.

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APPENDIX
Items on Rating Scales

Measure	Rating Scale Items
TRF – Inattention Problems	Acts young; hums; fails to finish things; can't concentrate; can't sit still; confused; fidgets; day-dreams; difficulty following directions; impulsive; nervous; difficulty learning; apathetic; poor school work; clumsy; messy; inattentive; stares; underachiever; & fails to carry out assigned tasks
Work Habits Items	Follows classroom procedures; works well independently; works neatly and carefully; uses time wisely; completes work promptly; keeps material organized
Teacher-Student Relationships	I share an affectionate, warm relationship; If upset, student will seek comfort from me; Student is uncomfortable with physical affection; Student values his/her relationship with me; When I praise the child, he/she beams with pride; Student spontaneously shares information about him/herself; Student spontaneously shares feelings with teacher; it is easily to be in tune with what the student is feeling; Student openly shares his/her feelings and experiences with me. Student and I always seem to be struggling; Student easily becomes angry with me; Student remains angry/resistant after being disciplined; Dealing with the student drains my energy; If student wakes up in bad mood, we are in for a long/difficult day; Student's feelings toward me can be unpredictable; Student is sneaky or manipulative with me

APPENDIX A
Items on Rating Scales

Measure	Rating Scale Items
Kindergarten Social Skills (example items)	Controls temper in conflict situations; introduces him/herself to new people; Appropriately questions rules that may be sensitive; compromises in conflict situations; response appropriately to peer pressure; says nice things about him/herself; invites others to join in activities; uses free time in an acceptable way; finishes class assignments in time; makes friends easily; responds appropriately to teasing by peers; receives critics well, uses time appropriately when waiting for teacher; produces correct school work; tells when he/she things he/she is treated poorly; accepts peers' ideas; gives complements to peers; follows your direction; volunteers to help children with classroom tasks; ignores peer distractions when doing class work; gets along with people who are different.