



## Relations among motor, social, and cognitive skills in pre-kindergarten children with developmental disabilities



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### ABSTRACT

Despite the comorbidity between motor difficulties and certain disabilities, limited research has examined links between early motor, cognitive, and social skills in preschool-aged children with developmental disabilities. The present study examined the relative contributions of gross motor and fine motor skills to the prediction of improvements in children's cognitive and social skills among 2,027 pre-kindergarten children with developmental disabilities, including specific learning disorder, speech/language impairment, intellectual disability, and autism spectrum disorder. Results indicated that for pre-kindergarten children with developmental disabilities, fine motor skills, but not gross motor skills, were predictive of improvements in cognitive and social skills, even after controlling for demographic information and initial skill levels. Moreover, depending on the type of developmental disability, the pattern of prediction of gross motor and fine motor skills to improvements in children's cognitive and social skills differed. Implications are discussed.

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## 1. Introduction

Children require the coordination of many different skills to be successful in school. Physical, cognitive, and social skills have all been highlighted as critical components of school readiness (Diamond, 2010; Duncan et al., 2007; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010). In particular, early motor performance has been recognized as an important contributing factor for both cognitive and social functioning (Cameron et al., 2012; Cummins, Piek, & Dyck, 2005; Davis, Pitchford, & Limback, 2011; Kim et al., 2015; Piek, Barrett, Smith, Rigoli, & Gasson, 2010; Piek, Baynam, & Barrett, 2006; Piek, Bradbury, Elsley, & Tate, 2008a). Motor development may act as a "control parameter" where certain motor abilities are necessary for the acquisition or practice of other developmental functions, including cognitive and social development (Bushnell & Boudreau, 1993; Campos et al., 2000). In other words, motor abilities, such as crawling or walking, may afford a child the opportunity to explore his or her environment more and do so in novel ways, thus, increasing his or her cognitive and social skills. On the other hand, delayed or deviant motor development in the early years of life is considered to be a precursor to developmental language and learning problems (Sala, Shulman, Kennedy, Grant, & Chu, 1999), problems with attention skills (Piek & Pitcher, 2004), and poor academic and social abilities (Losse et al., 1991; Piek et al., 2008a, 2010).

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Children with developmental disabilities are of particular interest in the study of motor skills because some developmental disabilities, including specific learning disorder (SLD), intellectual disability (ID), Autism Spectrum Disorder (ASD), and language disorders, may have a shared etiology, and poor motor skills have been implicated as one of the shared factors (Diamond, 2000; Dziuk et al., 2007; Martin, Piek, Baynam, Levy, & Hay, 2010). Children who have fine or gross motor impairments often exhibit cognitive delays and learning difficulties; similarly, children with cognitive disorders and intellectual disabilities are more inclined to experience motor problems (Diamond, 2000; Hartman, Houwen, Scherder, & Visscher, 2010). In addition, children with language disorders, as well as children with ASD often show problems with motor functioning (Diamond, 2000) and social skills (Dziuk et al., 2007; Hellendoorn et al., 2015).

Difficulties in motor functioning often provide valuable insights into developmental disorders and can also serve as indicators or markers for deficits in brain systems that are involved in cognition and social functioning (Dziuk et al., 2007). Despite the comorbidity between motor difficulties and certain developmental disabilities, limited research has examined links between early motor, cognitive, and social skills in preschool-aged children with developmental disabilities. Further, although some common traits underlie most developmental disabilities, young children with developmental disabilities are a heterogeneous group; hence, it is difficult to generalize patterns of findings given that these children exhibit various characteristics related to their developmental disorders. The purpose of the present study is to investigate differences in the pattern of prediction between motor skills and improvements over time in cognitive and social skills in an ethnically-diverse sample of preschool children with specific types of developmental disabilities, including SLD, speech/language impairment (SLI), ID, and ASD.

### 1.1. *Links between motor, cognitive, and social skills*

Research has established a clear link between motor, cognitive, and social skills. Studies show that gross motor skills, which use larger muscles, such as the legs and trunk, and are involved in activities like running, throwing, and catching, have been linked to children's cognitive functioning (Bushnell & Boudreau, 1993; Piek et al., 2006; Piek, Dawson, Smith, & Gasson, 2008b; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011), as well as social functioning (Piek et al., 2006). Poor gross motor coordination has been linked to risk of lowered self-worth (Piek et al., 2006), poor attention and working memory (Niederer et al., 2011), as well as lower perceived scholastic ability (Piek et al., 2006) and higher probability of low academic achievement (Lopes, Santos, Pereira, & Lopes, 2013).

Recently, fine motor skills – which involve smaller muscles such as the hands and fingers, and are involved in activities like eating with utensils, finger-painting, cutting with scissors, and writing – were found to be more strongly related to cognitive and social skills, as compared to gross motor skills, in typically-developing young children. For example, Grissmer et al. (2010) found evidence suggesting that early fine motor skills in kindergarten, rather than gross motor skills, were strongly and consistently associated with later school achievement. Additionally, Davis et al. (2011) examined the interrelations between cognitive and motor skills in children ages 4–11 years old and found that the association between cognitive and motor domains was largely due to fine motor control and visual processing, as opposed to more gross motor functioning, such as body coordination or strength and agility. Although research has examined gross motor and fine motor skills separately, very few studies have included both types of motor skills when examining associations with cognitive and social skills, specifically in children with developmental disabilities. It is unclear how gross motor and fine motor skills may relate to cognitive and social skills for preschool children with developmental disabilities, and specifically those with SLD, ID, SLI, or ASD. Therefore, we include measures of both gross motor and fine motor skills in our study to examine their relative contributions to improvements in cognitive and social skills across a preschool year in an ethnically-diverse group of children with developmental disabilities.

Several explanations are provided for the co-occurrence of motor, cognitive, and social skills. First, neurobiological evidence offers support for specific relations between cognitive and motor development. Motor development, especially the development of fine motor skills, requires neural networks and pathways that substantially overlap with those that underlie cognitive development (Floyer-Lea & Matthews, 2004; Pangelinan et al., 2011; Staines, Padilla, & Knight, 2002). For instance, tasks that activate the prefrontal cortex (PFC), an area of the brain associated with general cognitive ability, also activate areas of the brain, including the cerebellum and basal ganglia, necessary for motor learning (Diamond, 2000). Motor and social skills are connected at the neurophysiological level, as well. The PFC and the amygdala have a reciprocal connection and are both highly involved in aspects of social behavior and motor planning and execution (Bar-Haim & Bart, 2006). This close interrelation of motor, cognitive, and social development is also seen when looking at functional neuroimages of children with developmental disorders, including children with ASD (Davis, Pass, Finch, Dean, & Woodcock, 2009; Piek & Dyc, 2004). Structural abnormalities are found in brain regions that mediate the neural circuits involved in cognitive and motor performance, including the cerebellum and the PFC, suggesting that the neuroanatomical areas are interconnected, and that dysfunction in one region of the brain system may affect the other (Carper & Courchesne, 2000; Diamond, 2000; Dziuk et al., 2007).

Second, automaticity theory provides additional support for the connections between motor, cognitive, and social skills. The ability to perform a motor task accurately without exerting one's full attention allows for attentional resources to become available, making simultaneous performance of a second attention-demanding task easier (Floyer-Lea & Matthews, 2004; Huang & Mercer, 2001). Motor, cognitive, and social skills compete for the limited amount of attentional resources that are available. In early childhood classrooms, automaticity of motor skills is important because children often encounter

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