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The relation between cognitive and motor performance and their relevance for children's transition to school: A latent variable approach

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ABSTRACT

Both theoretically and empirically there is a continuous interest in understanding the specific relation between cognitive and motor development in childhood. In the present longitudinal study including three measurement points, this relation was targeted. At the beginning of the study, the participating children were 5–6-year-olds. By assessing participants' fine motor skills, their executive functioning, and their non-verbal intelligence, their cross-sectional and cross-lagged interrelations were examined. Additionally, performance in these three areas was used to predict early school achievement (in terms of mathematics, reading, and spelling) at the end of participants' first grade. Correlational analyses and structural equation modeling revealed that fine motor skills, non-verbal intelligence and executive functioning were significantly interrelated. Both fine motor skills and intelligence had significant links to later school achievement. However, when executive functioning was additionally included into the prediction of early academic achievement, fine motor skills and non-verbal intelligence were no longer significantly associated with later school performance suggesting that executive functioning plays an important role for the motor-cognitive performance link.

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1. Introduction

Theoretically, the notion that motor and cognitive development are closely intertwined goes back to Gesell's maturational theory, a biological perspective assuming that physical, motor, and cognitive development alike are determined primarily by biological predispositions (Gesell & Thompson, 1934). Similarly, according to Piaget's cognitive-developmental theory, motor and cognitive development are strongly related and driven by heredity: in his view, a child's unfolding motor skills give rise to increasing possibilities to explore and understand the environment, leading to more and more differentiated cognitive structures (Piaget & Inhelder, 1966). In the present paper, a latent variable approach will be presented exploring (a) the relation between motor and cognitive performance (in terms of intelligence and executive functioning) longitudinally and (b) their relative contributions to early academic achievement in a sample of 5–6-year-olds.

There has been an unchanging curiosity about the relation between cognitive and motor development, especially in young children, providing different lines of evidence supporting the theoretical assumption of a relationship between cognitive and motor development: Research documents that both aspects follow similar developmental timetables, with an accelerated progression in the kindergarten and elementary school years and a protracted development into adolescence (e.g., Ahnert, Schneider, & Bös, 2009). Delayed or atypical motor development typically co-occurs with certain cognitive deficits and *vice versa* (e.g., Piek et al., 2004). And, there is increasing neurophysiological and neuroimaging evidence that the prefrontal cortex, the cerebellum, and the connecting structures (among others the basal ganglia) get co-activated in certain cognitive and motor tasks (for an overview see Diamond, 2000). Thelen and Adolph outlined a dynamic system theory based on which motor development is a domain of development in which general principles such as, adapting task mastery from feedback loops, using motor actions for generating new information, and prospective control of motor and cognitive actions, is acquired (Adolph & Berger, 2006; Thelen & Smith, 1998). Moreover, with an increasing interest in prerequisites for a successful transition into school, that is, when searching for reliable and valid indicators of young children's school readiness, especially fine motor skills (especially manual dexterity/hand-eye-coordination) have been found to be substantial predictors for academic achievement in the first elementary school years (Bart, Hajami, & Bar-Haim, 2007; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Luo, Jose, Huntsinger, & Pigott, 2007; Pagani, Fithpatrick, Archambault, & Janosz, 2010; Son & Meisels, 2006). And finally, not only individual differences in early academic achievement appear to be related to earlier fine motor skills, but also precursors of mathematics and literacy, such as letter knowledge, phonological awareness, and number sense in kindergarten are specifically predicted by preschoolers' fine motor skills (Cameron et al., 2012).

Despite these different lines of evidence suggesting an association between motor and cognitive development, relatively little theoretical progress has been made trying to explain the underlying mechanisms leading to this relation. In the following paragraphs, we will outline two possibilities that are – among others – discussed in the literature and will then, with our own data, seek for empirical support of these two different assumptions.

For one, according to Piaget's theoretical assumptions development in different domains is driven by a general biological factor that may explain why motor and cognitive performance are substantially associated. Moreover, developing (thus improving) motor skills (such as locomotion or manual dexterity) give rise to the formation and differentiation of cognitive concepts (such as object permanence or tool use), which in turn will affect a child's examination and manipulation of her or his environment, suggesting a reciprocal relation between cognitive and motor development. From this perspective, one might assume that general cognitive abilities may explain the relation between motor performance and, for example, academic performance. Support for this perspective is provided in the Munich Longitudinal Study (LOGIC; Weinert & Schneider, 1999). In that study, indicators of intelligence (i.e., verbal intelligence) and motor performance were matched onto latent variables (allowing error-free estimations) and revealed a substantial, cross-sectional link between general motor and intellectual performance in kindergarten children accounting for 40% of the explained variance (Schneider, 1993). Moreover, both cross-lagged paths (from earlier verbal intelligence to later motor skills and from earlier motor skills to later intelligence) were reliable pointing to a bi-directional relationship

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