RELATIONS BETWEEN MOTOR, SOCIAL, AND COGNITIVE SKILLS IN YOUNG CHILDREN WITH DEVELOPMENTAL DISABILITIES

by

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ABSTRACT

RELATIONS BETWEEN MOTOR, SOCIAL, AND COGNITIVE SKILLS IN YOUNG CHILDREN WITH DEVELOPMENTAL DISABILITIES

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The importance of children's motor abilities, in relation to other developmental areas, has been acknowledged in both theory and research. However, researchers have typically focused on gross motor abilities in relation to cognitive and social abilities, and associations between fine motor, cognitive, and social abilities have received little research attention. In addition, very few studies have looked at the potential interrelations between motor, social, and cognitive abilities in preschool-aged children with developmental disabilities. The current study examined three areas of development, motor (both fine and gross motor), social, and cognitive skills, in preschool-aged children with developmental disabilities, to see whether there were associations between the three areas. The data for the study come from the Miami School Readiness Project (MSRP; Winsler et al., 2008), a large-scale, collaborative, school readiness project, taking place in Miami-Dade County, Florida. Participants were children receiving early childhood special education services ($N = 3{,}191$), who were assessed for overall development and socio-emotional protective factors in the Fall and Spring of their pre-kindergarten year, using the LAP-D (Nehring, Nehring, Bruni, & Randolph, 1992) and the DECA (LeBuffe & Naglieri, 1999). Results indicated that there were definite associations between motor, cognitive, and social skills. Also, both fine motor and gross motor skills in the Fall of the pre-kindergarten year significantly predicted later cognitive and social skills, measured in the Spring of the pre-kindergarten year, after controlling for child gender, age, and disability type; however, associations were stronger for fine motor skills, as opposed to gross motor skills, for both cognitive and social skills. In addition, disability category moderated the associations between motor and social and cognitive skills; however, gender was not a moderator, suggesting that the underlying associations between the three areas are similar for both boys and girls. The findings from this study have important implications for early educational programs and interventions, as well as for policymakers.

INTRODUCTION

In recent years, researchers have recognized and highlighted the importance of understanding the complex interplay of the different areas of development in young children, including motor, cognitive, and social domains (Diamond, 2000; 2011). This interaction of the developmental areas is evident in motor development research. In fact, developmental psychologists have long recognized that perceptual-motor development in infancy may be the foundation of all mental life (Lockman & Thelen, 1993). Piaget (1953) proposed that motor experiences are important for the emergence of cognitive ability, and Gesell (1933) also supported this position and believed that the processes by which infants learned to control and coordinate their bodies set the stage for all further development and exemplified more general developmental processes.

Recent advances in the science of human movement also indicate that motor development and cognitive development may be much more interrelated than has been previously thought (Diamond, 2000). There is evidence suggesting that motor development may act as a “control parameter” for further development, where some motor abilities may be a prerequisite for the acquisition or practice of other developmental functions, such as cognitive ability (Bushnell & Boudreau, 1993). Specifically, if an infant is unable to engage in a motor behavior that is required for the acquisition or practice of certain perceptual or cognitive skills, then that lack of motor behavior may hinder the emergence of the related cognitive ability (Bushnell & Boudreau, 1993).

The study of locomotion in infants provides evidence of the interrelation between different developmental domains. When infants are first beginning to move, they are not only increasing their motor skills but are also “learning to learn,” through adapting to novel situations and finding solutions to maneuver around (Adolph, 2008). In addition, locomotor experiences impact social development by profoundly affecting the infants’ number of opportunities for social interaction, as well as their attachment relationship and attentiveness (Campos et al., 2000).

It is clear that motor skills play a crucial role in children’s cognitive and social functioning. Poor motor skills have been linked to problems in social functioning, including anxiety (Skinner & Piek, 2001) and social reticence (Bar-Haim & Bart, 2006). In addition, studies have shown that cognitive and motor disorders tend to co-occur (Diamond, 2000). Children who have motor impairments often exhibit cognitive delays and learning difficulties; similarly, children with cognitive disorders are more inclined to experience motor problems (Diamond, 2000). Despite an increased interest in motor development, few studies have examined interrelations between motor, social, and cognitive abilities in preschool children with disabilities or the possible differential effects of motor skills on cognitive and social skills for different disability types. Therefore, in the current study, I investigated the links between motor, social, and cognitive skills in preschool children with developmental disabilities to examine: a) motor skills in this population of children, b) the extent to which fine and gross motor skills predict later social and cognitive skills, and c) whether gender and disability type moderate associations between motor skills and cognitive and social skills.

Development During the Preschool Years

The preschool years, from age two to five years old, are marked by children's significant growth and development. In the area of physical and motor development, children become more coordinated, stronger, faster, and display tireless energy (Trawick-Smith, 2010). According to Gesell (1954) and his principle of developmental direction, motor development progresses such that large muscles, such as the legs and trunk (i.e., gross motor movements), develop first and provide a solid base for the development of smaller muscles (i.e., fine motor movements). There are remarkable advances in the development of fine motor skills in the preschool years. By the end of the preschool years, children usually are able to eat with utensils, independently put on clothing and shoes, finger-paint, cut with scissors, manipulate puzzle pieces, write some letters or one's name, and coordinate hand and arm movements with other senses (Trawick-Smith, 2010).

There are also major advancements in cognitive development. Children achieve important basic knowledge and skills concerning thinking. Children are able to do simple, visual perspective-taking; understand "intentionality" of others' behaviors; and grasp simple causal relations among desire, outcomes, and actions (Flavell, 2000). Social and emotional growth are also seen during the early childhood period. The social worlds broaden, and children often become self-assured, more independent, and social, acquiring the desire and ability to interact with adults and peers (Denham, Wyatt, Bassett, Echeverria, & Knox, 2009; Trawick-Smith, 2010). Prosocial behaviors and interactions emerge, and children show initiative in play activities, form friendships, and show specific social skills, including understanding emotions (Denham et al., 2009). The question is, to what degree may this motor (fine and gross) skill development have an impact on these cognitive and social gains?

Theoretical and Empirical Connections Between Motor, Cognitive, and Social Skills

Both theoretical and empirical connections have been made between motor abilities and cognitive skills (Diamond, 2000; Wilson, Maruff, Ives, & Currie, 2001) and social skills (Denham, Brown, & Domitrovich, 2010; Lobo & Winsler, 2006). However, the majority of these studies have focused mainly on general motor performance (Diamond, 2000; Hartman, Houwen, Scherder, &Visscher, 2010), without distinguishing between fine and gross motor skills. In the very few studies that have examined both fine and gross motor performance, evidence is mixed as to whether it is fine or gross motor skills that are more related to cognitive and/or social skills. One reason for the inconsistency in results could be due to the fact that studies used a variety of measures; therefore, the differences in outcomes may have depended on the type of measure used to assess motor, cognitive, and social skills.

Some studies have shown that gross motor skills, but not fine motor skills, are associated with both social skills (Piek, Barrett, Smieth, Rigoli, & Gasson, 2010) and cognitive skills (Piek, Dawson, Smith, & Gasson, 2008a) in typically developing preschool-aged children. For instance, Piek et al. (2010) examined whether early gross and fine motor skills development are predictive of later school-aged anxious and depressive symptomatology. Results indicated that early gross motor, rather than fine motor, ability predicts school-age anxiety problem scores and anxious/depressed scores. In addition, Piek et al. (2008a) examined whether information obtained on early gross and fine motor development offers predictive information for later school-aged motor and cognitive development. Results once again showed that gross motor skills, rather than fine motor skills, were a significant predictor of later cognitive performance.

Despite evidence suggesting associations between gross motor skills and both social and cognitive skills, recently, other recent studies have shown that fine motor skills were more strongly related to some cognitive skills than gross motor abilities in typically developing young children (Bart, Hajami, & Bar-Haim, 2007; Carlson, Kim, Winsler, & Curby, under review; Dinehart & Manfra, in press; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010). For instance, Bart et al. (2007) assessed relations between basic motor abilities in kindergarten and scholastic, social, and emotional adaptation in the transition to formal schooling. In kindergarten, the children were given a battery of motor skills at each child's home, assessing visual-motor integration, fine motor accuracy, visual-spatial perception, and motor planning ability. A year later, the children's adjustment to school was assessed using a series of questionnaires, completed by both the teachers and children themselves. Results showed that fine motor accuracy in kindergarten significantly and uniquely contributed to the prediction of school adjustment.

In addition, Grissmer et al. (2010) also found evidence suggesting that fine motor skills are important developmental predictors of later achievement in typically developing children. They examined kindergarten readiness factors, including fine and gross motor skills, socio-emotional skills (attention, externalizing behaviors, internalizing behaviors, social skills), and cognitive skills (reading and math scores), to determine which of children's developing skills measured around kindergarten entrance would predict later reading and math achievement in elementary school. They found that fine motor skills, rather than gross motor skills, were strongly and consistently associated with later school achievement (Grissmer et al., 2010).

Motor performance and cognitive skills. The potential impact of motor development on the emergence of abilities in other domains has already been recognized in "milestones" achieved during infancy, including self-generated locomotion (Campos et al., 2000) and haptic perception, which is the ability to acquire information about objects with the hands (Bushnell & Boudreau, 1993). Campos and colleagues (2000) have argued that the onset of self-generated locomotion is functionally related to a wide variety of developmental changes, including perceptual-cognitive changes, such as using landmarks to code for locations rather than in terms of self, and social-emotional changes, such as the emergence of the ability to engage in social referencing. Moreover, Bushnell and Boudreau (1993) have argued that the timetable for haptic perception is mainly determined by motor development, where the developmental inability to execute appropriate hand movements may serve as a constraint on the ability to perceive a certain object property, such as hardness, shape, or weight. Evidence like this has led to a dramatic resurgence of interest in the relation between motor development and cognitive development.

Wassenberg et al. (2005) investigated the relation between cognitive and motor performance in a sample of 5- to 6-year-old typically and atypically performing children. With regard to cognition, the children were assessed on aspects of verbal and perceptual abilities, working memory, and executive functioning. Motor performance, including the acquisition of fundamental movement patterns and of motor milestones, was assessed. Results showed a positive linear relation between general cognitive performance and motor performance, further supporting the notion that motor and cognitive development are related.

In addition, neurobiological evidence for specific relations between cognitive and motor development, such as the fact that common brain structures are used for both motor and cognitive performance, has led to a steady interest in the relation between cognitive and motor performance in children (Piek et al., 2008a; Wassenberg et al., 2005). Using functional neuroimaging, Diamond (2000) found that, in typically developing children, there was co-activation of both the neocerebellum and dorsolateral prefrontal cortex, not only for cognitive functions but also for motor functions. This close interrelation of motor and cognitive development was also seen when looking at functional neuroimages of children with developmental disorders (Diamond, 2000). For each disorder, abnormalities were found in both the cerebellum and in the prefrontal cortex showing that the neocerebellum and prefrontal cortex are interconnected parts and that a dysfunction in one component of the system can affect the other components. Furthermore, she found that although cognitive and motor strengths or weaknesses do not always co-vary, along with prominent cognitive deficits apparent in many disorders, such as ADHD, dyslexia, autism, or language disorders, many children appear to have concomitant motor problems, further showing that perhaps the cognitive and motor systems are more interrelated than has traditionally been thought.

The relation between motor and cognitive systems is further evident when examining children with intellectual impairment, including children with Down syndrome (DS), a chromosomal anomaly that is one of the leading causes of intellectual impairment (Elliot & Bunn, 2004). Infants with DS are usually born with hypotonia, a condition associated with reduced levels of "tone" in the skeletal muscle (Elliot & Bunn, 2004). In addition, these children have an enlarged third brain ventricle, which contributes to the abnormal development of a surrounding brain area, such as the thalamus, hypothalamus, or deep white matter of the brain (Davis, 2008). These areas are important for cognitive processing, which may explain some of the cognitive deficits that are present in children with DS. Other affected areas include the frontal lobe, temporal lobe, cerebellum, and the myelination process, which are all important for cognitive processing. Of special importance is the abnormal development of the cerebellum because this area is associated with motor timing, motor coordination, and balance, which are consistent with the type of hypotonia, articulation, and motor coordination problems seen in children with DS (Davis, 2008).

The idea that a dysfunction in one developmental domain can affect other areas is seen in a study by Hartman et al. (2010). They examined motor skills and executive function (EF) among typically developing children and children with borderline and mild intellectual disabilities (ID). EF refers to a wide range of cognitive abilities, including attentional control, cognitive flexibility, goal setting, and specific aspects of information processing (fluency, processing speed) that are involved in the control and coordination of information (Willoughby, Wirth, Blair, & Greenberg, 2010). Compared to typically developing children, children with ID were less well developed in motor skills. Furthermore, the findings showed that motor performance (locomotor and object control skills) and EF are associated, which may be due to the fact that motor activity and EF are closely coupled in terms of neural substrates or that motor performance and EF are assumed to share certain underlying skills, particularly in skill sequencing (Diamond, 2000; Hartman et al., 2010). Although this study only looked at gross motor skills and found a relation between gross motor skills and EF, it does give insight as to why motor skills and cognitive skills may be related, which could be applied to fine motor skills as well.

Motor performance and social skills. Social skills are comprised of a variety of components, including but not limited to self-awareness, self-management, social awareness, responsible decision-making, and relationship and social skills (Denham et al., 2010). The literature uses a number of different words to describe this general construct, including social competence (Hartup, 1989; Howes, 1987; Lobo & Winsler, 2006), social-emotional competence (Denham et al., 2009), social skills (Duncan et al., 2007), and social-emotional skills (Grissmer et al., 2010). For the purposes of this paper, the general term 'social skills' will be used to refer to this collection of closely related constructs that refers to a child's ability to establish meaningful and positive relationships with others and feel emotionally secure (Bart et al., 2007).

Research has demonstrated the importance of social skills on children's school achievement and development. Children who are able to understand self and others; regulate emotion, attention, and behavior; make good decisions; and engage in a range of prosocial behaviors tend to be successful in school (Denham et al., 2010). On the other hand, children with poor social skills are at considerable risk for a variety of problems throughout their childhood, adolescence, and beyond, including peer rejection, delinquency, school failure, and emotional maladjustment (Lobo & Winsler, 2006; Ogg, Dedrick, Brinkman, & Carlson, 2010).

Increasingly, the literature has recognized the importance of motor competence in relation to social skills in children. Previous research (e.g., Schoemaker & Kalverboer, 1994; Skinner & Piek, 2001) has shown that motor skills play a crucial role in a child's functioning in the social domain, and that children with motor difficulties often have emotional difficulties and poor social skills. Research has linked poor coordination to attention disorders (Piek & Pitcher, 2004), anxiety, and depression (Piek et al., 2010), and poor self-concept (Skinner & Piek, 2001). Children with poor motor skills have also been found have problems scholastically (Piek et al., 2010) and with peer relationships (Miyahara & Cratty, 2004).

Recently, Cummins, Piek, and Dyck (2005) investigated whether children with poor motor ability have poor emotion recognition skills, and whether these could be linked to problems in social behavior. The two groups of participants in the study were typically developing children and children who were identified as having motor coordination disorder. Results showed that children with poor motor coordination are less accurate and slower in responding to facial emotion cues. Children with motor difficulties may be at a disadvantage when socializing with their peers because they have difficulty detecting emotional states of others and using this information to guide their behavior in social contexts (Cummins et al., 2005).

In addition, Piek, Bradbury, Elsley, and Tate (2008b) also found a link between poor motor ability and social development in typically-developing, preschool-aged children. They investigated the relations between motor coordination, emotional recognition and understanding, and internalizing behaviors in kindergarten children. Children's motor ability, empathic ability, externalizing and internalizing behaviors, and general cognitive ability were measured in kindergarten. Unlike Cummins et al. (2005), Piek et al. (2008b) did not find evidence for a direct relation between motor coordination difficulties and deficits in facial emotion recognition; however, they did find an association between motor coordination and anxious/depressed behavior in preschool-aged children.

Furthermore, Schoemaker and Kalverboer (1994) examined relations between poor motor coordination and social-emotional difficulties in typically-developing children and found that children, ages 6-9 years with poor motor coordination were more likely to have higher levels of anxiety than those with no coordination difficulties. Research has also shown that children have an increased risk of an emotional disorder in adolescence if they have both motor deficits and anxiety problems in childhood (Shaffer et al., 1985; Sigurdsson, van Os, & Fombonne, 2002).

Gender Differences

Motor skills. Across the preschool years, gender differences have been reported in both gross and fine motor tasks. In the area of gross motor performance, boys, compared to girls, show superior performance on physical tasks, including standing broad jump and shuttle run, whereas girls, compared to boys, tend to perform better on body coordination and balancing tasks, such as balancing backwards and hopping on one foot (Krombholz, 2006). In addition, girls outperform boys in fine motor performance. Girls, compared to boys, show superior performance regarding drawing, handwriting, and manual dexterity in both hands (Krombholz, 2006). During preschool, the physical characteristics of girls and boys are very similar; therefore, it seems plausible that these gender differences seen in motor performance may be attributable to the preference of motor activities by boys and girls, in part due to environmental influences, including the process of gender-role identification (Krombholz, 2006; Thomas & French, 1985).

Motor, social, and cognitive skills. Gender differences have been found in the impact of motor skills when predicting later social skills, specifically pro-social behavior, for typically developing children (Bart et al., 2007). None of the motor variables measured in kindergarten, including visual-motor integration, visual-spatial perception, fine motor accuracy, muscle tone, imitation of postures, and kinesthesia, predicted pro-social behaviors in first grade for boys; however, for girls, muscle tone, visual-spatial perception, and imitation of postures in kindergarten significantly and uniquely contributed to the prediction of pro-social behavior (Bart et al., 2007). In addition, some studies have found gender differences in young children in the strength of the association between overall cognitive and motor abilities, with females having a stronger relation than males in a group of typically developing young children (Davis, Pitchford, & Limback, 2011; Planinsec, 2002). There were also similar gender differences in the strength of the association between fine motor and cognitive abilities (Davis et al., 2011), suggesting that associations between motor, cognitive, and social skills may be different for boys and girls. Therefore, the current study investigated whether gender differences found in typically-developing children in the associations between these three domains also exist in this population of children with developmental disabilities.

The Importance of Studying Children with Developmental Disabilities

For centuries, scientists and researchers have been interested in children's development, aiming to describe typical development (Trawick-Smith, 2010). In addition, researchers have recognized that studies of normal development and abnormal development can be mutually informative (Cicchetti, 1990). The present study focuses on children with developmental disabilities. Children with developmental disabilities are unique in that various developmental disorders have a shared etiology, and poor motor coordination has been implicated as one of the shared factors (Martin, Piek, Baynam, Levy, & Hay, 2010). In fact, motor problems are often found in children with cognitive deficits and intellectual disabilities (ID; Diamond, 2000; Hartman et al., 2010). ID, also known as mental retardation, can be characterized by substantial limitations in intellectual functioning, including learning, reasoning and problem solving, and adaptive behavior (Hartman et al., 2010).

Connections have been made between motor, cognitive, and social skills in typically developing children; however, due to the comorbidity between motor difficulties and disabilities that have a cognitive component as part of their diagnoses (e.g., intellectual disability), the impact of motor skills on cognitive and social skills may be different for children with disabilities, compared to typically developing children. Furthermore, research has indicated that there are differences in the relationship between movement problems and different developmental disabilities (Martin et al., 2010. For instance, poor fine motor ability has been most closely linked to attention deficit hyperactive disorder (ADHD; Pitcher, Piek, & Hay, 2003), whereas developmental coordination disorder (DCD) has been primarily associated with gross motor deficits (Martin et al., 2010). Although the current study does not include children with ADHD or DCD, it can be assumed that motor skills may not only look different for different disabilities but also have differential impacts on cognitive and social skills for different disability types.

Between 1997 and 2008, there has been a significant increase in the prevalence of children with developmental disabilities in the United States, from 12.84% in 1997-1999 to 15.04% in 2006-2008 (Boyle et al., 2011). In other words, in 2008, about one in six children have a developmental disability. Developmental disabilities are a diverse group of severe chronic conditions that result in mental and/or physical impairments, which can cause problems with major life activities such as language, mobility, learning, self-help, and independent living (Centers for Disease Control and Prevention, 2004). Developmental disabilities share the essential feature of a predominant disturbance in the acquisition of cognitive, motor, language, and/or social skills that have a significant and continuing impact on the development of a child (Shevell, Majnemer, Platt, Webster, & Birnbaum, 2004). Developmental disabilities include, but are not limited to, autism, deafness, deaf-blindness, emotional disturbance, orthopedic impairment, hearing impairment, speech and language impairment, and developmental delay (Individuals with Disabilities Education Act of 2004, 2004).

Developmental delay is the most common subtype of childhood developmental disability, with a prevalence of 10 percent in the general population (First & Palfrey, 1994; Shevell et al., 2004). Frequently, developmental delay, a temporary diagnosis until the child is old enough to be diagnosed by formal testing, is used to identify children with delays in meeting developmental milestones in one of more areas of development, including physical skills, cognitive skills, speech and language, and psychosocial abilities (First & Palfrey, 1994; Petersen, Kube, & Palmer, 1998). Although there is no consensus on the specific definition, the Division for Early Childhood (DEC; Division for Early Childhood, 1991), a division of Council for Exceptional Children (CEC), defines developmental delay as “a condition which represents a significant delay in the process of development…and that without special intervention, it is likely that educational performance at school age will be affected” (p.1).

THE PRESENT STUDY

Although there has been an increase in research concerning motor, cognitive, and social skills, research focusing on the connections between these three areas of development is limited in several ways. First of all, even though studies (e.g., Piek et al., 2010) have found a relation between gross motor abilities and social skills, the question still remains about a potential relation between fine motor skills and social skills. Second, despite the fact that, in recent years, research has acknowledged the importance of understanding the complex interplay of the different areas of development in young children (e.g., Bart et al., 2007; Denham et al., 2010; Diamond, 2000; Grissmer et al., 2010; Piek et al., 2008), particularly in relation to academic success, these studies have mostly focused on children who are typically developing. Therefore, relatively little is known about the links between motor skills and cognitive and social skills in the population of preschool-aged children with developmental disabilities.

The data for the present study come from the Miami School Readiness Project (MSRP; Winsler et al., 2008), a large-scale, collaborative study that took place in Miami-Dade County, Florida. In this project, essentially the entire population of 4-year-old children attending subsidized childcare or public school pre-kindergarten in the county was studied in the context of childcare quality improvement and program evaluation. The population of children involved in the MSRP is large (N= ~45,000) and diverse

(~60%Latinos/Hispanics, ~30% African American, and ~10% White/Other).

The children in this study all were identified as having special needs and attended a special education preschool program implemented by the public schools (N = 3,191). I was interested in the population of preschool children with developmental disabilities, and therefore, although there were other children in the study who received special education services at some point during kindergarten and beyond, if they did not receive special education services in pre-kindergarten, they were excluded from the current study.

In the present study, I examined motor, social, and cognitive skills in preschool-aged children with developmental disabilities, for potential links between the three areas in this population of children, as well as, the effects of gender and disability category on the associations between motor, social, and cognitive skills. Figure 1 shows the full model for the associations that were investigated between motor, social, and cognitive skills, while controlling for the effects of age in months of the child when motor assessments were conducted, gender, and disability category types. Figure 2 shows the full model with the interaction terms between both fine and gross motor skills and disability category types included in the model as predictors of later cognitive and social skills, while controlling for the main effects of age, gender, and disability category. Both gross motor and fine motor skills were assessed to explore and clarify the associations between both types of motor skills and cognitive and social skills. The raw scores of fine motor and gross motor skills at time 1 (T1; Fall) and cognitive and social skills measured at time 2 (T2; Spring) were used in the analyses to examine whether early fine and gross motor skills measured during the Fall of preschool predicted later cognitive and social skills, measured during the Spring of preschool. Due to potential confounds, age, gender, and disability category were added to the model as control variables. The goals of the study were addressed with the following research questions:

1. What do fine and gross motor skills look like in this population of children with developmental disabilities?
2. Do gender and disability category impact cognitive and social skills?
3. Are there associations between motor, cognitive, and social skills in preschool children with developmental disabilities?
4. Which aspect of early motor skill (fine or gross), measured in the Fall, is a better predictor of later social and cognitive skills, measured in the Spring?
5. Do gender and disability category moderate associations between motor, social, and cognitive skills?

METHOD

Participants

The participants in the study consist of a sub-sample of 3,191 children from four yearly cohorts who received pre-kindergarten special education services during the academic years of 2003-2004 to 2006-2007. The cohorts represent yearly enrollment in pre-kindergarten based on children's age (e.g., at least 4 years old on September 1st of each study year), as stated by county standards. For the subsample for which ethnicity information was available (n = 2,894), 66% were Hispanic/Latino, 22% were Black/African American (including those of Caribbean origin), and 12% were White/Other. At the beginning of the year, children were on average 55 months of age, and for the subsample (n = 2,925) for which gender information was available, 73% were male. There is evidence of an overrepresentation of boys receiving special education services (Oswald et al., 2003); therefore, as anticipated, boys were overrepresented in this sample of children with disabilities as compared to the sample of typically-developing preschoolers, $\chi^2 = 469.82$, $p < .001$. Demographic information can be found in Table 1.

Disability Classification

All children receiving special education services in pre-kindergarten were labeled by the schools as having a 'developmental delay'. Children were given a label of developmental delay if they were between the ages of 3 and 5 years and were two standard deviations below the mean (or 25% delay) on standardized assessments yielding scores in months in at least one area of development or were 1.5 standard deviations below the mean (or 20% delay) on standardized assessments yielding scores in months in at least two of the following areas of development: adaptive or self-help; cognitive; communication; social or emotional; and physical including fine, gross, or perceptual motor.

Starting in kindergarten, the children continuing to receive special education services, were assessed within the Miami-Dade county school system for eligibility, and were assigned primary disability categories (more specific than developmental delay), in order for an Individualized Education Plan (IEP) to be developed. At the time of data collecting for MSRP, the Miami-Dade county school system used 17 primary disability classifications including: educable mentally handicapped, trainable mentally handicapped, orthopedically impaired, speech impaired, language impaired, deaf or hard of hearing, visually impaired, emotionally handicapped, specific learning disabled, hospital/homebound, profoundly mentally handicapped, dual-sensory impaired, autistic, severely emotionally disturbed, traumatic brain injured, developmentally delayed, and other health impaired.

Consistent with other work examining preschool children with developmental disabilities (Crane, 2010), children who eventually received a primary diagnosis that was sensory (visual or hearing impairment), orthopedic, involved traumatic brain injuries, or children who are hospitalized or homebound were excluded from the data analyses (total n = 110, not included in the numbers above). This is due to the fact that certain characteristics of these disability types could have a major impact on the children's abilities to perform on the assessments of interest. The remaining children were collapsed into six groups, according to the primary disability category received in kindergarten. The six groups are: learning disability (LD; n = 898); speech/language impairment (SLI; n = 192, speech impaired, language impaired combined); intellectual disability (ID; n = 509, educable mentally handicapped, trainable mentally handicapped, profoundly mentally handicapped, developmental delay combined); emotional disability (ED; n = 168, emotionally handicapped or severely emotionally disturbed combined); autism (A; n = 430); and other health impairment (OHI; n = 50). There is also a group of children who had kindergarten grades and assessment information but did not receive a disability category (n = 316). It was assumed that these children were significantly delayed in pre-k but who improved and did not qualify for special education services after pre-kindergarten. This group of children was included in the study because they are part of the population of interest--preschool children who were receiving special education services in pre-k. It is important to keep in mind that these primary disability categories are used by the school system to determine eligibility for special education services, which may be different from a primary or secondary diagnosis given by a clinician.

Measures and Assessments

During the MSRP, children attending special education preschool programs in Miami-Dade County were assessed at least twice yearly, near the beginning of the academic year (T1: September-October) and at the end of the academic year (T2: April-May), at age four for both general developmental skills and for social skills.

Developmental skills assessment. To evaluate motor and cognitive performance, the children were assessed using the Learning Accomplishment Profile-Diagnostic (LAP-D; Nehring, Nehring, Bruni, & Randolph, 1992). The LAP-D is used to determine instructional and developmental milestones for children ages 36 to 72 months and is scored through analysis of tasks performed by the children (Lidz, 2003). The LAP-D can also be used to identify and place special needs students, assist in program planning, and assess a child's progress (Nehring et al., 1992). Raw scores in four major developmental areas with two sub-scale scores per domain were used in the analyses: Cognitive (matching and counting; raw score ranges from 0 to 57), Fine Motor (writing and manipulation; raw score ranges from 0 to 59), Gross Motor (body and object movement; raw score ranges from 0 to 57), and Language (comprehension and naming; raw score ranges from 0 to 53). The scores are also given as equivalents to months of age and can be converted into standardized scores and percentile rankings (Nehring et al., 1992).

We focus on the cognitive, fine motor, and gross motor subscales in the current study. Example cognitive matching items include "matches pictures of like animals" and "completes 8-piece puzzles in 3 minutes." Example cognitive counting items include "responds to concepts of tall, long, short" and "counts blocks to 10." Example fine motor writing items include "copies circle" and "adds 3 parts to incomplete person." Example fine motor manipulation items include "builds tower of 10 small blocks" and "laces through holes in outline of picture on lacing card." Example gross motor body movement items include "balances on 1 foot for 8 seconds" and "walks backward heel to toe in imitation for 8 steps." Example gross motor object movement items include "kicks large rolling ball" and "catches bean bag with hands." The LAP-D, which the teachers, who had completed extensive, multi-day trainings conducted by personnel from the local collaborating university and the publisher of the instrument, administered the LAP-D assessments for the children in pre-kindergarten special education, in either Spanish and English, depending on which language the teacher believed was the child's strongest language.

The LAP-D was standardized using a sample of typically-developing preschoolers (N = 792), and internal consistency for the LAP-D during standardization was reported (Nehring et al., 1992). Alphas were high in magnitude, ranging from α = 0.76 – 0.92 (Nehring et al., 1992). Convergent validity was established by administering several other established instruments. Correlations with domains in these instruments and the LAP-D were significant and moderately high in magnitude, ranging from r = 0.68 – 0.80 (Nehring et al., 1992). Internal consistency reliabilities for the total MSRP data were .93 for the cognitive scale, .95 for language, and .94 for fine motor (Winsler et al., 2008).

Social skills assessment. In order to assess children's social skills, the Devereux Early Childhood Assessment (DECA; LeBuffe & Naglieri, 1999) was used. The DECA is a parent- and teacher-report instrument developed to assess resiliency by examining socio-emotional protective factors and behavioral concerns in preschool children. In order to be consistent with teacher-assessed LAP-D subscales, the current study used teacher-reported scores on 37-items, with responses ranging from zero (*Never*) to four (*Very Frequently*). It is divided into four subscales: Initiative (i.e., "choose to do a task that was challenging," "participate actively in make-believe play with others," "try or ask to try new things or activities"), Self-Control (i.e., "control one's anger," "handle frustration well," "cooperate with others"), Attachment (i.e., "respond positively to adult comforting when upset," "act happy or excited when parent/guardian returned," "seek help from children/adults when necessary"), and Behavioral Concerns (i.e., "get easily distracted," "destroy or damage property," "fight with other children"). The first three subscales can be added together to form a Total Protective Factors (TPF) score ranging from 0 to 108, with larger scores indicating more social protective factors.

The DECA was standardized using a sampling of typically-developing preschool children ($N = 2{,}000$) who closely represented the U.S. population on various demographic characteristics (LeBuffe & Naglieri, 1999). Internal reliability coefficients were all above 0.71, and many were above 0.90, indicating high internal consistency. The DECA is able to accurately discriminate between preschoolers with and without identified emotional and behavioral problems (LeBuffe & Naglieri, 1999). A strong correlation ($r = -.65$) has been reported between scores on the Behavioral Concern and TPF scales, indicating adequate construct validity (LeBuffe & Naglieri, 1999).

The overall internal consistency reliability for the DECA in the larger MSRP project was .94 for teacher reports for Total Protective Factors and .81 for teacher reports for Behavior Concerns (Crane, Mincic, & Winsler, 2011; Winsler et al., 2008). The internal consistency reliability for the English version of DECA was .94 for teacher reports for Total Protective Factors, and .81 for teacher reports for Behavior Concerns (Crane et al., 2011). The internal consistency reliability for the Spanish version of DECA was .94 for teacher reports for Total Protective Factors and .80 for teacher reports for

Behavior Concerns (Crane et al., 2011).

Using the current sample of children with developmental delays from the Miami data, the internal consistency reliability for the teacher-reported DECA was examined. All alphas were above .80, which indicates good reliability. The Initiative subscale had very high internal consistency reliability, Cronbach's $\alpha = .90$. The Attachment subscale had the lowest internal consistency reliability of the five DECA subscales but was still considered to have good reliability, Cronbach's $\alpha = .80$. The Self-Control subscale had very high internal consistency reliability, Cronbach's $\alpha = .93$, and Behavioral Concerns subscale was also considered to have high internal consistency reliability, Cronbach's $\alpha = .83$. The Total Protective Factors subscale, which is a combination of Initiative, Attachment, and Self-Control subscales, had the highest internal consistency reliability of the five DECA subscales, Cronbach's $\alpha = .94$. These findings show that the DECA has strong internal consistency for teacher-reported scales within this preschool population of children with developmental delays.

Data Analysis

Analyses were performed in a Structural Equation Modeling framework using AMOS software (Arbuckle, 2003). Full-information maximum-likelihood (FIML) estimation was used to account for missing data (See Table 1). FIML is optimal for dealing with missing data in SEM because it uses all the available information to provide a more efficient estimate (Acock, 2005; Arbuckle, 1996). The disability categories were effects-coded to examine the difference between the mean of the group in question (coded as 1) and the grand mean of all of the groups. The students who had kindergarten grades but did not have a disability label were used as the base group (coded as -1).

Path analysis in a structural equation modeling (SEM) framework was used to evaluate the relations between both fine and gross motor skills at T1 and cognitive and social skills at T2, while controlling for the effects of gender, age, and disability category (Figure 1). Interaction terms between the effects-coded disability categories and both fine motor and gross motor scores were created and entered as predictors directly into the model, simultaneously with the original variables (Figure 2), allowing the testing of differences in the strengths of the associations in motor skills and cognitive and social skills for different disability categories, as compared to the average of the disability groups (Cohen, Cohen, West, & Aiken, 2003). Again, path analysis was used to examine the degree to which the disability category moderates these associations, rather than using multi-group analysis to test for differences between the disability categories. This is due to the fact that since, fundamentally, this is an exploratory study, we have no definite hypotheses about how each of the specific disability categories will affect the relations between motor, cognitive, and social skills. Therefore, we used effects-coding to compare each category to the mean of all of the groups to test for differences against the average disability. All predictors were allowed to correlate, saturating the model and making the analyses comparable to a regression. In order to investigate the moderating effects of gender, multi-group analysis in SEM was conducted to determine the extent to which the model was consistent across both groups of gender.

RESULTS

Research Question 1

What do fine and gross motor skills look like in this population of children with developmental disabilities?

Preliminary analyses. Preliminary analyses were conducted to investigate what fine and gross motor skills look like for children with developmental disabilities. Descriptive statistics for the variables were first examined (Table 1). Children were, on average, 55 months old at the time of the motor assessments; however, due to the variation around the mean age at the motor assessments (ranged from 37-71 months), age at the time of the motor assessments was added as a control variable. The mean for fine motor skills was 35.84 points out of a possible 59 points. This average score translates to a percentile rank of 11. The mean for gross motor skills was 37.72 points out of a possible 57 points, which translates to a percentile rank of 9. The mean for cognitive skills was 36.95 points out of a possible 57 points, which translates to a percentile rank of 54. For social skills, the mean was 68.84 points out of a possible 108 points, which translates to a percentile rank of 46.

Correlations between variables can be found in Table 2. Fine motor and gross motor skills were positively correlated with each other (r = .54). In other words, 29.2% of the variance in gross motor skills can be explained by the variance in fine motor skills, after controlling for age (in months) at the time of the assessments. Both fine motor and gross motor skills were significantly, negatively correlated with intellectual disability and autism. In other words, children with intellectual disability and autism had significantly lower fine motor and gross motor skills, as compared to children with other types of disabilities. Fine motor skill was significantly positively correlated with speech/language impairment and children who "got better", indicating that these children had higher fine motor skills compared to children with other types of disabilities. In addition, gross motor skill was significantly, positively correlated with the disability categories of emotional disability and children who "got better", indicating that children with emotional disability and who "got better" had higher gross motor skills, as compared to children with other disability categories. Interestingly, both fine motor and gross motor skills had the highest negative correlation with intellectual disabilities, suggesting that children with intellectual disability have lower motor skills overall compared to children with other types of disabilities. All of the dummy-coded disability categories were negatively correlated with each other, indicating that children in one disability category tend not to be part of another disability category. In other words, being in a specific disability category decreases the likelihood of a child being diagnosed as having a different type of disability.

Research Question 2

Do gender and disability category impact cognitive and social skills?

Main effect of gender. The results of the path analysis revealed significant gender differences for both cognitive (β = -.06, p < .001) and social skills (β = .11, p <

.001); however, these gender differences were small. Girls were less than a tenth of a standard deviation unit below boys in cognitive skills and about a tenth of a standard deviation unit higher than boys in social skills. See Table 3 for path coefficients.

Main effect of disability category. Path analysis in SEM framework was conducted to examine the main effect of disability category on cognitive and social skills. There were significant disability category differences in both cognitive and social skills. Children with an intellectual disability label scored significantly lower on the LAP-D cognitive subtest (b = -2.33; p < .001) but were not significantly different from the average of the groups on the DECA social skills assessment (b = -.1.22, p = .18). Children with a speech/language impairment label scored higher on both the LAP-D cognitive subtest (b = 1.55; p < .05) and on the DECA social skills assessment (b = 8.98, p < .001) than the average of the groups. Children with an emotional disability label scored lower on the LAP-D cognitive subtest than the average of the groups (b = -1.73, p < .05). They also scored significantly lower on the DECA social skills assessment (b = -9.16; p < .001). Children with a learning disability label scored significantly lower on the LAP-D cognitive subtest groups (b = -1.04 p < .01) but scored significantly higher on the DECA social skills assessment (b = 2.84; p < .001) than the average of the groups. Children with an autism label scored significantly lower on the LAP-D cognitive subtest (b = -1.16; p < .05), and also on the DECA social skills assessment (b = -8.69, p < .001) than the average of the groups. Children with other health impairment label did not score significantly differently than the average of the groups for both cognitive (b = 1.16; p = .32) and the social skills assessment (b = -1.04; p = .64).

Research Question 3 and 4

Are there associations between motor, cognitive, and social skills in preschool children with developmental disabilities? Which aspect of motor skill (fine or gross) is a better predictor of social and cognitive skills?

Associations between motor, cognitive, and social skills. Results from the path analysis revealed significant associations between both motor skills at T1 and cognitive and social skills at T2. Fine motor skills significantly predicted cognitive skills ($\beta = .54$, $p < .001$), as well as social skills ($\beta = .26$, $p < .001$), after controlling for age, gender, and disability category. Gross motor skills also significantly predicted both cognitive skills ($\beta = .13$, $p < .001$), as well as social skills ($\beta = .08$, $p < .05$), after controlling for age, gender, and disability category. Notably, the associations between gross motor and cognitive and social skills are not as strong as those for fine motor.

Research Question 5

Do gender and disability category moderate associations between motor, social, and cognitive skills?

Disability category as a moderator. Path analysis was used to examine the degree to which the disability category moderates the associations between motor skills and cognitive and social skills. It is important to keep in mind that the disability categories were effects-coded; therefore, the disability group in question is being compared to the average of all of the disability group means. For fine motor skills, we detected moderated effects for learning disability (LD) and intellectual disability (ID) categories, when predicting cognitive skills at T2, after controlling for the main effects of gross motor, fine motor, gender, age, and disability category. All other interaction terms were not significant.

As mentioned above, there was a significant interaction effect between fine motor skills and the LD group on cognitive skills scores, $b = -.12$, $p < .05$, where the effect of early fine motor skill on later cognitive skills varied as a function of whether or not the child had an LD label. Both groups show a positive relationship between fine motor and cognitive skills; however, the relationship between fine motor and cognitive skills is significantly stronger for children with LD. Children with LD had significantly higher cognitive skill scores than the average child with a disability regardless of their fine motor skill scores; however, at lower fine motor scores, the difference in cognitive skill scores between children with LD and the average child with a disability was smaller, as compared to at higher fine motor skill levels, where the gap in cognitive skill scores is much larger (Figure 3). In other words, having higher fine motor skills has a significant positive impact on the cognitive skills of children with LD.

There was also a significant interaction for children with intellectual disability (ID), $b = .20$, $p < .01$, where the positive relationship between early fine motor and later cognitive skills was stronger for children with ID. In other words, even though children with ID were always lower in cognitive skills than the average child with a disability, children with ID who had higher fine motor skills in the Fall were closer to the mean cognitive level of children with disabilities in the Spring (Figure 4).

For gross motor skills, we detected moderated effects for intellectual disability (ID), speech/language impairment (SLI), and autism when predicting cognitive skills at

T2, after controlling for the main effects of gross motor, fine motor, gender, age, and disability category. All other interaction terms were not significant, including all of those for social skills.

There was a significant interaction effect between gross motor skills and ID category on cognitive scores, $b = .14$, $p < .05$, where the effect of early gross motor skills on later cognitive skills varied as a function of whether or not the child had an ID label. The relationship between gross motor and cognitive skills was significantly stronger for children with ID than for the average of all of the disability groups. Even though children with ID had lower cognitive skill scores than the average of all the children with disabilities, among those with lower gross motor skills, there was a significant difference in cognitive skill scores for those with and without an ID label. However, for those with higher gross motor skills, the difference in cognitive skill scores was smaller between children with and without ID (Figure 5). In other words, children with ID with higher fine motor skills in the Fall were closer to the average child with a disability in terms of cognitive skill scores in the Spring. This suggests that having higher gross motor skills may be beneficial for children with intellectual disabilities.

There was also a significant interaction effect between gross motor skills and children with autism on cognitive skills scores, $b = .27$, $p < .01$, where the effect of gross motor skill varied as a function of whether or not the child had an autism label. Both groups show a positive relationship between gross motor and cognitive skills; however, the relationship between fine motor and cognitive skills is significantly stronger for children with autism. In other words, even though children with autism, as compared to those without the autism label, had significantly lower cognitive scores, regardless of their gross motor scores, for those with higher gross motor skills in the Fall, the difference in cognitive skill scores was smaller in the Spring when compared to the average children with a disability (Figure 6). This suggests that having higher gross motor skills may be especially beneficial in increasing cognitive skills for children with autism.

Furthermore, children with speech/language impairment (SLI), as compared to those without the label, had significantly higher cognitive scores, regardless of their gross motor scores. There was a significant interaction effect between early gross motor skills and the SLI group on later cognitive skill scores, $b = -.18$, $p < .05$, which indicated a difference in the relationship between gross motor and cognitive skills between children with SLI and the average child with a disability. In fact, the relationship between early gross motor and later cognitive skills was stronger for the average child with a disability, rather than for those with SLI. In other words, even though the average child with a disability has lower cognitive skills scores, as compared to children with SLI, the average child with a disability who had higher gross motor skills got closer to the cognitive skill level of children with SLI (Figure 7). This suggests that having higher gross motor skills is more beneficial for children with a disability label other than speech/language impairment.

The moderated effect for learning disability (LD) on the association between gross motor and cognitive skills was marginal, $b = -.11$, $p = .06$. Regardless of gross motor skill scores, children with LD had significantly higher cognitive skills scores than the average child with a disability; however, the relationship between gross motor and cognitive skills was weaker for children with LD. Even though the cognitive skill level is always lower for the average child with a disability, if the child had higher gross motor skills, their cognitive level was closer to the cognitive level of children with LD.

Gender as a moderator. A multi-group analysis in SEM was conducted to investigate whether gender was a significant moderator in the relations between motor, cognitive, and social skills. We first examined the chi-square value to see if gender moderated the associations between motor, cognitive, and social skills. In other words, we examined whether the structural weights were significantly different for boys than for girls. Multi-group analysis indicated that the model for the boys and girls are not significantly different from each other ($\chi^2_{(18)} = 20.79$, $p = .29$); in other words, the model fit equally well for boys and girls. A closer examination of beta weights also indicates that there are not substantial differences in the associations between motor, cognitive, and social skills between boys and girls.

DISCUSSION

Both theory and research have acknowledged the importance of motor abilities in relation to other developmental areas in children (Diamond, 2000; Lockman & Thelen, 1993; Piaget, 1953). However, research has either examined general motor abilities, without distinguishing between fine and gross motor skill (e.g., Hartman et al., 2010), or has typically focused on gross motor abilities in relation to cognitive and social abilities (e.g., Piek et al., 2010). Until very recently, associations between fine motor abilities and cognitive and social abilities have received very little research attention, and the research that has been done has mostly been with children other than the preschool population (e.g., Bart et al., 2007; Grissmer et al., 2010). In addition, no studies, to my knowledge, have compared differences in the associations between motor, social, and cognitive skills across various disability types. This study examined the interrelations between both fine and gross motor, cognitive, and social skills in preschool-aged children with developmental delays, investigated whether fine or gross motor skill was a better predictor of social and cognitive skills, and analyzed the effects of gender and disability category as moderators of these relations.

Four main findings emerged from this study. Results indicated that fine and gross motor skills were negatively correlated with all disability types, suggesting that children with low gross motor scores also tended to have lower fine motor scores. Also, there were significant associations between motor, cognitive, and social skills. In the area of motor skills, fine and gross motor abilities seem to be two distinct skills, rather than a single ability, relating differently to both social and cognitive skills. In addition, both fine and gross motor skills significantly predicted cognitive and social skills; however, fine motor skills were more strongly associated with both cognitive and social skills. Finally, associations between motor, cognitive, and social skills were similar for boys and girls, but there were differences in the associations across certain disability categories. These results are further discussed below.

Motor Skills in Preschool Children with Developmental Disabilities

Most activities involve numerous motor skills, such as moving around the environment and manipulating materials. The development of motor skills follows certain progressions: head to foot, gross to fine, and proximal to distal (Rainforth, Giangreco, & Dennis, 1989). In the current study for this population of children with disabilities, gross and fine motor skills were strongly, positively correlated, and, on average, the children had slightly higher gross motor skills than fine motor skills. This finding is in line with earlier studies that have shown that children with delays have more problems with skills that involve object control (i.e., fine motor skills) than with locomotor skills (e.g., Hartman et al., 2010). Children with developmental disabilities may have more difficulties with fine motor skills because they involve coordinating small muscle movements when manipulating objects (Essa, Young, & Lehne, 1998). Although children with moderate and severe disabilities tend to achieve the typical motor milestones and follow the normal sequences, they do so at a slower rate (Rainforth et al., 1989);

therefore, these children in the current study may have not yet successfully achieved some fine motor milestones.

In line with previous research that found gender differences in motor skills (Krombholz, 2006; Thomas & French, 1985), there were also similar gender differences for both fine motor and gross motor skills in this population of children. Specifically, boys, as compared to girls, had higher gross motor scores but lower fine motor scores. These were very slight differences, which may be due to the fact that biologically, the physical characteristics of boys and girls are very similar in early childhood, prior to puberty, suggesting gender similarity in motor performance, rather than large gender differences (Thomas & French, 1985). The small gender differences that were found may be due to environmental or social factors. For instance, studies have indicated that parents tend to emphasize the development of gross motor skills in boys, more so than in girls, such as "rough and tumble" play during early childhood (Thomas & French, 1985). Therefore, differences in expectations for boys and girls concerning motor tasks may lead to differences in the amount of encouragement and practice opportunities for gross motor activities for boys and fine motor activities for girls, increasing the gender differences in motor skills.

Associations Between Motor, Cognitive, and Social Skills

A recent focus of motor research has been on examining associations between motor abilities and cognitive (Diamond, 2000) or social abilities (Denham et al., 2010; Lobo & Winsler, 2006), along with attempting to predict academic achievement (Bart et al., 2007; Grissmer et al., 2010) and social adjustment (Piek et al., 2008b; Piek et al., 2010; Schoemaker & Kalverboer, 1994). Findings from this study also indicate that associations exist between motor, cognitive, and social skills in this population of children with developmental disabilities. These associations are clearly evident when fine and gross motor skills were used to predict later cognitive and social skills.

Both fine and gross motor skills assessed in the Fall semester of preschool significantly contributed to the prediction of cognitive and social skills (assessed in the Spring semester), even after controlling for age, gender, and disability type of the child. However, both types of motor skills were more strongly associated with cognitive skills than social skills. The strong association may be due to the underlying neural network that serves both motor and cognitive processing, which links both areas consistently across childhood (Davis et al., 2011; Diamond, 2000). In fact, there is considerable evidence that physical activity and movement improves brain functioning, especially in the pre-frontal cortex, and cognitive skills, at the molecular, cellular, and behavioral levels (Diamond, 2011; Hillman, Erickson, & Kramer, 2008). In addition, predictive studies (e.g., Campos et al., 2000) have also indicated a link between motor and cognitive development, suggesting that early motor experiences facilitate cognitive development. Our finding supports previous theories and research indicating that motor skills are important for the emergence of cognitive ability (Bushnell & Boudreau, 1993; Piaget, 1953). However, this somewhat contradicts previous research that found that either fine motor (Bart et al., 2007; Grissmer et al., 2010) or gross motor (Piek et al., 2008a; Wassenberg et al., 2005) skills were related to cognitive skills, but not both.

One possible reason for the discrepant findings may arise from differences in the measures used to assess motor and cognitive skills in these different studies. For example, Bart et al. (2007) used the Developmental Test of Visual-Motor Integration (VMI; Beery, 1989) to assess motor skills, whereas Piek et al. (2008a) used the Ages and Stages Questionnaires (ASQ; Squires, Potter, & Bricker, 1995), as well as the McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1997). Piek et al. (2008a) used the Wechsler Intelligence Scale for Children-4th ed. (WISC-IV; Wechsler, 2004) to assess cognitive skills, whereas Grissmer et al. (2010) used standardized reading and math scores to assess cognitive skills.

The current study also showed evidence of a link between motor skills and social skills, although to a lesser degree than with cognitive skills. This finding supports previous studies that have indicated a significant association between social behavior and motor ability (Bar-Haim & Bart, 2006; Cummins et al., 2005; Piek et al., 2008b). For instance, Bar-Haim and Bart (2006) found that children with low motor abilities displayed lower frequencies of social play and higher frequencies of solitary play. Thus, children with lower motor abilities may be unable to participate in many social activities due to their lack of ability to carry out the motor functions necessary for play, which can lead to social estrangement. In fact, motor difficulties have been recognized as a contributing factor for poor social functioning in young children (Cummin et al., 2005; Piek et al., 2008b). Furthermore, there is evidence suggesting that motor and social skills are connected at the neurophysiological level. The pre-frontal cortex (PFC) and the amygdala have a reciprocal connection that are both highly involved in aspects of social behavior and motor planning and execution (Bar-Haim & Bart, 2006). These transactions between brain structures may be an explanation as to why there were associations between motor and social skills in children with disabilities.

Fine Motor Is a Stronger Predictor of Cognitive and Social Skills

As mentioned previously, both fine motor and gross motor skills, measured in the Fall of preschool, significantly predicted later cognitive and social skills; however, fine motor skill was a stronger predictor of both cognitive and social skills, measured in the Spring of preschool, and more so for cognitive than for social skills. The fact that fine motor skill, as compared to gross motor skill, more strongly predicted social skills was surprising in that it contradicted previous research that found the significance of gross motor skills, in relation to social skills (Piek et al., 2008b). A possible explanation for the significance of fine motor skill is that, in preschool, children usually sit at tables in groups when working on fine motor activities, which provides affordances for social interactions; however, for those students who do not enjoy or have good fine motor skills may avoid these activities, missing out on these social opportunities.

Recent research has established a connection between early fine motor skills and later cognitive performance in typically-developing children, specifically when examining children's readiness skills for transition to formal school and in predicting later academic achievement (Grissmer et al., 2010; Son & Meisels, 2006). The current study also shows that early fine motor skills are a strong predictor of later cognitive skills in children with developmental disabilities. One explanation for this association is found when looking at recent advances in the science of human movement, which indicate that motor and cognitive skills are closely related not only at the behavioral level, but also in terms of similar cortical and subcortical neural structures in both typically and atypically developing children (Diamond, 2000; Pangelinan et al., 2011). Evidence from neuroimaging studies shows a close interrelation of the dorsolateral prefrontal cortex and the neocerebellum, which were previously thought to be unrelated in their functions (Diamond, 2000). New evidence indicates that the cerebellum is important not only for motor functions, but also for cognitive functions. In the same way, cognitive tasks that involve the dorsolateral prefrontal cortex also require the neocerebellum (Diamond, 2000). Thus, the results from the current study indicated a strong association between fine motor and cognitive skills, further supporting these studies that found motor-cognitive linkages in the brain structures.

Children in early childhood programs, such as Head Start, spend a considerable portion of their day (37%) participating in some type of fine motor activity, and this increases to 46% in kindergarten classrooms (Marr, Cermak, Cohn, & Henderson, 2003). These fine motor activities may provide opportunities for children to expand their cognitive capacities, through the challenges encountered while developing new motor skills. Therefore, another possibility that may partially account for the link between fine motor and cognitive skills is the fact that fine motor skill is involved in many activities that are related to cognitive functioning, including writing, speaking, and reading; therefore, children with poor fine motor skills may have more difficulties with cognitive performance because of the concurrent need for fine motor skills in cognitive activities (Grissmer et al., 2010).

Moderation of Gender and Disability Categories

Unlike previous findings (e.g., Davis et al., 2011; Planinsec, 2002) of gender differences in the strength of the relationship between motor and cognitive skills, our findings do not show this. The multi-group analysis indicated that there were no gender differences in the associations between motor, cognitive, and social skills. This does not mean that the mean levels are the same for all three areas for both genders; however, this does suggest that the underlying associations between the three areas are similar for both boys and girls. This is surprising because previous studies using typically developing children have found gender differences in the developmental trajectory of motor skills in early childhood, with girls developing fine motor skills ahead of boys, and boys developing gross motor skills before girls (Davis et al., 2011; Livesey, Coleman, & Piek, 2007). However, the current study involved children with developmental disabilities; therefore, it is possible that in this population, gender does not have has much of an impact, as these children are already operating with deficits that have a stronger impact on their motor and cognitive performance, thus, masking any possible gender difference.

The results of the current study found evidence of a stronger relationship between motor skills and cognitive skills for certain disability categories, after controlling for the main effects of gross motor, fine motor, gender, age, and disability category. Surprisingly, disability category did not moderate the associations between both fine and gross motor skills and social skills. Previous studies have found associations between motor skills and social problems, including anxious/depressed behavior in preschoolers, where children at risk of having a motor disability, such as Developmental Coordination

Disorder (DCD), demonstrated higher anxious/depressed symptomatology than children with typical motor skills (Piek et al., 2008b). One explanation for our results is that there may be a cognitive component to being able to carry out age-appropriate social skills, such as processing social and affective cues, and since the association between motor skills and cognitive skills was stronger than the association between motor and social skills, any interaction effects that may exist between disability category and motor skills on the prediction of social skills may have been masked. In addition, the participants in the study are children living in low-income, urban areas in Miami Dade County (Winsler et al., 2008), where unfortunately, as of the year 2000, 22.9% of children under the age of 18 are living below the federal poverty level (U.S. Census Bureau, 2000). In the current sample, 67% of children were of low socioeconomic status. When one compounds the negative effects that exist with having a disability with low socioeconomic status, where the availability of social resources is minimal, motor skills may not have much of an impact on children's social skills, regardless of the type of disability.

In contrast to our findings for social skills, for the disability categories of learning disability (LD) and intellectual disability (ID), relations between fine motor and cognitive skills were stronger. This finding suggests that fine motor skill may have a compensatory effect for children with LD and ID, which are types of disabilities that are defined by poor cognitive skills. The connection between fine motor and cognitive skills has already been established in research with typically developing children (e.g., Grissmer et al., 2010), and the current study found similar links for children with disabilities. Therefore, because of the fact that children with LD and ID have lower cognitive abilities due to the nature of their disabilities, having good fine motor skills may provide an advantage that is especially stronger for these children, as compared to children with other types of disabilities where there may not be as strong of a deficit in cognitive abilities.

In addition, relations between gross motor skills and cognitive skills were stronger for children with ID, speech/language impairment (SLI), and autism. Having higher gross motor skills was more beneficial for children with ID and autism, which are two types of disabilities that have a cognitive deficit element as part of the diagnosis (Pangelinan et al., 2011). However, the opposite was true for children with SLI, where having better gross motor skills was more beneficial for children without the SLI label. An explanation that is similar to the one for fine motor skills can be applied to these findings. It may be that motor and cognitive abilities are not only interrelated at the brain level (Diamond, 2000), but also at the behavioral level, where cognitive and motor behaviors may be mutually influential in the development of these abilities (Pangelinan et al., 2011). Children with ID and autism may have a larger cognitive deficit, and therefore, the impact of gross motor skills may be stronger on their cognitive skills than for children with other types of disabilities.

Limitations and Future Directions

There are some limitations that are worth mentioning. One limitation is that these relations are correlational and should not be interpreted causally. It may be that children with higher cognitive and social skills have better motor skills, or other factors may serve as a causal source for both motor difficulties and poor cognitive and social outcomes. Further experimentally-oriented research is needed to clarify the causal mechanisms involved in the associations between motor ability and cognitive and social skills.

Another limitation of the study is that the assessment used to measure social skills (Total Protective Factor scores of the DECA) encompasses items that tap into children's abilities to show initiative, self-control, and attachment skills, which may not necessarily be a comprehensive measure of children's social skills. There may be other aspects of social skills that were not included in the assessment that may be related to motor skills, or there may have been items included in the assessment that does not actually measure social skills. This could explain the weaker relations between motor skills and social skills, as well as the lack of significant findings for the moderation of disability categories on the association between motor and social skills.

Also, studies have shown that there are problems with the implementation of testing that are more complicating with preschool-aged children than with older students, especially on more demanding motor tasks (Rajtmajer, 1993; Planinsec, 2002). These problems may be even more pronounced for children with disabilities. Therefore, results should be interpreted with caution due to problems in collecting data on preschoolers' motor abilities, which can have an effect on assessment scores.

Finally, this study used aggregate fine motor and gross motor skills. Future studies could examine whether the separate subscales contribute differently to the prediction of cognitive and social skills. Recently, there has been the suggestion that different types of fine motor tasks impact later cognitive skills and academic achievement. In fact, research conducted on typically developing children in the MSRP has found that there were different degrees of association between two types of fine motor tasks, fine motor coordination and fine motor writing, with fine motor writing being a strong predictor of later school achievement, while fine motor coordination along did not have an impact on achievement (Carlson et al., under review; Dinehart & Manfra, in press). Overall, higher levels of fine motor writing skills in preschool significantly predicted academic achievement above and beyond the effects of child gender, socioeconomic status, and preschool cognitive, language, and social-emotional protective factors, through third grade (Carlson et. al., under review; Dinehart & Manfra, in press). Research has not compared differential impacts of the two types of fine motor skills on later cognitive or social skills in children with developmental disabilities, but it would be worthwhile for future studies to examine whether these differences in associations found in typically developing children is similar for the population of children with developmental disabilities. In addition, future research should examine concurrent and longitudinal comparisons of the associations between motor, cognitive, and social skills in typically developing children and children with developmental disabilities to explore whether there are fundamental differences in the associations between these two groups.

Implications

This study extends previous work that has examined fine motor or gross motor abilities, but not both, in relation to cognitive or social skills in typically-developing children. A unique feature of this study is that it examined both types of motor skills in a population of children with disabilities, with the finding that fine motor is a better predictor of cognitive and social skills. However, these associations differ depending on the type of disability of the child.

The findings from this study have important implications for early educational programs and interventions and for policymakers. There are various factors that can have a negative impact on children's outcomes that are difficult to manipulate, such as parent education levels and low socioeconomic status. However, research in the occupational therapy field indicates that it is possible to successfully improve existing fine and gross motor skills, as well as help children's acquisition of new motor skills, in young children with and without disabilities, which can lead to better cognitive and social outcomes (Case-Smith, 1996; Dankert, Davies, & Gavin, 2003; van der Putten, Vlaskamp, Reynders, & Nakken, 2005). Therefore, early intervention programs should incorporate motor activities in their daily routines or focus on improving specifically delayed motor skills. In addition, the fact that there is a close developmental association between motor, cognitive, and social areas in children with developmental disabilities suggests the possibility that intervening in one developmental domain may support and improve the development of another, thereby, maximizing learning potential.

In addition, there has been a resurgence of interest in establishing policies and programs in early childhood education and during the transition to formal school that promote academic achievement. There has also been much debate concerning what skills are needed to learn and be successful in school, in other words, what factors are associated with school readiness and what skills predict later school achievement (Duncan et al., 2007). Therefore, understanding which specific skills are related to children's academic achievement and later positive outcomes has important implications for early educational programs, as well as early interventions aimed at enhancing these skills prior to transitioning to elementary school. The results of the current study indicate that motor skills may be important for later cognitive and social skills. Therefore, motor skills can be included as one of the indicators of school readiness for transition to school entry. Including motor skills as part of the assessments for school readiness can help increase the predictability of later academic achievement and also help identify children who may be at-risk for future school difficulties.

APPENDIX: TABLES AND FIGURES

Table 1.

Descriptive Statistics

	n	%	% Missing	*M*	*SD*	Min	Max	Possible Range
Child Characteristics								
Age of Child at T1	2244		29.7	55.01	4.05	37	71	
Gender	2925		8.3					
Boy	2124	72.6						
Girl	801	27.4						
Ethnicity	2894		9.3					
Hispanic/Latino	1908	65.9						
Black	629	21.7						
White/Other	357	12.3						
Disability Categories	2563		19.7					
Intellectual Disability	509	19.9						
Speech/Language Disability	192	7.5						
Emotional Disability	168	6.6						
Learning Disability	898	35.0						
Autism	430	16.8						
Other Health Impairment	50	2.0						
Got Better	316	12.3						
Assessment Scores								
Fine Motor Skills at T1 (LAP-D)	2112		33.8	35.84	9.08	18	56.5	0-59
Gross Motor Skills at T1 (LAP-D)	1383		56.7	37.72	9.77	18	56.5	0-57
Cognitive Skills at T2 (LAP-D)	1936		39.3	36.95	10.07	14	55.5	0-57
Social Skills at T2 (DECA)	2102		34.1	68.84	17.58	0	108	0-108

Note. LAP-D = Learning Accomplishment Profile-Diagnostic; DECA = Devereux Early Childhood Assessment; T1 = Time 1 (Fall); T2 = Time 2 (Spring)

Table 2.

Correlations Between Predictor and Outcome Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Age of Child at T1	-												
2	Gender	-0.06**	-											
3	Fine Motor	0.24**	0.06**	-										
4	Gross Motor	0.17**	-0.08**	0.54**	-									
5	Intellectual Disability	-0.20**	0.07**	-0.25**	-0.21**	-								
6	Speech/Language Disability	-0.05*	0.01	0.14**	0.03	-0.14**	-							
7	Emotional Disability	0.08**	-0.06**	-0.01	0.13**	-0.13**	-0.08**	-						
8	Learning Disability	0.10**	-0.03	0.02	0.05	-0.37**	-0.21**	-0.20**	-					
9	Autism	0.04	-0.13**	-0.18**	-0.19**	-0.22**	-0.13**	-0.12**	-0.33**	-				
10	Other Health Impairment	0.003	-0.02	0.02	0.003	-0.07**	-0.04*	-0.04	-0.10**	-0.06**	-			
11	"Got Better"	0.03	0.16**	0.31**	0.23**	-0.19**	-0.11**	-0.10**	-0.28**	-0.17**	-0.05**	-		
12	Cognitive Skills	0.18**	-.001	0.65**	0.44**	-0.21**	0.13**	-0.02	-0.05*	-0.14**	0.04	0.33**	-	
13	Social Skills	0.02	0.18**	0.37**	0.22**	-0.11**	0.19**	-0.13**	0.12**	-0.34**	-0.004	0.30**	0.39**	-

Note. $^{*}p < .05$, $^{**}p < .01$; In this correlation matrix, disabilities categories were dummy coded.

Table 3.

Path Coefficients for Motor Skills Predicting Cognitive and Social Skills and the Moderating Effect of Disability Category on the Association Between Motor, Cognitive, and Social Skills

	Cognitive Skills			Social Skills		
	b (SE)	*B*	*p*	*b (SE)*	*B*	*p*
Model 1 - Main Effects Only						
Fine Motor Skills (FM)	0.58 (.03)	0.54	≤ .001	0.49 (.06)	0.26	≤ .001
Gross Motor Skills (GM)	0.13 (.03)	0.13	≤ .001	0.13 (.06)	0.08	0.02
Gender	-1.41 (.42)	-0.06	≤ .001	4.24 (.79)	0.11	≤ .001
Intellectual Disability (ID)	-2.33 (.47)	-0.13	≤ .001	-1.22 (.90)	-0.04	n.s.
Speech/Language Impairment (SLI)	1.55 (.66)	0.07	0.02	8.98 (1.23)	0.23	≤ .001
Emotional Disability (ED)	-1.73 (.70)	-0.07	0.01	-9.16 (1.31)	-0.23	≤ .001
Learning Disability (LD)	-1.04 (.39)	-0.07	0.01	2.84 (.72)	0.11	≤ .001
Autism (AUT)	-1.16 (.51)	-0.06	0.02	-8.69 (.96)	-0.27	≤ .001
Other Health Impairment (OHI)	1.16 (1.18)	0.04	n.s.	-1.04 (2.21)	-0.02	n.s.
Model 2a - Fine Motor Interaction Effects						
FM x ID	0.20 (.07)	0.39	0.01	-.01 (.14)	-0.01	n.s.
FM x SLP	-.12 (.09)	-0.21	n.s.	-.05 (.17)	-0.05	n.s.
FM x ED	-.04 (.09)	-0.06	n.s.	.25 (.18)	0.25	n.s.
FM x LD	-.12 (.05)	-0.3	0.02	-.11 (.10)	-0.18	n.s.
FM x AUT	.07 (.07)	0.14	n.s.	-.17 (.14)	-0.2	n.s.
FM x OHI	.17 (.15)	0.25	n.s.	.02 (.29)	0.02	n.s.
Model 2b - Gross Motor Interaction Effects						
GM x ID	.14 (.07)	0.29	≤ .05	.04 (.13)	0.05	n.s.
GM x SLP	-.18 (.09)	-0.33	≤ .05	-.09 (.18)	-0.1	n.s.
GM x ED	.07 (.10)	0.12	n.s.	.24 (.19)	0.26	n.s.
GM x LD	-.11 (.06)	-0.28	0.06	-.18 (.11)	-0.29	n.s.
GM x AUT	.27 (.08)	0.54	≤ .001	-.08 (.17)	-0.1	n.s.
GM x OHI	-.05 (.15)	-0.08	n.s.	.01 (.30)	0.01	n.s.

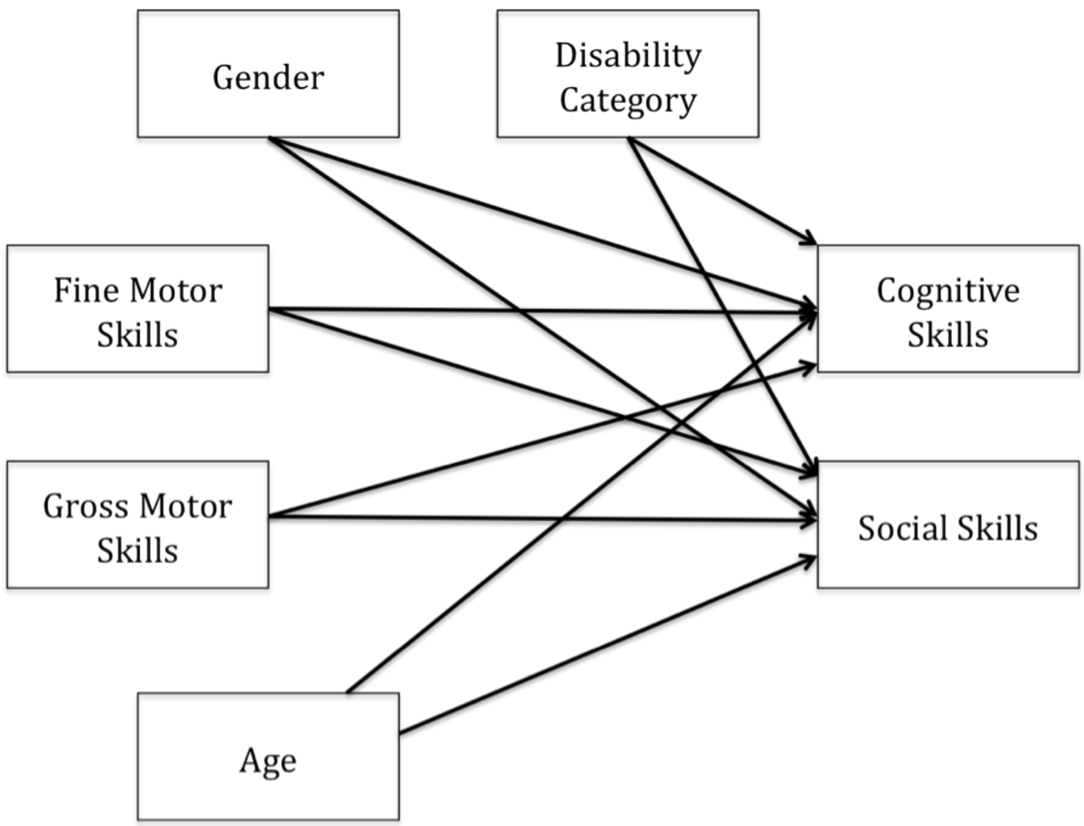

Figure 1. Full model for path analysis conducted in a structural equation modeling (SEM) framework, which was conducted to examine the relations between both fine and gross motor skills at T1 and cognitive and social skills at T2, while controlling for the effects of gender, age, and disability category. All predictors were correlated with each other, and the outcome variables were also correlated.

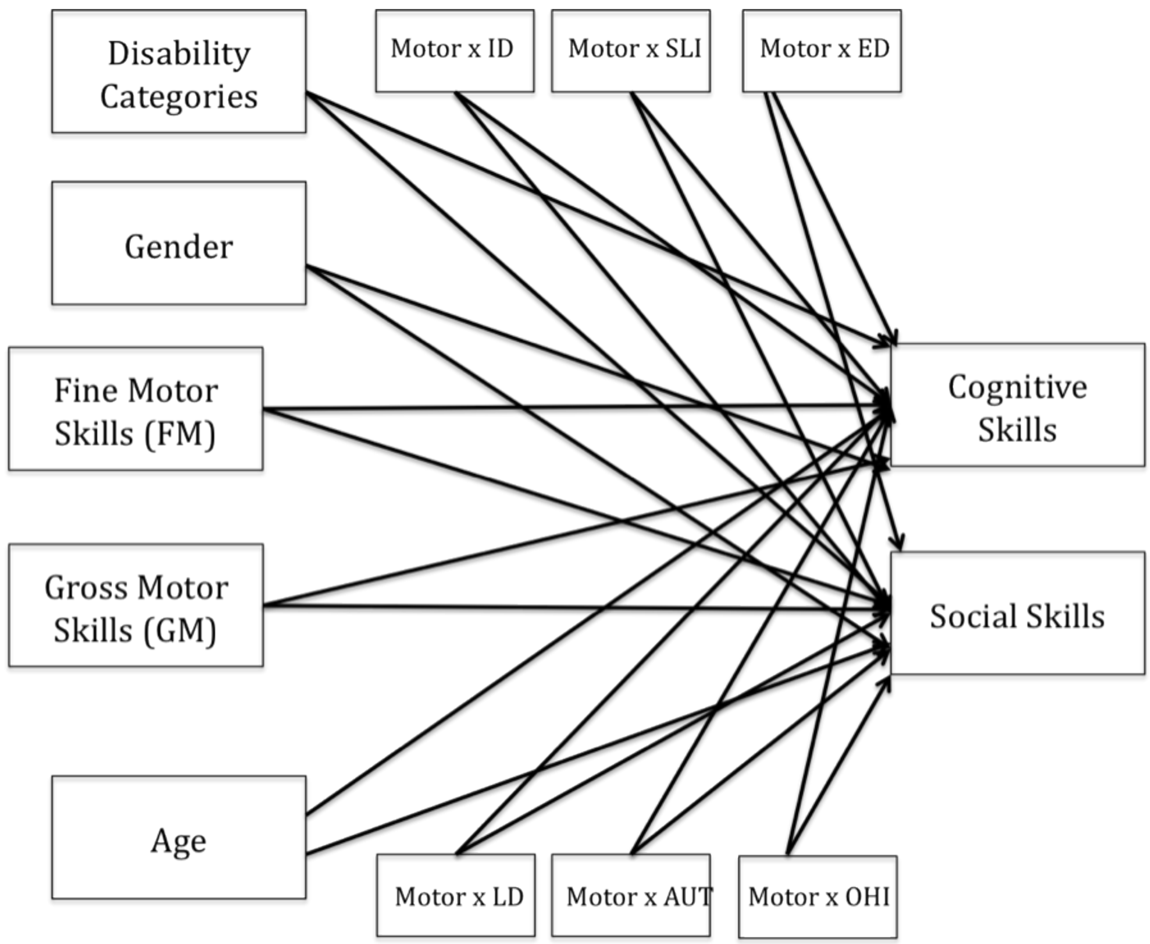

Figure 2. Full model with interaction terms between effects-coded disability categories and both fine and gross motor skills. Path analysis in SEM framework was used to examine the degree to which the disability category moderates these associations. All predictors were correlated with each other, and the outcome variables were also correlated.

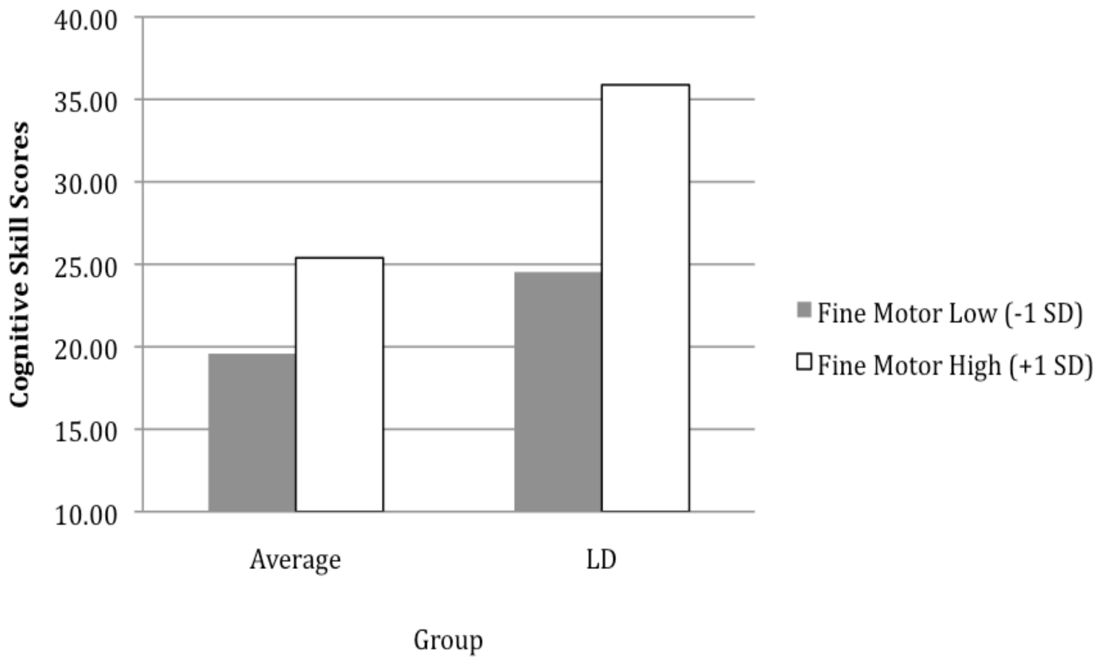

Figure 3. Fine motor skills at time 1 (T1; Fall) by learning disability (LD) category on cognitive skill raw scores on the Learning Accomplishment Profile-Diagnostic (LAP-D) at time 2 (T2; Spring). This shows a significant interaction effect between fine motor skill and LD on cognitive skill raw scores, where the effect of fine motor skill varies as a function of whether or not the child had an LD label, $b = -.12$, $p < .05$. Disability categories were effects-coded, so the LD group is being compared to the averaged cognitive scores of all of the other disability groups. Age in months of child at the time when assessment were given was a covariate in this model (Age = 55.01 months).

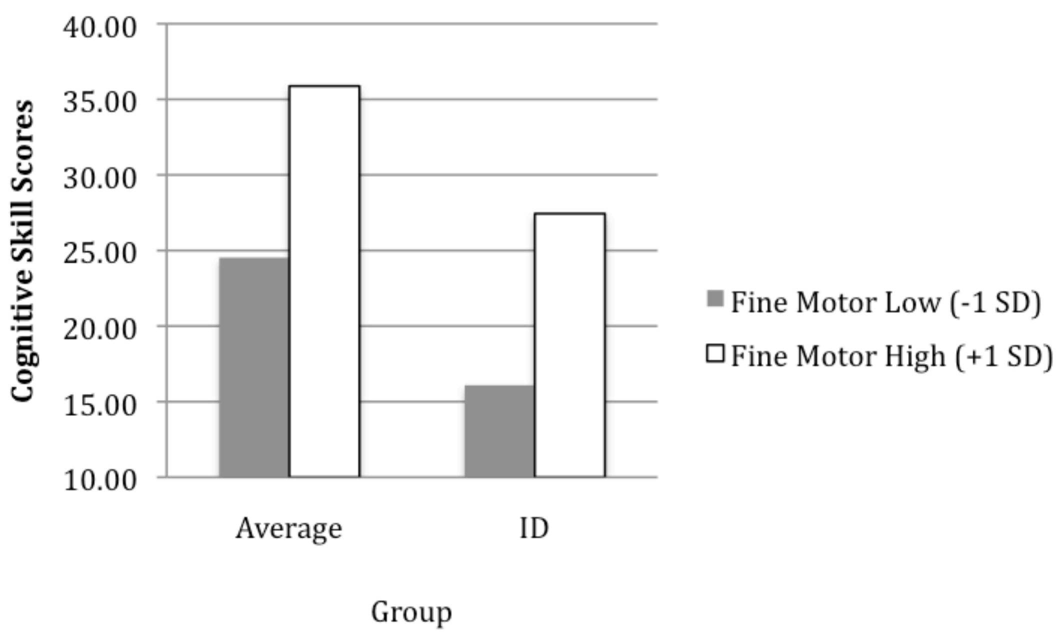

Figure 4. Fine motor skills at time 1 (T1; Fall) by intellectual disability (ID) category on cognitive skill raw scores on the Learning Accomplishment Profile-Diagnostic (LAP-D) at time 2 (T2; Spring). This shows a significant interaction effect between fine motor skill and ID on cognitive skill raw scores, where the effect of fine motor skill varies as a function of whether or not the child had an ID label, $b = .20$, $p < .01$. Disability categories were effects-coded, so the ID group is being compared to the averaged cognitive scores of all of the other disability groups. Age in months of child at the time when assessment were given was a covariate in this model (Age = 55.01 months).

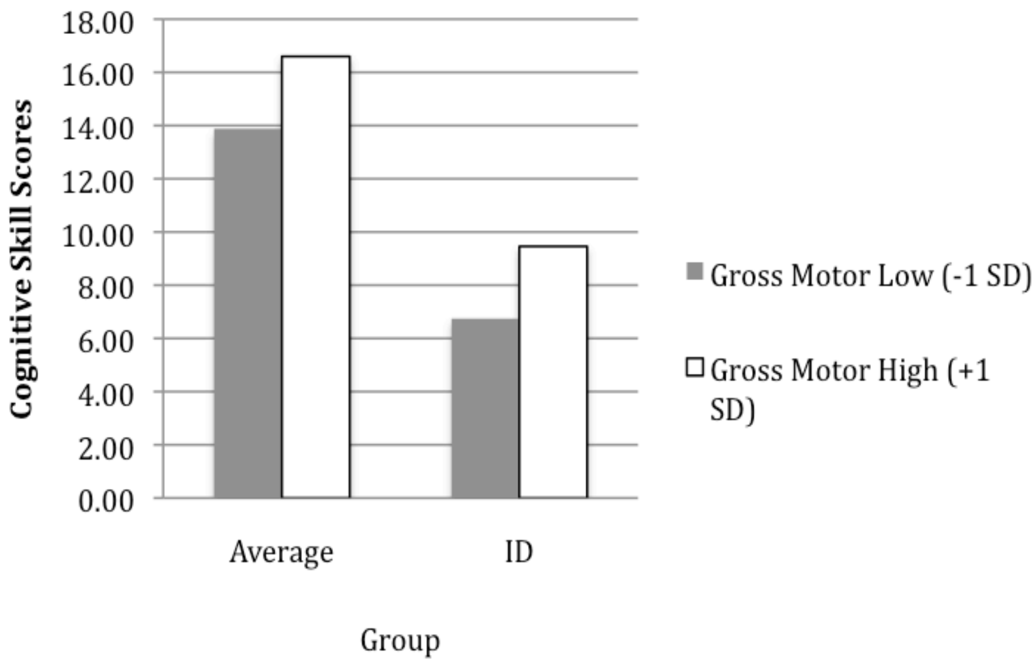

Figure 5. Gross motor skills at time 1 (T1; Fall) by intellectual disability (ID) category on cognitive skill raw scores on the Learning Accomplishment Profile-Diagnostic (LAP-D) at time 2 (T2; Spring). This shows a significant interaction effect between gross motor skill and ID on cognitive skill raw scores, where the effect of gross motor skill varies as a function of whether or not the child had an ID label, $b = .14$, $p < .05$. Disability categories were effects-coded, so the ID group is being compared to the averaged cognitive scores of all of the other disability groups. Age in months of child at the time when assessment were given was a covariate in this model (Age = 55.01 months).

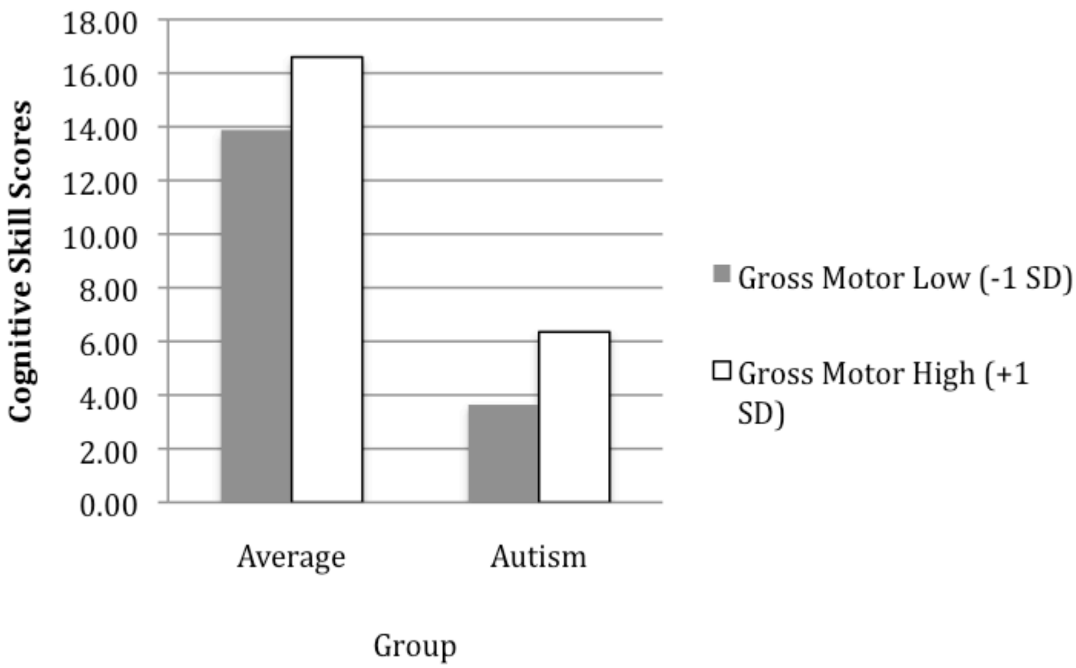

Figure 6. Gross motor skills at time 1 (T1; Fall) by autism category on cognitive skill raw scores on the Learning Accomplishment Profile-Diagnostic (LAP-D) at time 2 (T2; Spring). This shows a significant interaction effect between gross motor skill and autism on cognitive skill raw scores, where the effect of gross motor skill varies as a function of whether or not the child had an autism label, $b = .27$, $p < .01$. Disability categories were effects-coded, so the autism group is being compared to the averaged cognitive scores of all of the other disability groups. Age in months of child at the time when assessment were given was a covariate in this model (Age = 55.01 months).

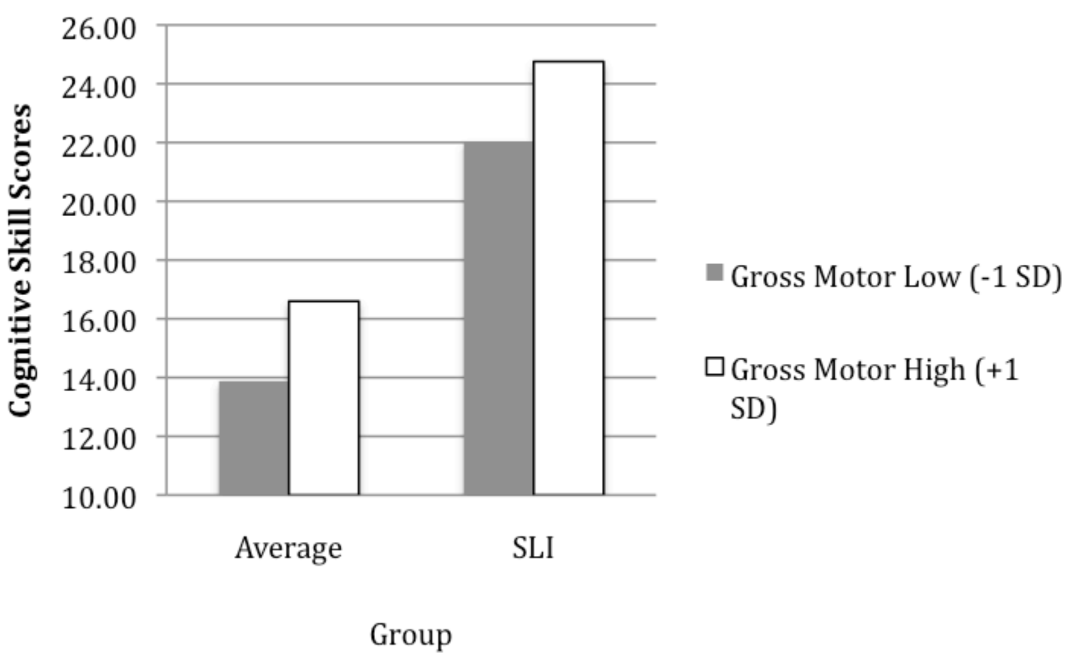

Figure 7. Gross motor skills at time 1 (T1; Fall) by speech/language impairment (SLI) category on cognitive skill raw scores on the Learning Accomplishment Profile-Diagnostic (LAP-D) at time 2 (T2; Spring). This shows a significant interaction effect between gross motor skill and SLI on cognitive skill raw scores, where the effect of gross motor skill varies as a function of whether or not the child had an SLI label, $b = -.18$, $p < .05$. Disability categories were effects-coded, so the SLI group is being compared to the averaged cognitive scores of all of the other disability groups. Age in months of child at the time when assessment were given was a covariate in this model (Age = 55.01 months).

REFERENCES

REFERENCES

Acock, A. C. (2005). Working with missing values. *Journal of Marriage and Family*, *67*, 1012-1028. doi: 10.1111/j.1741-3737.2005.00191.x

Adolph, K. (2008). Learning to move. *Current Directions in Psychological Science*, *17*, 213-218.

Arbuckle, J. L. (2003). *Amos* (Version 5.0) [Computer Program]. Chicago, IL: SPSS.

Bar-Haim, Y., & Bart, O. (2006). Motor function and social participation in kindergarten children. *Social Development*, *2*, 296-310.

Bart, O., Hajami, D., & Bar-Haim, Y. (2007). Predicting school adjustment from motor abilities in kindergarten. *Infant and Child Development*, *16*, 597-615. doi:10.1002/icd.514

Beery, K. E. (1989). *The developmental test of visual-motor integration (3rd ed.)*. Cleveland, OH: Modern Curriculum Press.

Boyle, C. A., Boulet, S., Schieve, L. A., Cohen, R. A., Blumberg, S. J., Yeargin-Allsopp, M.,…Kogan, M. D. (2011). Trends in the prevalence of developmental disabilities in US children, 1997-2008. *Pediatrics*, *127*, 1034-1042.

Bushnell, E. W., & Boudreau, J. P. (1993). Motor development and the mind: The potential role of motor abilities as a determinant of aspects of perceptual development. *Child Development*, *64*, 1005-1021.

Campbell, S. B. (1997). Behavior problems in preschool children: Developmental and family issues. *Advances in Clinical Child Psychology*, *19*, 1-26.

Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. (2000). Travel broadens the mind. *Infancy*, *1*, 149-219.

Carlson, A. G., Kim, H., Winsler, A. W., & Curby, T. W. (under review). Early fine motor skills predict third grade achievement among low-income, ethnically diverse children. *Journal of Educational Psychology*.

Case-Smith, J. (1996). Fine motor outcomes in preschool children who receive occupational therapy services. *American Journal of Occupational Therapy*, *50*, 52-61.

Centers for Disease Control and Prevention (2004). *Developmental disabilities*. Retrieved from http://www.cdc.gov/ncbddd/dd/default.htm

Cicchetti, D. (1990). A historical perspective on the discipline of developmental psychopathology. In J. Rolf, A. Masten, D. Cicchetti, K. Nuechterlein, & S. Weintraub (Eds.). *Risk and protective factors in the development of psychopathology* (pp. 2-28). Cambridge, UK: Cambridge University Press.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Erlbaum.

Coutinho, M. J., & Oswald, D. P. (2000). Disproportionate representation in special education: A synthesis and recommendations. *Journal of Child and Family Studies, 9,* 135-156.

Cummins, A., Piek, J. P., & Dyck, M. J. (2005). Motor coordination, empathy, and social behaviour in school-aged children. *Developmental Medicine & Children Neurology*, *47*, 437-442.

Crane, J. (2010). Preschool children with special educational needs: Achievement, retention, and classification through second grade. Ph.D. dissertation, George Mason University, United States -- Virginia. Retrieved April 5, 2012, from Dissertations & Theses @ George Mason University - WRLC. (Publication No. AAT 3394597).

Crane, J., Mincic, M. S., & Winsler, A. (2011). Assessing socio-emotional protective factors among ethnically diverse preschoolers in poverty: Parent-teacher agreement on the Devereux Early Childhood Assessment (DECA). *Early Education and Development*, *22*, 520-547.

Dankert, H. L., Davies, P. L., & Gavin, W. J. (2003). Occupational therapy effects on visual-motor skills in preschool children. *The American Journal of Occupational Therapy*, *57*, 542-549.

Davis, A. S. (2008). Children with Down syndrome: Implications for assessment and intervention in the school. *School Psychology Quarterly*, *23*, 271-281.

Davis, E. E., Pitchford, N. J., & Limback, E. (2011). The interrelation between cognitive and motor development in typically developing children aged 4-11 years is underpinned by visual processing and fine manual control. *British Journal of Psychology*, *102*, 569-584.

Denham, S., Brown, C., & Domitrovich. C. (2010). “Plays nice with others”: Social-emotional learning and academic success. *Early Education and Development*, *21*, 652-680.

Denham, S., Wyatt, T., Bassett, H., Echeverria, D., Knox, S. (2009). Assessing social-emotional development in children from a longitudinal perspective. *Journal of Epidemiology Community Health*, *63*, i37-i52. doi: 10.1136/jech.2007.070797

Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development*, *71*(1), 44-56. doi:10.1111/1467-8624.00117

Diamond, A. (2011). *Biological and social influences on cognitive control processes dependent on prefrontal cortex*. Progress in Brain Research, 189, 319-339.

Dinehart, L.H.B., & Manfra, L. (in press; accepted 10/25/2011). Association between early fine motor development and later math and reading achievement in early elementary school. Early Education and Development.

Division for Early Childhood. (1991). *Statement to the U.S. Senate subcommittee on disability policy with respect to reauthorization of part H and amendments to part B of the Individuals with Disabilities Education Act, regarding services to children from birth to age six and their families.* Pittsburgh, PA: Division for Early Childhood.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., …Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, *43*, 1428-1446. doi:10.1037/0012-1649.43.6.1428

Elliot, D., & Bunn, L. (2004). Motor disorders in children with intellectual disabilities. In D. Dewey & D. E. Tupper (Eds.), *The science and practice of neuropsychology* (pp. 427-442). New York, NY: Guilford.

Essa, E., Young, R., & Lehne, L. (1998). *Introduction to early childhood education* (2nd ed.). Toronto, Canada: Nelson.

First, L. R., & Palfrey, J. S. (1994). The infant or young child with developmental delay. *The New England Journal of Medicine*, *330*, 478-483.

Flavell, J. H. (2000). Development of children’s knowledge about the mental world. *International Journal of Behavioral Development*, *24*, 15-23.

Gesell, A. (1933). Maturation and the patterning of behavior. In C. Muchison (Ed.), *A handbook of children psychology* (pp.209-235).Worcester, MA: Clark University Press.

Gesell, A. (1954). The ontogenesis of infant behavior. In L. Carmichael (Ed.), *Manual of child psychology* (pp. 335-373). New York, NY: John Wiley & Son.

Grissmer, D., Grimm, K. J., Aiyer, S. M., Murrah, W. M., & Steele, J. S. (2010). Fine motor skills and early comprehension of the world: Two new school readiness indicators. *Developmental Psychology*, *46*, 1008-1017. doi:10.1037/a0020104

Hartman, E., Houwen, S., Scherder, E., & Visscher, C. (2010). On the relationship between motor performance and executive functioning in children with intellectual disabilities. *Journal of Intellectual Disability Research*, *54*, 468-477.

Hartup (1989). Social relationships and their developmental significance. *American Psychologist*, *44*, 120-126.

Howes, C. (1987). Social competence with peers in young children: Developmental sequences. *Developmental Review*, *7*, 252-272.

Individuals with Disabilities Education Act of 2004, 20 U.S.C. §1400 et seq. (2004).

Krombholz, H. (2006). Physical performance in relation to age, sex, birth order, social class, and sports activities of preschool children. *Perceptual and Motor Skills*, *102*, 477-484.

LeBuffe, P. A., & Naglieri, J. A. (1999). *The Devereux Early Childhood Assessment (DECA). Technical Manual.* Lewisville, NC: Kaplan Press.

Lidz, C. S. (2003). *Early childhood assessment.* Hoboken, NJ: John Wiley & Sons.

Livesey, D., Coleman, R., & Piek, J. (2007). Performance on the Movement Assessment Battery for Children by Australian 3-to 5-year-old children. *Child: Care, Health and Development*, *33*, 713-719.

Lobo, Y. B., & Winsler, A. (2006). The effects of a creative dance and movement program on the social competence of Head Start preschoolers. *Social Development*, *15*, 501-519.

Lockman, J.J., & Thelen, E. (1993). Developmental biodynamics: Brain, body, behavior connections. *Child Development*, *64*, 953-959. doi: 10.1111/j.1467-8624.1993.tb04181.x

Marr, D., Cermak, S., Cohn, E.S., & Henderson, A. (2003). Fine motor activities in head start and kindergarten classrooms. *American Journal of Occupational Therapy*, 57, 550 –557.

Martin, N. C., Piek, J., Baynam, G., Levy, F., & Hay, D. (2010). An examination of the relationship between movement problems and four common developmental disorders. *Human Movement Science*, *29*, 799-808.

McCarron, L. (1997). *McCarron assessment of neuromuscular development: Fine and gross motor abilities (revised ed.)*. Dallas, TX: Common Market Press.

McGraw, M. B. (1935). *Growth: A study of Johnny and Jimmy*. New York, NY: Appleton-Century.

Miyahara, M., & Cratty, B. J. (2004). Developmental motor disorders: A neuropsychological perspective. In D. Dewey & D. E. Tupper (Eds.), *The science and practice of neuropsychology* (pp. 427-442). New York, NY: Guilford.

Nehring, A. D., Nehring, E. F., Bruni, J. R., & Randolph, P. L. (1992). *LAP-D: Learning Accomplishment Profile Diagnostic standardized assessment.* Lewisville, NC: Kaplan Press.

Ogg, J. A., Dedrick, R. F., Brinkman, T. M., & Carlson, J. S. (2010). Factor structure and invariance across gender of the Devereux Early Childhood Assessment Protective Factor Scale. *School Psychology Quarterly*, *25*, 107-118.

Oswald, D. P., Best, A. M., Coutinho, M. J., & Nagle, H. A. (2003). Trends in the special education identification rates of boys and girls: A call for research and change. *Exceptionality*, *11*, 223-237.

Oswald, D. P., Coutinho, M. J., Best, A. M., & Singh, N. N. (1999) Ethnic representation in special education: The influence of school-related economic and demographic variables. *The Journal of Special Education*, *32*, 194-206.

Pangelinan, M. M., Zhang, G., VanMeter, J. W., Clark, J. E., Hatfield, B. D., & Haufler, A. J. (2011). Beyond age and gender: Relationships between cortical and subcortical brain volume and cognitive-motor abilities in school-age children. *NeuroImage*, *54*, 3093-3100.

Piaget, J. (1953). *The origin of the intelligence in the child*. London, UK: Routledge.

Petersen, M. C., Kube, D. A., & Palmer, F. B. (1998). Classification of developmental delays. *Seminars in Pediatric Neurology*, *5*(1), 2-14.

Piek, J. P., Barrett, N. C., Smieth, L. M., Rigoli, D., & Gasson, N. (2010). Do motor skills in infancy and early childhood predict anxious and depressive symptomatology at school age? *Human Movement Science*, *29*, 777-786.

Piek, J. P., Bradbury, G. S., Elsley, S., & Tate, L. (2008a). Motor coordination and social-emotional behaviour in preschool-aged children. *International Journal of Disability, Development, and Education*, *55*, 143-151.

Piek, J. P., Dawson, L., Smith, L. M., & Gasson, N. (2008b). The role of early fine and gross motor development on later motor and cognitive ability. *Human Movement Science*, *27*, 668-681. doi:10.1016/j.humov.2007.11.002

Piek, J. P., & Pitcher, T. M. (2004). Developmental motor disorders: A neuropsychological perspective. In D. Dewey & D. E. Tupper (Eds.), *The science and practice of neuropsychology* (pp. 313-327). New York, NY: Guilford.

Pitcher, T., Piek, J., & Hay, D. (1999). Motor coordination and kinaesthesis in boys with attention deficit-hyperactivity disorder. *Developmental Medicine and Child Neurology*, *41*, 525-535.

Planinsec, J. (2002). Relations between the motor and cognitive dimensions of preschool girls and boys. *Perceptual and Motor Skills*, *94*, 415-423.

Rainforth, B., Giangreco, M.F., & Dennis, R. (1989). Motor skills. In A. Ford, R. Schnorr, L. Meyer, L. Davern, J. Black, & P. Dempsey (Eds.), *Syracuse community-referenced curriculum guide for students with moderate and severe disabilities* (pp. 211 - 230). Baltimore, MD: Brookes.

Rajtmajer, D. (1993). Comparative analysis of psychomotor structure of boys and girls aged 5-5.5 years. *Sport*, *41,* 36-40.

Schoemaker, M. M., & Kalverboer, A. F. (1994). Social and affective problems of children who are clumsy: How early do they begin. *Adapted Physical Activity Quarterly*, *11*, 130-140.

Shaffer, D., Schonfeld, I., O'Connor, P. A., Stokman, C., Trautman, P., Shafer, S., & Ng, S. (1985). Neurological soft signs: Their relationship to psychiatric disorder and intelligence in childhood and adolescence. *Archives of General Psychiatry*, *42*, 342–351.

Shevell, M., Majnemer, A., Platt, R. W., Webster, R., & Birnbaum, R. (2004). Developmental and functional outcomes at school age of preschool children with global developmental delay. *Journal of Child Neurology*, *20*, 648–654.

Sigurdsson, E., van Os, J., & Fombonne, E. (2002). Are impaired childhood motor skills a risk factor for adolescent anxiety? Results from the 1958 UK birth cohort and the national child development study. *American Journal of Psychiatry*, *159*, 1044–1066.

Skinner, R. A., & Piek, J. P. (2001). Psychosocial implications of poor motor coordination in children and adolescents. *Human Movement Science*, *20*, 73-94.

Son, S. H., & Meisels, S. J. (2006). The relationships of young children's motor skills to later reading and math achievement. *Merrill-Palmer Quarterly, 52*(4), 755-778. doi:10.1353/mpq.2006.0033

Squires, J. K., Potter, L., & Bricker, D. (1995). *The Ages and Stages Questionnaire: Users guide*. Baltimore, MD: Brookes.

Thomas, J. R., & French, K. E. (1985). Gender differences across age in motor performance: A meta-analysis. *Psychological Bulletin*, *98*(2), 260-282.

Trawick-Smith, J. W. (2010). *Early childhood development: A multicultural perspective* (5th ed.). Upper Saddle River, NJ: Pearson.

U.S. Census Bureau. (2000). *Demographic profile, Miami-Dade County Department of Planning and Zoning*. Planning Research Section, 2002.

U.S. Department of Education. (1992). *Fourteenth annual report to Congress on the implementation of the Individuals with Disabilities Education Act*. Washington, DC: Author.

Van der Putten, A., Vlaskamp, C., Reynders, K., & Nakken, H. (2005). Children with profound intellectual and multiple disabilities: The effects of functional movement activities. *Clinical Rehabilitation*, *19*, 613-620.

Wassenberg, R., Feron, F. J., Kessels, A. G., Hendriksen, J. G., Kalff, A. C., Kroes, M.,…Vles, J. S. (2005). Relation between cognitive and motor performance in 5- to 6-year-old children: Results from a large-scale cross-sectional study. *Child Development*, *76*, 1092-1103.

Willoughby, M. T., Wirth, R. J., Blair, C. B., & Greenberg, M. (2010). The measurement of executive function at age 3 years: Psychometric properties and criterion validity of a new battery of tasks. *Psychological Assessment*, *22*, 306-317.

Wilson, P. H., Maruff, P., Ives, S., & Currie, J. (2001). Abnormalities of motor and praxis imagery in children with DCD. *Human Movement Science*, *20*, 135-159. doi:10.1016/S0167-9457(01)00032-X

Winsler, A., Tran, H., Hartman, S. C., Madigan, A. L., Manfra, L., & Bleiker, C. (2008). School readiness gains made by ethnically diverse children in poverty attending center-based childcare and public school pre-kindergarten programs. *Early Childhood Research Quarterly, 23,* 314-329. doi:10.1016/j.ecresq.2008.02.003

CURRICULUM VITAE

Helyn Kim graduated with a Bachelors degree in psychology, as well as a Master of Arts in Teaching degree in Early Childhood Developmental Risk, from the University of Virginia, Charlottesville. During her time in the Applied Developmental Psychology Masters program at George Mason University, she has gained experience in research methodology and applied developmental research. Helyn wants to gain deeper understanding of the complex interplay of developmental domains and the various factors that contribute to children's development, in order to facilitate optimal development and improve later outcomes. She will pursue her doctoral degree in educational psychology at the University of Virginia.