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The Home Literacy and Numeracy Environment in Preschool: Cross-Domain Relations of Parent Practices and Child Outcomes

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THE HOME LITERACY AND NUMERACY ENVIRONMENT IN PRESCHOOL: CROSS-DOMAIN RELATIONS OF PARENT PRACTICES AND CHILD OUTCOMES

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ABSTRACT

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There is ample evidence indicating that early literacy and numeracy skills are important to later academic achievement, and that these early skills develop together. There is also evidence that parent-child literacy and numeracy practices are predictive of children's literacy and numeracy skills within their respective domains. However, there is limited research on the relations between the home literacy environment (HLE) and numeracy outcomes, and the home numeracy environment (HNE) and literacy outcomes. Thus, the purpose of the present study was to investigate the relations of the HLE and HNE to children's literacy and numeracy practices, both within and across domains. Participants were 114 preschoolers and their parents. Preschoolers ranged in age from 3.01 and 5.17 (M = 4.09) and were 54% female and 72% Caucasian. Parents reported the frequency of parent-child literacy and numeracy practices. Children were assessed in the fall and spring of their preschool year on their literacy (definitional vocabulary, phonological awareness, and print knowledge) and numeracy skills. Four hierarchical multiple regression analyses were conducted to predict each of the child outcomes. Results indicate that, although the HLE was not broadly predictive of children's literacy and numeracy outcomes, the HNE was predictive of numeracy, definitional vocabulary, and

phonological awareness outcomes. These findings emphasize the importance of parent-child home numeracy practices to children's academic outcomes at an early age. Specifically, the relation between the HNE and vocabulary development contributes to the growing body of research indicating the important relations between early numeracy and language development.

CHAPTER 1. INTRODUCTION

It is well documented that early academic skills are predictive of later achievement (Aunio & Niemivirta, 2010; Duncan et al., 2007; Rouse, Brooks-Gunn, & McLanahan, 2005; Stevenson & Newman, 1986). Despite the importance of these early skills, children often enter the school setting with considerable individual differences in their academic abilities (Klibanoff, Levin, Huttenlocher, Vasilyeva, & Hedges, 2006; Starkey, Klein, & Wakeley, 2004). Compared to their peers with less developed skills, children who enter school with adequately developed basic literacy and numeracy skills have an increased likelihood of success not only in kindergarten, but in subsequent grades as well (Byrnes & Wasik, 2009). One key factor associated with these school-entry ability differences is the home learning environment (Chazan-Cohen et al., 2009; Young-Loveridge, 1989). The importance of home learning opportunities and experiences to early academic achievement has been found above and beyond various family-, parent-, and child-level factors, including family income and maternal education (Kohen & Guèvremont, 2014; Yeo, Ong, & Ng, 2014).

What parents do – or do not do – in the home environment to engage their children in educational activities is related to the skills, motivation, and interests that children have when they enter formal academic settings (Fantuzzo et al., 2013; Lukie,

Skwarchuk, LeFevre, & Sowinski, 2014; Sonnenschein & Munsterman, 2002; Yeo et al., 2014). The quality of the early home environment, including parents' support of learning experiences, is predictive not only of academic achievement, but also of employment later in life (Pungello et al., 2010). Though considerable progress has been made in recent years to understand the specific mechanisms by which the home environment impacts children's development of early academic skills, these advances have been made primarily in the domain of literacy (e.g., Sonnenschein, Baker, & Serpell, 2010). Less research has been conducted examining children's home numeracy experiences. Additionally, though it is clear that the domains of early literacy and numeracy develop together and are related to each other (Hecht, Torgesen, Wagner, & Rashotte, 2001; Purpura, Hume, Sims, & Lonigan, 2011; Welsh, Nix, Blair, Bierman, & Nelson, 2010), little research has been conducted to examine connections between preschoolers' home literacy and numeracy experiences and the cross-domain relations of these experiences to child outcomes (cf. Anders et al., 2012; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010). Establishing a clear understanding of associations between home learning environments and children's outcomes may inform interventions designed to reduce the achievement gap that affects many children at school entry (Brooks-Gunn & Markman, 2005). Thus, the central goal of this study was to assess how home literacy and numeracy practices contribute to children's literacy and numeracy outcomes both within and across academic domains during the preschool year.

1.1 School Readiness

School readiness in early childhood education refers to the behavioral, social-emotional, and cognitive skills that children need in order to meet the academic demands of formal schooling, and it has long been considered foundational for understanding the disparities in children's learning-related outcomes (Mahatmya, Lohman, Matjasko, & Farb, 2012). Two of the key school readiness domains in which children need to have sufficient mastery are early literacy and numeracy (Welsh et al., 2010). Importantly, disparities in these two areas are evident in children even as young as three years old (Brooks-Gunn, Klebanov, Smith, Duncan, & Lee, 2003) and are highly predictive of later achievement (Duncan et al., 2007). It is critical to understand the development of these early skills before kindergarten entry in order to provide children with the best opportunity to succeed throughout their academic careers.

1.1.1 Early Literacy

Early, or emergent, literacy skills are the foundational skills and knowledge which pre-readers need in order to develop the ability to read and write (Roberts, Jurgens, & Burchinal, 2005; Whitehurst & Lonigan, 1998). Three specific literacy components that are related to children's developing reading abilities are print knowledge, oral language, and phonological awareness (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003). These key components are defined in the following ways: print knowledge includes conventions of print (e.g., the direction that print is read and the way a book is held), alphabet knowledge, and print recognition; oral language includes vocabulary, grammar, and comprehension; and phonological awareness includes detection and manipulation of the parts of language, such as words and syllables (Pullen & Justice,

2003; Storch & Whitehurst, 2002). These early skills are the foundation upon which later reading skills are built and are predictive of later reading ability (Hurford, Schauf, Bunce, Blaich, & Moore, 1994; Snow, Burns, & Griffin, 1998). Many researchers view these early skills as the beginning of a developmental continuum which begins early in life and continues as children enter the school setting (Whitehurst & Lonigan, 1998).

Though children's individual literacy skills improve, their skill level in comparison to their peers generally remains stable throughout preschool and elementary school (i.e., low-achieving children in the early years are typically low-achieving in later years as well; Cabell, Justice, Logan, & Konald, 2013; Storch & Whitehurst, 2002; Wagner et al., 1997). However, when they do change over time, gaps in reading ability are likely to widen, producing what has been termed the Matthew Effect – students with positive early literacy experiences are able to build upon those experiences to facilitate greater learning, and those who lack positive early experiences continue to struggle (Chatterji, 2006; Stanovich, 1986). Torgesen (2002) argued that struggling readers require more intensive instruction in order to develop skills at the same rates as their peers, not because they are unable to learn at the same rate, but because they have so much more to learn. Additionally, he speculates that differences in home support are a primary reason as to why children differ in preparedness for learning to read, and that home support is an important factor in helping children who have fallen behind to catch up to their peers.

1.1.2 Early Numeracy

There are also foundational numeracy skills that children need in order to develop more complex math skills, including: counting/quantification, numerical relations, and

arithmetic operations (National Mathematics Advisory Panel [NMAP], 2008; Purpura & Lonigan, 2013). Counting/quantification includes knowledge of the counting sequence and cardinality, numerical relation skills include ability to compare sets of quantities, and arithmetic operations include the rules of addition and subtraction (Purpura & Lonigan, 2013). There is evidence that children are capable of developing an understanding of numerical ideas from a very young age and should be exposed to numeracy concepts early in life (Ginsburg, Lee, & Boyd, 2008; Jordan & Levine, 2009). For example, infants appear to display evidence of understanding quantification as well as numerical equivalence for small numbers (Feigenson & Carey, 2003; Mix, Huttenlocher, & Levine, 2002). These skills build on a trajectory, and simpler concepts must be understood before more complex mathematical skills can be learned (Clements, Baroody, & Sarama, 2013).

As with literacy skills, differences in students' numeracy abilities tend to remain stable throughout preschool and elementary school (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Jordan, Kaplan, Ramineni, & Locuniak, 2009). As such, the early years are a critical period for the development of these skills because they set the developmental trajectory for later skills. Gersten and Chard (1999) postulate that, through interactions in the home, children informally gain an understanding of numeracy concepts before kindergarten entry; a child who is not exposed to numeracy interactions in the home may not develop this understanding as readily as his/her peers.

1.2 Domain-Specific Relations Between the Home Environment and School Readiness

As Gersten and Chard (1999) emphasized, the foundation for children's development of academic skills is created in the home environment. Given that in 2013 approximately 45% of three and four year old children in America did not attend

preschool (United States Census Bureau, 2013), it is important to understand how the home setting functions as children's first, and often primary, learning environment. Further, for children who do attend preschool, it is important to understand how practices in the home may supplement instruction at school. The early home learning environment has been shown to have significant and lasting effects on early academic outcomes, as well as later academic attainment (Baker & Iruka, 2013; Bradley, Burchinal, & Casey, 2001; Brooks-Gunn & Markman, 2005; Melhuish et al., 2008; Pungello et al., 2010). Moreover, the quality of the home learning environment is related to children's early academic development independent of structural characteristics of the home, such as income, education, and ethnic background (Adi-Japha & Klein, 2009; Kluczniok, Lehrl, Kuger, & Rossbach, 2013).

The home learning environment is predictive of children's academic abilities at school entry. For example, Melhuish and colleagues (2008) found that children of parents who reported greater frequencies of learning-related activities (i.e., reading, going to the library, playing with numbers, painting/drawing, learning letters and numbers, and learning songs or rhymes) were more likely to be higher achieving in both literacy and numeracy, whereas children whose parents reported practicing these activities less often were more likely to be lower achieving. These differences were found at five years old and were partially maintained when measured two years later. Fewer home learning practices during the preschool years was predictive of low achievement at seven years old, but more frequent learning practices was not predictive of higher achievement. Thus, though the relation between parents' early home learning practices (i.e., before school

entry) and children's academic achievement may be reduced as children advance through school, they remain an important predictor of achievement.

Melhuish et al. (2008) identified possible reasons why the home learning environment is important for children's academic development. They suggest that the relations may be due to the teaching of specific skills, but that they are also likely due to the general academic motivation promoted in the overall environment; in a positive, encouraging setting where children are exposed to various learning experiences, they are "learning to learn" (p. 108). The authors argue that, in line with Vygotsky's (1978) theory that children learn from the environment around them, and specifically from adults, children are stimulated and their learning is reinforced by encouragement from their parents.

General, positive interactions in the home environment may teach children to become learners, but it is also the case that targeting domain-specific skills in the home setting may aid children in acquiring specific skillsets. Two domains that parents commonly target in the home are literacy and numeracy, and the home environments specific to each have been shown to relate to children's domain-specific outcomes (i.e., the home literacy environment is related to literacy outcomes and the home numeracy environment is related to numeracy outcomes; Baker, 2014; Kleemans, Peeters, Segers, & Verhoeven, 2012). Understanding the relations between specific home environment domains and children's outcomes may provide insight as to whether it is specific practices that relate to specific outcomes, or whether, as Melhuish and colleagues (2008) speculated, a broad, generally supportive home learning environment is an adequate way of understanding how parent-child practices relate to children's academic outcomes.

1.2.1 Home Literacy Environment

There is a wealth of information on the importance of the home literacy environment (HLE) for children ranging from infancy to adolescence, with the majority of this research focusing on the preschool and early elementary years (e.g., Bus, van IJzendoorn, & Pellegrini, 1995; Lee & Croninger, 1994; Schmitt, Simpson, & Friend, 2011). The HLE has been broadly defined as the characteristics of the home setting that are thought to contribute to the development of children's pre-reading and reading skills (Foster, Lambert, Abbott-Shim, McCarty, & Franze, 2005; Payne, Whitehurst, & Angell, 1994). These characteristics include: literacy materials in the home, frequency of storybook reading, parents' own literary enjoyment and practices, maternal engagement, enrichment activities, parents' literacy beliefs, and parents' literacy abilities. Each aspect of the HLE has been found to contribute to children's acquisition of early literacy skills (Levy, Gong, Hessels, Evans, & Jared, 2006; Sonnenschein & Munsterman, 2002). Specifically, parent-child literacy practices and parents' active role in engaging their children in literacy activities are important to children's early literacy development (Baker, 2014; Bennett, Weigel, & Martin, 2002; Burgess, Hecht, & Longian, 2002). Parent reports of shared book reading and practices focused on letter name and sound identification and letter writing have been found to be related to each of the fundamental early literacy domains (print knowledge, oral language, and phonological awareness; Bennett et al., 2002; Foy & Mann, 2003; Levy et al., 2006).

The HLE is especially important during the preschool years when children are beginning to develop the early literacy skills that they need to become successful readers, as these early experiences lay the foundation for more advanced reading skills (Hood,

Conlon, & Andrews, 2008; Whitehurst & Lonigan, 1998). Though not all researchers have found significant relations between the HLE and children's literacy outcomes (e.g., Baroody & Diamond, 2012), the majority of research indicates that the HLE predicts children's literacy outcomes, and these relations have been demonstrated across varying language, ethnic, and economic backgrounds (Daniels, 2012; Farver, Xu, Lonigan, & Eppe, 2013; Hindman & Morrison, 2012). Additionally, the deficits related to an early HLE lacking in consistent, quality exposure to literacy activities are persistent and differences in children's abilities can be observed years later (Schmitt et al., 2011; Sonnenschein et al., 2010). There are clear connections between preschoolers' HLE, pre-reading skills, and later reading abilities (Levy et al., 2006; Sénénchal & LeFevre, 2002). Thus, it is evident that when parents provide a home environment that encourages literacy interest and promotes literacy skills, they are helping their children to achieve long-term reading success.

1.2.2 Home Numeracy Environment

Whereas the relations between the HLE and children's literacy skills are fairly well established, the relations between the home numeracy environment (HNE) and children's numeracy skills are less well understood. Though limited research has examined the HNE of preschoolers (e.g., Anders et al., 2012; Niklas, Cohrssen, & Tayler, 2015), the predominance of the evidence showing associations between the HNE and children's numeracy skills has been established in kindergarten (e.g., LeFevre, Polyzoi et al., 2010). However, children begin developing mathematical abilities very early in life and the HNE in kindergarten, particularly parental involvement and engagement in mathematical activities, plays a unique role in the development of mathematics skills,

emphasizing the need for these connections to be examined earlier in life (Hill, 2001; Kleemans et al., 2012; LeFevre et al., 2009; Niklas & Schneider, 2013; Young-Loveridge, 1987). Similar to the HLE, the HNE consists of the values, beliefs, knowledge, background, experience, physical resources, practices, and attitudes in the home that promote the development of children's numeracy skills (Street, Baker, & Tomlin, 2008). Parents' observed and reported numeracy practices are positively related to children's early numeracy concepts in preschool (Anders et al., 2012; Niklas et al., 2015) and kindergarten (Kleemans et al., 2012; LeFevre, Clarke, & Stringer, 2002; Vandermaas-Peeler & Pittard, 2014).

Despite the fact that parents' numeracy practices are related to children's understanding of math at a very young age (i.e., three years old; LeFevre et al., 2002), parents report engaging in fewer mathematical activities with younger preschool children than with older preschool children (i.e., three vs. four years old; Son & Morrison, 2010). Only recently have researchers begun to examine the HNE at the early preschool level (e.g., Anders et al., 2012; DeFlorio & Beliakoff, 2014). Anders and colleagues (2012) found that the HNE (i.e., presence of toys that teach shapes and colors; presence of toys that teach numbers; and stimulation to learn shapes, colors, spatial relationships, digits, and counting) accounted for significant variance in three-year-olds' numeracy abilities at preschool entry. Further, the relation between high-quality HNE and children's numeracy abilities remained significant over the next two years of preschool, illustrating the positive, lasting implications of parents' numeracy practices on very young children. DeFlorio and Beliakoff (2014) also examined aspects of the HNE in preschool. Although they did not report analyses of the relations between parents' numeracy practices and

preschoolers' outcomes, their findings indicate that there are important relations between parents' beliefs about their role in their children's numeracy development, expectations about typical numeracy development, and their children's numeracy outcomes.

Though the majority of the current literature available on the HNE shows a promising relation between the home environment and children's mathematical development, a few studies have found negative relations between parents' numeracy practices and children's outcomes (Blevins-Knabe & Musin-Miller, 1996; Missall, Hojnoski, Caskie, & Repasky, 2015). For example, in a study examining the HNE of four to six year old children, Blevins-Knabe and Musin-Miller (1996) found that, although four parent-reported activities (i.e., child saying numbers 1-3, parent using numbers 1-3, child mentioning number facts, and parent mentioning number facts) positively related to children's numeracy outcomes, four other activities (i.e., parent using "same number" concept, parent teaching child to count, parent reciting numbers 1-10, and parent teaching child to recite numbers) were negatively related to children's numeracy outcomes. However, the age of the child was not used as a control variable in analyses, and the activities which appeared to negatively affect outcomes were those that would be expected of parents of younger children who were just beginning to develop these concepts (e.g., reciting numbers). These analyses may have made it appear as though the practices were negatively related to outcomes, when in actuality the practices were associated more with younger children with less-developed numeracy skills.

An alternative explanation of these negative relations can be generated from the findings of Sonnenschein and colleagues (2012) which suggest that parents' numeracy practices vary with children's age, a pattern also found by other researchers (LeFevre et

al., 2002). Sonnenschein et al. (2012) found that parents of younger children (i.e., preschool and kindergarten aged) reported practicing more "basic" math skills with their children (counting objects, identifying shapes, doing puzzles, watching math television programs) while parents of older children (i.e., elementary school aged) reported engaging in more adding/subtracting, writing numbers, using math workbooks, using calendars, and telling time. Though it is not surprising that parents engage older children in more complex activities, many of the more complex activities examined by Sonnenschein et al. have been identified as developmentally appropriate for younger children (Seo & Ginsburg, 2004). It is possible that negative relations between the HNE and children's numeracy abilities were found because parents do not always understand which types of numeracy practices are age-appropriate for their children (Fluck, Linnell, & Holgate, 2005; Holloway, Rambaud, Fuller, & Eggers-Piérola, 1995; Skwarchuk, 2009), or because parents practice more basic skills with older children who are struggling or who are behind in numeracy development. The inconsistencies found in the current research on the relation between the HNE and numeracy outcomes highlight a need for further evaluation of these early skills in general, and their relation to parents' home practices specifically. Further, as numeracy skills develop rapidly in the early years, it is important for children's age to be included in analyses to account for developmentally appropriate differences in ability.

1.3 Cross-Domain Relations

1.3.1 Literacy and Numeracy Across Domains

It is evident that literacy and numeracy development are related (Purpura et al., 2011; Savage, Carless, & Ferraro, 2007). Children who struggle in one domain often

experience difficulties in the other (Light & DeFries, 1995), and it has been suggested that an emphasis on building literacy and numeracy skills simultaneously is a promising way to prepare children for formal schooling (Munn, 1994). There is a large body of work which suggests that early literacy and language skills are related to early numeracy skills, as well as later mathematics abilities (Bloom & Wynn, 1997; Davidse, De Jong, & Bus, 2014; Grimm, 2008; Kurdek & Sinclair, 2001; Lopez, Gallimore, Garnier, & Reese, 2007; Purpura & Ganley, 2014; Savage et al., 2007; Zhang et al., 2014). Although all three aspects of emergent literacy have been found to be generally related to mathematics performance (Hecht et al., 2001; Piasta, Purpura, & Wagner, 2010; Romano, Babchishin, Pagani, & Kohen, 2010), particularly strong relations have been found between print knowledge and vocabulary and early numeracy (LeFevre, Fast, et al., 2010; Purpura et al., 2011; Purpura & Napoli, 2015). The relation between print knowledge and early numeracy is likely due to similarities in the processes of learning code-based print that is present in both literacy and numeracy development (Brizuela, 2004; Pupura & Napoli, 2015).

Despite extensive evidence that language and numeracy are related, it is unclear whether this relation is facilitative (language allows for the use of numeracy concepts) or causal (language is the foundation of numeracy) in nature (Gelman & Butterworth, 2005). Regardless of the nature of the relation, language is a critical component in the connection between early literacy and numeracy. For example, though studies with infants show that a person does not necessarily need to be able to speak in order to understand basic numeracy concepts (e.g., quantification; Mix et al., 2002), a person does need to have an understanding of word meanings in order to be able to understand, and

express understanding, of more complex concepts (e.g., discrete quantification; Slusser, Ditta, & Sarnecka, 2013). Furthermore, evidence indicates that an interactive and engaging mathematics curriculum may also have positive benefits for children's language skills (Sarama, Lange, Clements, & Wolfe, 2012). Thus, it appears likely that engaging in numeracy activities may also be related to children's language development.

1.3.2 HLE and HNE Across Domains

Specific to their domains, it is apparent that both the HLE and the HNE are important aspects in the development of children's early literacy and numeracy skills. However, engaging in literacy and numeracy activities at home may also be related to positive development across domains. Specifically, the HLE has also been found to be predictive of numeracy performance (Anders et al., 2012; Melhuish et al., 2008). Positive relations have also been found longitudinally between toddlers' HLE and their preschool numeracy abilities (Baker, 2014). Anders and colleagues (2012) found that, though the HLE and HNE were both significant predictors of numeracy skills, the HLE was a better predictor of numeracy skills at preschool entry than was the HNE. LeFevre, Polyzoi, et al. (2010) found similar relations between Greek, but not Canadian, five year olds' HLE and numeracy outcomes.

One mechanism which may explain the relations between the HLE and numeracy development is language. Anders and colleagues (2012) posit that one could argue that "adequate language skills are a prerequisite for the acquisition of mathematical knowledge" (p. 241). The general home environment (Roberts et al., 2005), and the HLE specifically (Payne et al., 1994), may contribute to children's language development, and strong relations have been found between language and numeracy development

(Kroesbergen, Van Luit, Van Lieshout, Van Loosbroek, & Van de Rijt, 2009; Purpura & Ganley, 2014). Further, parents' use of math-specific language is related to children's numeracy knowledge (Gunderson & Levine, 2011). It is possible that parents' literacy-focused activities provide children with the language skills necessary to understand and express mathematical skills. It is also likely that parents who frequently practice literacy activities with their children expose their children to math-specific language during those activities (e.g., counting or discussing spatial relations while engaging in shared reading).

Unfortunately, in the previously mentioned studies of the HLE and numeracy, LeFevre, Polyzoi, and colleagues (2010) and Anders and colleagues (2012) did not report assessing children's literacy outcomes and Baker (2014) did not collect information on home numeracy practices. Thus, they could not examine the cross-domain relations of the HNE and literacy outcomes. Though there is some evidence of the HLE supporting numeracy development, there has been little research examining the relations between the HNE and literacy outcomes. This lack of evidence is surprising given that early numeracy is a stronger predictor of later reading than is early literacy (Duncan et al., 2007; Romano et al., 2010) and that mathematics curricula may positively contribute not only to the development of numeracy skills, but also to the development of early language skills (Sarama et al., 2012). Given the extensive evidence that math is related to and predictive of early literacy skills, particularly language, it is likely that a home environment supportive of numeracy practices would have a positive impact on aspects of children's early literacy development due to increased opportunities for language-rich interactions.

The reasons underlying *why* literacy and numeracy are related are not fully understood. After finding a relation between preschoolers' narrative and later numeracy

abilities, O'Neill, Pearce, and Pick (2004) speculated that one cause may be similarities between literacy and numeracy in brain functioning. Borrowing from Devlin's (2000) rationale, they posited that the parts of the brain that allow humans to process math are the same parts that allow language use. Therefore, when children are exposed to numeracy concepts, they are also exercising their literacy skills. Similarly, Sarama and colleagues (2012) theorized that some skills which are developed through mathematics, specifically reasoning, problem solving, and communication, are also necessary for language. These skills, when practiced within a numeracy context, may also transfer to literacy concepts. Other researchers (e.g., Duncan et al., 2007) have made similar observations, and emphasize the importance of further examining the mechanisms behind the relations of literacy and numeracy. The understanding of these cross-domain relations is fundamental to understanding whether a home learning environment that includes activities rich in one domain (literacy or numeracy) can enhance the development of the other domain.

1.4 Current Study

The focus of the current study was to investigate both domain-specific and cross-domain relations between parent-reported HLE and HNE and preschoolers' academic outcomes. The study provides an additional investigation regarding the relations between the HLE and literacy outcomes and the HNE and numeracy outcomes. Further, it investigates the relation between the HLE and numeracy outcomes. Critically, and unique to this study, the relation between the HNE and literacy outcomes was also examined. Utilizing data of home literacy and numeracy practices, reported by parents in the fall of

the 2013 academic year, and children's fall 2013 and spring 2014 literacy and numeracy outcomes, there were two primary questions:

Question 1. Do parent-child literacy and numeracy practices in the fall (i.e., composite variables of each domain, as defined below) predict children's domain-specific spring literacy and numeracy outcomes?

Hypothesis 1a. Based on previous findings (Bennet et al., 2002; Burgess et al., 2002), it was predicted that parents' literacy practices with their children would predict children's print knowledge, definitional vocabulary, and phonological awareness outcomes.

Hypothesis 1b. Based on previous findings (Kleemans et al., 2012; LeFevre et al., 2002; Vandermaas-Peeler & Pittard, 2014), it was predicted that parents' numeracy practices with their children would predict children's numeracy outcomes.

Question 2. Do parent-child literacy and numeracy practices in the fall have cross-domain relations with spring academic outcomes? That is, do parents' literacy practices with their children predict children's numeracy outcomes, above and beyond numeracy practices? Additionally, do parents' numeracy practices with their children predict children's literacy outcomes, above and beyond literacy practices?

Hypothesis 2a. Consistent with prior findings (Anders et al., 2012; Baker, 2014), it was predicted that parents' literacy practices with their children would predict children's numeracy outcomes above and beyond numeracy practices.

Hypothesis 2b. Based on the findings that numeracy skills are predictive of literacy (Duncan et al., 2007; Romano et al., 2010) and that high-quality mathematics instruction may have positive impacts specifically on language skills (Sarama et al.,

2012), it was predicted that parents' numeracy practices with their children would predict definitional vocabulary, but not print knowledge or phonological awareness, outcomes above and beyond literacy practices.

CHAPTER 2. METHOD

2.1 Participants

Participants were recruited from twelve schools in the Greater Lafayette area of Indiana. Letters explaining the study, consent forms, and questionnaires were sent home to all parents of 3-5 year old children attending these schools. Parents of 125 preschoolers completed the background questionnaire, gave permission for their children to participate, and had children who participated in pretesting. Of those children, 11 were unavailable for posttesting and were not included in analyses. Children who were excluded from analyses did not significantly differ from those included in regards to age $F(1, 123) = 0.63$, $p = .428$. However, parents whose children remained in the study reported significantly higher educational attainment than those who left, $F(1, 123) = 5.29$, $p = .023$. The 114 preschoolers included in the analyses were 54% female, 72% white, 9% Asian, and 19% other or multiracial, which is approximately representative of the local demographics. Children ranged in age from 3.01 to 5.17 years ($M = 4.09$, $SD = 0.59$) at time of parental consent. Parents' highest education ranged from attainment of a GED to attainment of a graduate degree; 23% of parents had some college or less, 32% had an Associate's or Bachelor's degree, and 45% had a graduate degree.

2.2 Data Collection

Data were collected in the fall (September-December) and spring (February-May) of the 2013-2014 academic year as part of a larger project examining children's early academic development. As often as possible, children were assessed in the spring in approximately the same order as they were in the fall and with approximately the same number of months between assessments (i.e., a child assessed early in fall testing would also be assessed early in spring testing). Children were invited individually to participate in math and reading assessments and all participants included in analyses gave verbal or nonverbal assent. Participants received a sticker at the completion of each testing session. All data were collected in the students' preschools, most often in a quiet area outside of the classroom. Assessments took a total of approximately 60 to 90 minutes and were conducted in three or four sessions. All assessments were conducted by graduate or undergraduate students studying in the fields of human development and family studies or speech, language, and hearing sciences. All assessors completed two or three two-hour training sessions and were required to demonstrate their competence and knowledge of assessments by "testing out" in order to participate in data collection. The testing out process involved administering each of the assessments to a lead project member who ensured that administration and scoring were done correctly.

2.3 Measures

2.3.1 Test of Preschool Early Literacy (TOPEL)

The TOPEL (Lonigan, Wagner, Torgesen, & Rashotte, 2007) was used to evaluate preschoolers' literacy skills. The TOPEL includes three subtests: Print Knowledge (PK), Definitional Vocabulary (DV), and Phonological Awareness (PA). The

PK subtest measures letter name identification, letter sound identification, and concepts of print. The DV subtest measures children's vocabulary and ability to provide definitions of words. The PA subtest includes elision and blending tasks. The TOPEL has high internal consistency for each subtest (PK: $\alpha = .95$; DV: $\alpha = .94$; PA: $\alpha = .87$).

2.3.2 Preschool Early Numeracy Skills Screener – Brief Version (PENS-B)

The PENS-B (Purpura, Reid, Eiland, & Baroody, 2015) was used to evaluate preschoolers' numeracy skills. The PENS-B is a 24-item measure which takes approximately five minutes to administer and assesses the broad numeracy skills that children are exposed to in preschool and kindergarten. Specific assessment areas include: set comparison, numeral comparison, one-to-one correspondence, number order, numeral identification, ordinality, and number combinations. Children received one point for each correct answer. Although all 24 items were administered, a ceiling rule was applied to analyses and children did not receive points for any correct responses after three consecutive incorrect responses (Purpura et al., 2015). The PENS-B has high internal consistency ($\alpha = .93$) and is correlated with the Test of Early Mathematics Ability – 3rd Edition (TEMA-3; $r = .73$).

2.3.3 Parent Questionnaire

Parents were asked to complete a researcher-created background information questionnaire. They provided socioeconomic status information, such as educational achievement, income, and characteristics of the family and home environment. Parents also reported the frequency of practicing specific literacy and numeracy activities in the home with their children, with six options ranging from "never" (0) to "multiple times a

day" (5). Questions on the HLE and HNE were modified from previous research (LeFevre et al., 2009) in order to reflect age-appropriate activities for the current sample.

Questions from the background questionnaire were used to create composite variables representing the HLE and the HNE. Four questions regarding the frequency of parents' practices were used to create a composite variable of the frequency of home literacy practices ($\alpha = .67$): printing letters, reading storybooks, identifying letters, and identifying letter sounds. Eight questions regarding the frequency of parents' numeracy practices were used to create a composite variable of the HNE ($\alpha = .75$): counting objects, printing numbers, reading number storybooks, using number activity books, using the terms more and less, counting down, learning simple sums, and identifying written numbers.

Of the 125 parents who consented for their child to participate, 13 were missing at least one HLE or HNE item from the parent questionnaire. Rather than excluding these parents from analyses, the missing values function in SPSS was used to impute missing items using linear interpolation.

2.4 Covariates

Rapid automatized naming, number of children in the home, and parent education were used as covariates as these factors have been previously shown to be related to the home learning environment and/or child outcomes (Benigno & Ellis, 2004; Raikes et al., 2006; Skwarchuk, Sowinski, & LeFevre, 2014). Sex was also included as a covariate because there is evidence that there are gender differences in children's exposure to numeracy in the home (Chang, Sandhofer, & Brown, 2011). Age was also used as a covariate because it is expected that children's ability in both literacy and numeracy

increases with age. Lastly, fall assessment results were used as a covariate to control for previous ability.

Rapid automatized naming (RAN) tasks were utilized as a measure of cognitive processing. RAN is associated with both reading and mathematics skills and is considered a basic processing skills measure (Georgiou, Tziraki, Manolitsis, & Fella, 2013), and therefore was controlled for in all analyses. RAN was assessed using two tasks – a colors task and a pictures task. For the colors task, children were presented with a sheet of paper containing colored boxes (blue, red, green, and black) in four rows and eight columns. Children were asked to name the color of each box in order as quickly as possible and were timed doing so. For the pictures task, children were presented with a sheet of paper containing pictures (cars, cats, houses, and pigs) in five rows and eight columns. They were asked to name each object in order as quickly as possible and were timed doing so. A single RAN score was calculated by averaging the color and picture scores.

2.5 Analytic Strategy

Data were analyzed using IBM SPSS Statistics 22. In each model, either spring literacy or numeracy scores were used as dependent variables, as described below. RAN, number of children in the home, parent education, child sex, child age, and fall assessment results were used as control variables in the first step of all regression analyses. Specific predictor variables unique to each analysis are presented below.

Question 1. Do parent-reported literacy and numeracy practices in the fall (i.e., composite variables of each domain, as defined above) predict children's domain-specific spring literacy and numeracy outcomes?

Analytic plan 1a. To test the hypothesis that parent literacy practices would predict children's print knowledge, definitional vocabulary, and phonological awareness outcomes, three hierarchical multiple regressions were conducted. One analysis was conducted for each of the literacy outcome variables – print knowledge, definitional vocabulary, and phonological awareness. These were entered as dependent variables. In Step 1, control variables (RAN, number of children in the home, parent education, and child's sex and age) were entered. The fall literacy skill that matched the outcome literacy skill was also entered in Step 1 (e.g., fall PK scores were entered in the analysis for spring PK scores). In Step 2, the HLE composite variable was added to the model to determine if it contributed to literacy outcomes above and beyond the control variables.

Analytic plan1b. To test the hypothesis that that parents' numeracy practices would predict children's numeracy outcomes, one hierarchical multiple regression was conducted. The spring PENS-B score was used as the dependent variable. In Step 1, control variables and the fall PENS-B score were entered. In Step 2, the HNE composite variable was added to the model to determine if it contributed to numeracy outcomes above and beyond the control variables.

Question 2: Do parent-reported literacy and numeracy practices in the fall have cross-domain relations with spring academic outcomes? That is, do parents' literacy practices predict children's numeracy outcomes, above and beyond numeracy practices? Additionally, do parents' numeracy practices predict children's literacy outcomes, above and beyond literacy practices?

Analytic plan 2. Four hierarchical multiple regressions were conducted. To determine if numeracy practices uniquely related to literacy outcomes, the HNE

composite variable was added in Step 3 to the models described in Analytic Plan 1a. To determine if literacy practices uniquely related to numeracy outcomes, the HLE composite variable was added in Step 3 to the model described in Analytic Plan 1b.

CHAPTER 3. RESULTS

3.1 Descriptive Statistics

Means, ranges, standard deviations, skewness, and kurtosis for covariates, child outcomes, and home environment scores are presented in Table 1. Correlations between covariates, literacy and numeracy outcomes, and the HLE and HNE are presented in Table 2. Children's age was correlated with each of the child outcomes, as well as the HLE and HNE. The number of children in the home was not significantly correlated with any outcome variables or the HLE or HNE. RAN was correlated with each of the outcome variables, as well as the HLE and HNE. The HLE and HNE were also strongly correlated.

3.2 Regression Analyses

Results of regression analyses are presented in Tables 3-6.

Question 1. Do parent-child literacy and numeracy practices in the fall (i.e., composite variables of each domain) predict children's domain-specific spring literacy and numeracy outcomes?

Hypothesis 1a. The HLE predicted children's definitional vocabulary outcome, $F(1, 106) = 29.32$, $p = .050$, above and beyond covariates (i.e., RAN, number of children in the home, parent education, child's sex, child's age, and fall assessments scores).

However, the HLE did not significantly predict children's spring print knowledge, $F(1, 106) = 38.52$, $p = .295$, or phonological awareness, $F(1, 106) = 9.35$, $p = .136$, outcomes.

Hypothesis 1b. The HNE significantly predicted children's spring PENS-B outcomes, above and beyond covariates and the fall PENS-B score, $F(1, 106) = 19.62$, $p = .005$.

Question 2. Do parent-child literacy and numeracy practices in the fall have cross-domain relations with spring academic outcomes? That is, do parents' literacy practices with their children predict children's numeracy outcomes, above and beyond numeracy practices? Additionally, do parents' numeracy practices with their children predict children's literacy outcomes, above and beyond literacy practices?

Hypothesis 2a. The HLE did not significantly predict children's spring PENS-B outcomes above and beyond the HNE, $F(1, 105) = 17.34$, $p = .286$. Further, when the HLE was added to the model, the HNE was no longer a significant predictor. However, when the HNE was removed from the model, the HLE significantly predicted spring PENS-B outcomes above and beyond other covariates, $F(1, 106) = 19.01$, $p = .015$, suggesting that there may be shared variance between the two domains.

Hypothesis 2b. As hypothesized, the HNE significantly predicted children's spring definitional vocabulary score, above and beyond covariates, fall definitional vocabulary score, and the HLE, $F(1, 105) = 31.27$, $p < .001$. The HNE also predicted phonological awareness outcomes above and beyond covariates and the HLE, $F(1, 105) = 8.89$, $p = .051$. When the HNE was added to the model, the HLE was no longer a

significant predictor of definitional vocabulary. The HNE did not significantly predict print knowledge outcomes, $F(1, 105) = 33.87$, $p = .299$.

Supplemental analyses. To assess whether the home learning environment in general (e.g., including items from both the HLE and HNE in one measure) is a better predictor of child mathematics and literacy outcomes than considering the two factors separately, post hoc analyses were conducted. One composite variable that included the 12 items used to calculate the HLE (four items) and HNE (eight items) was created. The home learning environment variable ($\alpha = .80$) was entered into four hierarchical multiple regression analyses after covariates were added in the first step. The HNE and HLE variables were not included in these analyses as separate variables. The general home environment score significantly predicted spring definitional vocabulary, $F(1, 106) = 32.68$, $p = .001$, phonological awareness, $F(1, 106) = 10.88$, $p = .003$, and numeracy outcomes, $F(1, 106) = 18.57$, $p = .033$. The general home learning environment did not significantly predict spring print knowledge outcomes, $F(1, 106) = 39.03$, $p = .148$.

CHAPTER 4. DISCUSSION

4.1 Domain-Specific Relations of the Home Literacy and Numeracy Environments

4.1.1 HLE Predicting Literacy Outcomes

It was hypothesized that the HLE would be predictive of children's print knowledge, definitional vocabulary, and phonological awareness outcomes. In contrast to expectations, the HLE predicted only definitional vocabulary and did not significantly predict print knowledge or phonological awareness. Although there is a consistent body of evidence supporting the relations between the HLE and children's literacy outcomes, there are some contrary findings (e.g., Baroody & Diamond, 2012). Specifically, the findings of the present study are consistent with findings of Son and Morrison (2010) that the home learning environment is related to children's language skills but not to their general academic skills, including letter and word identification, even when the direct teaching of academic skills by parents is considered (e.g., encouraging children to learn to read a few words).

Previous research indicates that parents' active role in teaching their children early literacy skills is related to children's language outcomes (Bennett et al., 2002). Likewise, in the present study, the HLE was a significant predictor of children's oral language outcomes, as assessed through definitional vocabulary. It was found that more frequent parent-child literacy practices are related to better vocabulary outcomes. It is

likely that parent-child literacy practices are related to children's vocabulary development because these practices provide an opportunity for dialogue. Hindman, Skibbe, and Foster (2014) found that during activities such as shared book reading, parents are more likely to focus on meaning-related talk than on code-related talk, and that this meaning-related talk is related to preschoolers' vocabulary development. These findings may explain why relations were found between the HLE and definitional vocabulary, but not phonological awareness or print knowledge.

There are a few additional possible explanations for why the HLE did not predict print knowledge or phonological awareness. First, it is possible that quantity of practices is not a sufficient measure of the HLE and that quality indicators, such as the depth and clarity of parents' explanations, are more closely related to children's outcomes. Even parents who report frequently working with their children may not have the skills that are necessary to teach their children a broad range of early literacy skills. Second, it is possible that considering the HLE in broader terms, rather than considering only indicators thought to relate directly to literacy, may be a better way of predicting certain outcomes. Though the parent-child practices that were considered (e.g., identifying letter sounds) are closely aligned with the literacy outcomes that were assessed, there may be additional practices and behaviors that contribute to these outcomes. For example, Schmitt and colleagues (2011) included such variables as joint attention and shared conversation in their measure of the HLE. It may be that a more broadly defined HLE is a more appropriate measure of parent-child interactions and more accurately covers the scope of interactions that are related to children's language and literacy outcomes (Schmitt et al., 2011). Third, it is likely that children's teachers spent more class time on

literacy activities than on numeracy activities. Given that the majority of children in this study attended full-day preschool programs, and that there are often significant differences between the amount of literacy and numeracy instruction that preschoolers receive in the classroom (Skibbe, Hindman, Connor, Housey, & Morrison, 2013), children were likely exposed to literacy activities throughout the day, while not being equally exposed to numeracy activities. Thus, the relations of the HLE may not have been strong enough to account for changes in children's literacy skills above and beyond changes due to classroom instruction. In contrast, the HNE may be expected to account for variance in children's numeracy abilities if children were exposed to fewer numeracy practices in the classroom.

4.1.2 HNE Predicting Numeracy Outcomes

It was hypothesized that the HNE would predict children's numeracy outcomes. As expected, the HNE predicted preschoolers' numeracy outcomes above and beyond child- and family-level characteristics such as age and fall numeracy performance. The ability of the HNE to significantly predict preschoolers' numeracy outcomes indicates that parent-child numeracy practices in the home may contribute to children's early numeracy skills for children as young as three years old. More frequent parental engagement in children's numeracy practices, such as counting and learning about numbers, is related to children's acquisition of these skills. These findings contribute to a growing body of research that indicates that the HNE is related to children's numeracy abilities from a very early age (Anders et al., 2012; Niklas et al., 2015). This is particularly important given that parents report less frequent numeracy practices with younger preschool-aged children than they do with older preschool-aged children (Son &

Morrison, 2010). It is possible that increasing the frequency of numeracy practices with younger children may help them to acquire numeracy skills from a younger age.

Though at older ages the relation between the HNE and numeracy outcomes is generally consistent, research findings regarding the HNE in preschool have been mixed. Some researchers have found positive relations between the HNE and children's numeracy outcomes (Kleemans et al., 2012), and others have not (Blevins-Knabe & Musin-Miller, 1996). However, when age is included as a covariate in analyses, positive relations between the HNE and preschoolers' numeracy outcomes have often been found. Numeracy skills develop rapidly during the preschool years and age-related differences in early numeracy skills are expected when a range of ages are included in the sample, as were in the present study (i.e., three to five year olds). Additionally, differences in parents' practices based on their children's age, such as practicing more basic skills with younger children (Sonnenschein et al., 2012), may make it appear that those practices are related to poorer outcomes, when in actuality the outcomes are a reflection of younger children having less-developed numeracy skills than their older peers. This may explain why researchers such as Blevins-Knabe and Musin-Miller (1996) have found relations between the HNE and some numeracy skills, but not others. Utilizing age as a covariate, as was done in the current study, controls for these age-related differences in numeracy abilities and practices.

4.2 Cross-Domain Relations of the Home Literacy and Numeracy Environments

4.2.1 HLE Predicting Numeracy Outcomes

The hypothesis that the HLE would significantly predict preschoolers' numeracy outcomes was not supported. The HLE was not found to be a significant predictor of

children's numeracy outcomes above and beyond the HNE. However, similar to previous research (Anders et al., 2012), the HLE was a significant predictor of numeracy outcomes when the HNE was not included in the model. These findings may be due to the strong correlation between the HLE and the HNE. On average, parents who reported frequent parent-child literacy practices also reported frequent parent-child numeracy practices. The HNE and HLE likely account for shared variance of parents' home practices in general as both the HNE and the HLE significantly predicted preschoolers' numeracy outcomes when the other was not in the model.

4.2.2 HNE Predicting Literacy Outcomes

It was also hypothesized that the HNE would predict children's language outcomes, as measured by a definitional vocabulary assessment. This hypothesis was supported; the HNE predicted children's vocabulary outcomes not only above and beyond child- and family-level characteristics and the fall definitional vocabulary scores, but also above and beyond the HLE. Interestingly, when the HNE was added to the model, the HLE was no longer a significant predictor. The relation between the HNE and vocabulary outcomes is likely due to the opportunity that parent-child numeracy interactions present for in-depth verbal interactions. When parents scaffold their children's numeracy development, they are likely providing explanations to their children that may contribute to their vocabulary development. Though these outcomes cannot be interpreted causally, they support previous findings that a language-rich numeracy environment supports both numeracy and language development (Sarama et al., 2012) and provide support for these relations to be examined in more depth.

An unexpected relation of the HNE predicting phonological awareness outcomes was also found. Although this relation was not hypothesized due to some previous research findings on the cross-domain development of mathematics and literacy (e.g., Purpura et al., 2011), it is in line with other research that has found relations between numeracy and phonological awareness (Hecht et al., 2001). One potential explanation for this finding is that parents who engage their children in more frequent numeracy practices may also engage their children in more complex literacy practices. The only item that was included in the HLE score that would have a clear relation to phonological awareness was identifying letter sounds. It may be that there were unmeasured practices that parents engaged their children in, such as identifying rhyming words, that are more complex and more predictive of phonological awareness outcomes than those included in the HLE. The HNE may not be related to phonological awareness outcomes directly, but rather served as a proxy for more advanced home practices. An additional explanation, as speculated by Hecht et al. (2001), may be that phonological memory, which is necessary to perform phonological awareness tasks, is also related to numerical computations. If this is the case, when parents engage their children in numeracy activities, they may also be enhancing children's phonological memory, which then enhances abilities related to phonological awareness. Additional research is necessary in order to understand the mechanisms underlying the relations between specific literacy and numeracy skills, and *why* practices in each domain may be related to seemingly unrelated outcomes in the other domain.

The relation found between the HNE and literacy outcomes provides additional evidence of the connections between early numeracy and literacy development. The

finding that the HNE is predictive of literacy outcomes (i.e., definitional vocabulary and phonological awareness) above and beyond the HLE is well-aligned with previous findings that early numeracy skills are an even stronger predictor of later literacy skills than are early literacy skills (Duncan et al., 2007). The function of numeracy as a predictor of literacy outcomes is likely due to the strong language base underlying numeracy development. As explained by previous researchers (e.g., Anders et al., 2012), language is a necessary tool in the development of numeracy skills. It is likely that, because learning and refining numeracy skills requires complex and rich language, these practices may also contribute to the development of language skills.

4.2.3 The Home Learning Environment and Academic Outcomes

Despite targeted relations within and across domains, there appears to be significant overlap between the HLE and HNE. A strong correlation was found between the HLE and HNE, indicating that, on average, the more frequently parents practiced one domain with their child, the more frequently they also practiced the other. This relation may explain why the HNE was no longer a significant predictor of numeracy outcomes when the HLE was added to the model—essentially, the two home environment factors share significant variance. The strong correlations between the HLE and HNE, and the ability of the HNE to predict two of the three literacy outcomes, may indicate that the HLE and HNE are not two distinct constructs. It is possible that investigations that consider literacy and numeracy practices together, as one construct rather than competing factors, may be a more accurate way of understanding the relations between parents' practices and children's literacy and numeracy outcomes. For example, Melhuish and colleagues (2008) found that a broadly defined home learning environment which

included both literacy and numeracy practices predicted children's literacy and numeracy outcomes. This speculation was assessed in post hoc analyses. Utilizing a broad home learning environment as a predictor resulted in findings similar to when the HLE and HNE were utilized as separate predictors. The broad home learning environment significantly predicted definitional vocabulary, phonological awareness, and numeracy outcomes, but did not significantly predict print knowledge outcomes. Ultimately, more work on the nuanced relations within and across domains of the home environment is needed.

4.3 Limitations and Future Directions

Though the findings of this study offer an important contribution to the growing literature on the home learning environment, a few limitations should be noted. These limitations indicate future lines of study that should be explored. First, this study is correlational and should not be interpreted in a causal framework. The HNE was found to predict numeracy, vocabulary, and phonological awareness outcomes. However, it is impossible to deduce through the present study design that the HNE causes changes in numeracy or literacy development. Though causal inferences cannot be made, the results of this study are important in understanding the relations of parents' practices with their children's academic development. Further, the results provide evidence that parents' practices outside of literacy-based activities may support the development of children's literacy skills. Though preliminary research indicates that improving the HNE may positively affect children's outcomes (Niklas et al., 2015), additional research is needed to conclude whether or not there is a causal relation between the HNE and children's numeracy abilities.

A second limitation is that the sample used in this study was relatively homogeneous (e.g., 72% Caucasian). Though the sample included in these analyses is representative of the population from which it was drawn, a more inclusive sample should be utilized in future studies to examine the relations for families from various ethnic and linguistic backgrounds. The examination of cross-domain relations between the home environment and children's academic outcomes should be conducted in diverse samples to determine whether the relations found in this study hold true in various populations. In addition to ethnic homogeneity, parents' educational attainment was, on average, high in this study. It is important to determine whether the practices of parents who have lower levels of education are related to their children's academic outcomes in similar patterns that were found in the present study.

A third limitation is that the measures of the home literacy and numeracy environments were retrospective parent report. As in all cases of self-report, there is potential for reporter bias. It is also possible that parents did not remember or realize the frequency of their activities. Future studies may benefit from using a diary method so that parents can record their numeracy and literacy practices daily rather than relying on memory. Additionally, observations of parent-child numeracy interactions may provide researchers with more insight as to *why* numeracy practices are related to preschoolers' language and phonological awareness outcomes. There are also limitations of the measure of the HLE in the current study (i.e., the HLE was limited to four items). Future research should include broader measures of the HLE, as well as additional items focusing on language and literacy development.

Lastly, the effect sizes are relatively small. Though any insight into the relations between the home environment and children's outcomes is meaningful, there is still a significant amount of variability in children's performance left to be explained. This study is limited in its ability to account for factors beyond the home environment that account for children's literacy and numeracy development because other factors (e.g., the preschool setting) were not measured. The current investigation indicates that the HLE and HNE are only two of what are likely several predictors of children's outcomes. Further research is needed to determine the other factors that contribute to the prediction of children's literacy and numeracy outcomes. Subsequent studies should examine the relations between these predictors and children's outcomes, and also to examine the potential for interactions between predictors (e.g., the home and preschool environments).

Two additional areas for future research should be acknowledged. First, the outcomes of the cross-domain relations between the HNE and literacy outcomes draw attention for the need of an investigation as to *why* there are relations between numeracy and literacy development. Particularly, investigation is needed to determine how parents' numeracy practices are related to children's outcomes. The HNE was predictive of preschoolers' phonological awareness outcomes; the mechanisms underlying this relation should be examined in order to better determine how phonological awareness and numeracy are related.

Finally, there is a need to determine the relations between specific parent-child practices and children's outcomes. The HLE was differentially related to children's literacy outcomes, indicating that examining the general HLE may not be an ideal way to determine relations between practices and outcomes. It may be that examining the

relations between specific practices and specific outcomes is a better reflection of the relations between the home environment and children's outcomes. In addition to examining specific practices and outcomes, it is important for future investigations to include analyses of relations not only within domains, but across domains as well. This is particularly true for causal investigations as interventions designed to improve numeracy outcomes may also benefit language development (e.g., Sarama et al., 2012). Further investigation is needed to understand whether relations between the home environment and children's outcomes are better explained by examining specific practices or the general learning environment.

4.4 Conclusion

The findings of this study fill an important gap in the literature. The home numeracy environment was predictive not only of preschoolers' numeracy outcomes, but of their definitional vocabulary and phonological awareness outcomes as well. This finding goes beyond the important relations previously found between numeracy and literacy development and illustrates the ability of parent-child numeracy practices to predict children's language outcomes. Specifically, the outcomes provide rationale for conducting additional research on the HNE and the mechanisms underlying its cross-domain relations to literacy outcomes. These findings provide additional evidence that early literacy and numeracy development are related, as well as providing evidence of the cross-domain relations between the home numeracy environment and preschoolers' literacy outcomes. A deeper understanding of parents' numeracy practices is necessary to understand how preschoolers' literacy and numeracy learning may be promoted in the home setting.

TABLES

Table 1

Descriptive Statistics of Covariates, Child Outcomes, and Home Environment

Variable	*M*	*SD*	Range	Min.	Max.	Skew	Kurtosis
Covariates							
Age	4.09	0.59	2.16	3.01	5.17	0.00	-0.95
Children in Home	0.83	0.76	3.00	0.00	3.00	0.54	-0.34
RAN (seconds)	77.49	28.37	134.75	37.50	172.25	1.43	2.32
Fall Assessments							
PENS-B	10.46	5.79	23.00	0.00	23.00	0.21	-0.80
Print Knowledge	18.79	11.04	36.00	0.00	36.00	-0.15	-1.30
Definitional Vocabulary	50.90	12.21	58.00	8.00	66.00	-1.33	1.56
Phonological Awareness	14.89	5.47	22.00	5.00	27.00	0.16	-0.65
Spring Assessments							
PENS-B	13.55	5.95	24.00	0.00	24.00	-0.16	-0.98
Print Knowledge	24.13	9.90	34.00	2.00	36.00	-0.70	-0.69
Definitional Vocabulary	54.41	9.23	47.00	22.00	69.00	-1.12	1.33
Phonological Awareness	17.28	5.92	25.00	2.00	27.00	-0.51	-0.45
Home Literacy Environment	3.23	0.88	4.25	0.75	5.00	-0.46	0.06
Home Numeracy Environment	2.25	0.75	3.75	0.13	3.88	-0.36	-0.18

$N = 114$.

Note. RAN = Rapid Automatized Naming; PENS-B = Preschool Early Numeracy Scale – Brief Version

Table 2

Correlations Between Covariates, Child Outcomes, and Home Environment

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Covariates															
1. Age	–														
2. Children in Home	.17	–													
3. Child Sex	.21*	.09	–												
4. Parent Education	-.06	-.06	.09	–											
5. RAN	-.45***	-.04	-.04	-.10	–										
Fall Assessments															
6. PENS-B	.62***	.08	.01	.30***	-.53***	–									
7. PK	.42***	-.17	-.05	.39***	-.48***	.69***	–								
8. DV	.57***	.01	.01	.12	-.50***	.53***	.52***	–							
9. PA	.40***	-.06	-.02	.04	-.31***	.46***	.43***	.43***	–						
Spring Assessments															
10. PENS-B	.55***	-.06	.02	.19*	-.47***	.69***	.63***	.51***	.47***	–					
11. PK	.41***	-.04	-.20*	.29**	-.51***	.65***	.81***	.48***	.42***	.62***	–				
12. DV	.51***	.04	-.07	.32***	-.40***	.61***	.52***	.74***	.43***	.58***	.56***	–			
13. PA	.41***	.01	-.08	.22*	-.39***	.58***	.51***	.41***	.46***	.56***	.64***	.61***	–		
Home Environment															
14. HLE	.28**	-.04	-.08	.21*	-.26**	.29**	.39***	.28**	.17	.40***	.40***	.40***	.33***	–	
15. HNE	.30***	.05	.01	.12	-.19*	.29***	.29**	.21*	.13	.40***	.33***	.45***	.35***	.61***	–

N = 114.

Note. RAN = Rapid Automatized Naming; PENS-B = Preschool Early Numeracy Scale – Brief Version, PK = Print Knowledge, DV = Definitional Vocabulary, PA = Phonological Awareness, HLE = Home Literacy Environment, HNE = Home Numeracy Environment

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

Table 3

Hierarchical Regression Analysis Predicting Spring Print Knowledge

Variable	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1: Covariates									
RAN	-0.05	0.02	-0.14*	-0.05	0.02	-0.14*	-0.05	0.02	-0.14*
Children in the home	1.07	0.71	0.08	1.09	0.71	0.08	1.03	0.71	0.08
Parent education	0.27	0.36	0.05	0.22	0.36	0.04	0.22	0.36	0.04
Child sex	-3.90	1.08	-0.20***	-3.75	1.09	-0.19***	-3.78	1.09	-0.19***
Age	1.56	1.11	0.09	1.34	1.13	0.08	1.21	1.14	0.07
Fall Print Knowledge	0.62	0.06	0.69***	0.61	0.07	0.68***	0.61	0.07	0.68***
Step 2:									
HLE				0.68	0.65	0.06	0.23	0.78	0.02
Step 3:									
HNE							0.92	0.88	0.07
R^2		0.72			0.72			0.72	
ΔR^2		0.72***			0.00			0.00	

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

Table 4

Hierarchical Regression Analysis Predicting Spring Definitional Vocabulary

Variable	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1: Covariates									
RAN	0.01	0.02	0.03	0.01	0.02	0.04	0.01	0.02	0.04
Children in the home	0.29	0.71	0.02	0.39	0.70	0.03	0.21	0.66	0.02
Parent education	1.61	0.34	0.28***	1.46	0.34	0.26	1.44	0.32	0.25***
Child sex	-2.78	1.11	-0.15*	-2.43	1.11	-0.13	-2.51	1.04	-0.14*
Age	3.63	1.21	0.23**	3.13	1.22	0.20	2.50	1.15	0.16*
Fall Definitional Vocabulary	0.45	0.06	0.59***	0.44	0.06	0.58	0.45	0.05	0.59***
Step 2:									
HLE				1.23	0.65	0.12*	-0.36	0.74	-0.04
Step 3:									
HNE							3.36	0.84	0.27***
R^2		0.65			0.66			0.70	
ΔR^2		0.65***			0.01*			0.04***	

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

Table 5

Hierarchical Regression Analysis Predicting Spring Phonological Awareness

Variable	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1: Covariates									
RAN	-0.04	0.02	-0.17	-0.03	0.02	-0.15	-0.03	0.02	-0.16
Children in the home	0.07	0.61	0.01	0.13	0.61	0.02	0.06	0.60	0.01
Parent education	0.81	0.29	0.22**	0.70	0.29	0.19*	0.69	0.29	0.19*
Child sex	-1.86	0.94	-0.16*	-1.62	0.95	-0.14	-1.66	0.94	-0.14
Age	2.66	0.96	0.27**	2.31	0.98	0.23*	2.03	0.98	0.20*
Fall Phonological Awareness	0.31	0.09	0.29***	0.31	0.09	0.29***	0.32	0.09	0.29***
Step 2:									
HLE				0.85	0.56	0.13	0.10	0.67	0.02
Step 3:									
HNE							1.51	0.77	0.19*
R^2		0.37			0.38			0.40	
ΔR^2		0.37			0.01			0.02	

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

Table 6

Hierarchical Regression Analysis Predicting Spring PENS-B

Variable	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1: Covariates									
RAN	-0.02	0.02	-0.12	-0.02	0.02	-0.11	-0.02	0.02	-0.10
Children in the home	-1.02	0.53	-0.13*	-1.04	0.51	-0.13*	-0.99	0.51	-0.13
Parent education	0.16	0.28	0.04	0.08	0.27	0.02	0.02	0.27	0.00
Child sex	-0.36	0.83	-0.03	-0.23	0.81	-0.02	-0.09	0.82	-0.01
Age	2.27	0.97	0.23*	1.79	0.95	0.18	1.64	0.96	0.16
Fall PENS-B	0.50	0.10	0.49***	0.48	0.10	0.47***	0.49	0.10	0.48***
Step 2:									
HNE				1.55	0.54	0.20**	1.15	0.66	0.15
Step 3:									
HLE							0.62	0.58	0.09
R^2		0.53			0.56			0.57	
ΔR^2		0.53***			0.03**			0.01	

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

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