



## Home and preschool learning environments and their relations to the development of early numeracy skills

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### ABSTRACT

This study examined the influence of the quality of home and preschool learning environments on the development of early numeracy skills in Germany, drawing on a sample of 532 children in 97 preschools. Latent growth curve models were used to investigate early numeracy skills and their development from the first (average age: 3 years) to the third year (average age: 5 years) of preschool. Several child and family background factors (e.g., gender, maternal education, socioeconomic status), measures of the home learning environment (e.g., literacy- and numeracy-related activities), and measures of preschool structural and process quality (e.g., ECERS-E, ECERS-R) were tested as predictors of numeracy skills and their development. The analyses identified child and family background factors that predicted numeracy skills in the first year of preschool and their development over the three points of measurement—particularly gender, parental native language status (German/other), socioeconomic status, and mother's educational level. The quality of the home learning environment was strongly associated with numeracy skills in the first year of preschool, and this advantage was maintained at later ages. In contrast, the process quality of the preschool was not related to numeracy skills at the first measurement, but was significantly related to development over the period observed. The results underline the differential impact of the two learning environments on the development of numeracy skills. Interaction effects are explored and discussed.

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### 1. Introduction

It is well documented that children entering elementary school differ in their language, pre-reading, and early numeracy skills and that these differences are often maintained at later ages (e.g., Dornheim, 2008; Dubowy, Ebert, von Maurice, & Weinert, 2008; Magnuson, Meyers, Ruhm, & Waldfogel, 2004; National Institute for Child Health and Human Development Early Child Care Research Network [NICHD ECCRN], 2002a, 2005; Sammons et al., 2004; Tymms, Merell, & Henderson, 1997; Weinert, Ebert, & Dubowy, 2010). Promoting school readiness and better adjustment to school is hypothesized to be an efficient means of raising the achievement levels of all children, but especially of those children who experience a lack of parental support. It has been argued that investing in early education programs will have large long-term monetary and nonmonetary benefits (Heckman, 2006; Knudsen, Heckman, Cameron, & Shonkoff, 2006). These expectations have

led to increased state and federal support for early education programs in Germany, and strategies have recently been implemented to foster the promotion of emerging (pre)academic skills such as language skills, numeracy, and scientific thinking at preschool. To date, however, empirical evidence on the effects of preschool education in Germany is limited (Rossbach, Kluczniok, & Kuger, 2008).

Of course, children's cognitive development and educational careers are also influenced by characteristics of the family and home learning environment (e.g., European Child Care and Education [ECCE] Study Group, 1999; Melhuish et al., 2008; Sirin, 2005; Taylor, Clayton, & Rowley, 2004). Consequently, studies evaluating the potential benefits of early years education programs need to examine the influences of the home and preschool learning environments simultaneously. This article investigates how the two environments interact in shaping the development of early numeracy skills in preschool-age children in Germany. Research conducted in other European countries and in the United States has highlighted the potential benefits of early years education programs for children's cognitive development for some years now (ECCE Study Group, 1999; NICHD ECCRN, 2002a, 2005; Sammons et al., 2004). However, emerging numeracy has received less research attention than has emerging literacy, especially with respect to the nature and effects of the home learning environment.

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Yet emerging numeracy is seen as one of the most significant predictors of later school success in mathematics. The present study also offers the possibility to explore how findings from a German sample reflect previous results from other countries and to identify indicators of good practice that are independent of the national context.

In the following, we first outline the available research on the characteristics and impact of the early years home learning environment and of preschool experience. We then identify the research desiderata that are addressed in the present study. Finally, we describe the study framework and formulate our research questions.

### 1.1. Characteristics and impact of the early years home learning environment

The quality of the home learning environment is related to the availability of educational resources, such as books, and the nature of parenting activities, such as reading to the child, using complex language, playing with numbers, counting, and taking the child to the library (e.g., Hart & Risley, 1995; Melhuish et al., 2008; Snow & Van Hemel, 2008). Studies exploring the nature and variation of early years home learning environments have found high variation between families. Structural characteristics, such as family composition, housing, and income, as well as parental educational beliefs and expectations also impact the quality of the home learning environment (e.g., Bornstein & Bradley, 2008; Dowsett, Huston, Imes, & Genettian, 2008; Tietze, Rossbach, & Grenner, 2005). Specifically, results indicate that low socioeconomic status (SES) and low parental education are moderately associated with low quality of the home learning environment (Bornstein & Bradley, 2008; Foster, Lambert, & Abbott-Shim, 2005; Melhuish et al., 2008; Totsika & Sylva, 2004). Son and Morrison (2010) recently investigated the stability of the home environment as children approach school entry. On the one hand, their results indicated that the quality of the home environment at age 36 months was highly correlated with the quality of the home environment at age 54 months. On the other hand, they found that home environments are also subject to change and seem to improve as children approach school entry.

Numerous studies using different measures of the home learning environment have shown that it has a considerable influence on young children's cognitive development and educational outcomes. For example, quality of the home environment as measured by the Home Observation for Measurement of the Environment Inventory (HOME; Caldwell & Bradley, 1984) has been found to correlate with outcomes including general cognitive ability and language (Son & Morrison, 2010; Totsika & Sylva, 2004). Other indicators of the home learning environment associated with better cognitive outcomes are quality of dialogic reading (Whitehurst & Lonigan, 1998), use of complex language (Hart & Risley, 1995), responsiveness and warmth in interactions (Bradley, 2002), and library visits (Griffin & Morrison, 1997; Melhuish et al., 2008). With respect to the development of early numeracy skills, the overall quality of the home learning environment (Blevins-Knabe, Whiteside-Mansell, & Selig, 2007) as well as mathematical activities such as counting or identifying shapes (Blevins-Knabe & Musun-Miller, 1996) have been shown to influence children's mathematical development. These findings are supported by other studies showing that parents of preschoolers can successfully provide their children with specific opportunities to use and extend their early numeracy concepts and skills (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; LeFevre, Clarke, & Stringer, 2002; LeFevre et al., 2009).

### 1.2. Characteristics and impact of preschool experience

Conceptualizations of the quality of the preschool learning environment cover multiple dimensions and relate to structural characteristics (e.g., class size, staff qualification levels), teachers' beliefs and orientations with respect to learning processes, and the process quality of the interactions between teachers and children (NICHD ECCRN, 2002b; Pianta et al., 2005). Process quality involves global aspects such as child-appropriate behavior and warm climate (Harms, Clifford, & Cryer, 1998) as well as domain-specific stimulation in areas such as verbal and (pre)reading literacy, numeracy, and scientific literacy (Kuger & Kluczniok, 2008; Sylva, Siraj-Blatchford, & Taggart, 2003). Research has provided insights into variation in preschool quality. Not only are differences across individual preschools or types of preschool settings large, but the legal framework varies greatly across countries and federal states (Cryer, Tietze, Burchinal, Leal, & Palacios, 1999; Early et al., 2007; ECCE Study Group, 1999; Sylva, 2010). Additionally, it has been shown that the level of process quality is associated with structural characteristics of the preschool setting and class (Early et al., 2010; Pianta et al., 2005; Tietze et al., 1998). Drawing on a German sample of preschools, Kuger and Kluczniok (2008) showed that different aspects of process quality (climate, promotion of literacy and numeracy) were related to the average age of the children in the class and to the proportion of children with a native language other than German.

Large-scale longitudinal studies have produced accumulating evidence for beneficial effects of preschool education on students' cognitive development and outcomes (e.g., Belsky et al., 2007; ECCE Study Group, 1999; NICHD ECCRN, 2003, 2005; Peisner-Feinberg et al., 2001; Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2004). Whereas the evidence for short- and medium-term academic benefits of early education or preschool programs seems to be compelling, findings on longer-term benefits are mixed. It seems that the process quality of the preschool attended is a crucial factor in the magnitude and persistence of beneficial effects. Indeed, the effects of high-quality preschool education or intensive programs on cognitive skills have been shown to persist up to the ages of 8, 10, 11 or even 15 years (Anders et al., 2011; Belsky et al., 2007; ECCE Study Group, 1999; Gorey, 2001; Peisner-Feinberg et al., 2001; Sammons, Sylva, et al., 2008; Vandell et al., 2010).

### 1.3. Interactive effects of home and preschool learning environments

It is accepted that the effects of preschool education can be reliably evaluated only if family and home characteristics are considered at the same time. Whereas older studies tended to control for socioeconomic and family background characteristics without investigating the distinct influence of the home learning environment on development, recent studies have examined the influence of both factors (e.g., Melhuish, 2010; NICHD ECCRN, 2006). Nevertheless, few studies have yet explicitly analyzed the interactive effects of the two environments, although the potential benefits of the amount and quality of preschool education may depend on the quality of the home learning environment and vice versa. The findings of Burchinal, Peisner-Feinberg, Pianta, and Howes (2002) indicate that maternal education, parents' caregiving practices, and parents' attitudes are the strongest predictors of child outcomes, even among those children who experience full-time nonmaternal childcare. Adi-Japha and Klein (2009) examined the associations of parenting quality with cognitive outcomes such as receptive language and school readiness among children experiencing varying amounts of childcare. They found stronger associations among children who experienced medium amounts of childcare than among those who experienced high amounts of childcare. However, the

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