Soto-Calvo, E, Simmons, FR, Adams, AM, Francis, HN and Giofré, D

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Article

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Abstract

Research Findings. It has been proposed that the home literacy environment may influence the development of early number skills (see Anders et al., 2012 and Napoli & Purpura, 2018 for discussions). However, the results of studies examining the association between home literacy experiences and early number skills are mixed (e.g. Baker, 2014; Napoli & Purpura, 2018; Segers, Kleemans, & Verhoeven, 2015). This could be due to the way that the home literacy experiences are conceptualised and measured. This study examines the relationship between early number skills and aspects of the home learning environment. Alongside home number experiences and parental mathematical attitudes, two types of home literacy experiences were examined in a sample of 274 pre-schoolers (mean age 4:0, SD 4 months); code-focused home literacy experiences that focus on the phonological and orthographic features of language, and meaning-focused home literacy experiences that focus on sharing the meaning of language and text. Home number experiences and letter-sound interactions (interactive code-focused literacy experiences) were related to the children's counting, number transcoding and calculation skills whereas meaning-focused home literacy experiences and parental mathematical attitudes were largely unrelated to these early number skills. Structural equation models indicated that only letter-sound interactions could predict statistically significant unique variance in counting, number transcoding and calculation.

Practice or Policy. These findings suggest that code- rather than meaning-focused home literacy experiences are related to pre-schoolers early number skills. Supporting parents to engage in code-focused home literacy experiences may benefit pre-schoolers number skills as well as their emergent literacy.

Key words: counting, number transcoding, calculation, home learning environment, home literacy environment, home literacy experiences, preschool

Early number skills are basic numerical abilities that children develop early in life through formal or informal contact with the number system. These include counting, understanding numerical relations and performing basic arithmetic (see Aunio and Räsänen, 2016, and Torbeyns, Gilmore and Verschaffel, 2015, for reviews). Theoretical models and empirical studies have identified a developmental progression in children's formal number skills. Children first learn the count-word sequence before being able to apply it to enumerate sets of objects[1] and finally can apply their counting skills perform simple calculations often using their fingers or concrete objects for support (Bermejo, 1996; Fluck & Henderson, 1996; Krajewski & Schneider, 2009b; Wynn, 1990). Large individual differences have been identified in early number skills during preschool and at school entry (Davidson, Eng, & Barner, 2012; Dowker, 2008; Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Le Corre & Carey, 2007; Mussolin, Nys, Leybaert, & Content 2012; Mussolin, Nys, Content, & Leybaert, 2014; Sarnecka & Lee, 2009), with substantial evidence that these individual differences predict later mathematics (e.g. Jordan, Kaplan, Locuniak, & Ramineni, 2007; Jordan, Kaplan, Ramineni & Locuniak, 2009; Krajewski & Schneider, 2009a,b; Martin, Cirino, Sharp, & Barnes, 2014; Moll, Snowling, Göbel, & Hulme, 2015; Nguyen et al., 2016; Östergren & Traff, 2013; Passolunghi & Lanfranchi, 2012; Purpura, Hume, Sims, & Lonigan, 2011; Soto-Calvo, Simmons, Willis, & Adams, 2015; Stock, Desoete, & Roeyers, 2009a,b; van Marle, Chu, Li, & Geary, 2014; Watts, Duncan, Siegler, & Davis-Kean, 2014). Together

[1] We note that the relationship between counting and cardinality is complex with some models suggesting that cardinality can be understood even if counting knowledge or procedures are not robust (see Bermejo, Morales, and Garcia deOsuna, 2004 for a discussion). However, to use *counting* to ascertain the numerosity of the set children must first have accurate knowledge of the count-word sequence.

this research suggests that children's early number skills (including counting, number transcoding and calculation) already differ at preschool age and that these individual differences are predictive of later mathematical skills. The strength of the predictive relationship between individual differences in early number skills and later academic attainment underlines the importance of understanding the extent that environmental factors within the preschool period promote and constrain the growth of early number skills. The central focus of the present study is analysing the extent that preschool home number experiences and preschool home literacy experiences are associated with individual differences in early number skills.

Predictors of Early Number Skills

An increasing body of research has examined the precursors of early number skills. Much of this research has focused on cognitive abilities including working memory (see Clements, Sarama, and Germeroth, 2016, and Raghubar, Barnes, and Hecht, 2010, for reviews) and nonsymbolic quantitative skills (see De Smedt, Noël, Gilmore, and Ansari, 2013, for a review). Several environmental factors have also been associated with the development of early number skills. These factors include socio-economic status (SES) (Anders, Grosse, Roßbach, Ebert, & Weinert, 2013; Krajewski & Schneider, 2009a; Sirin, 2005), the quality and quantity of preschool education (Anders et al., 2013; Melhuish et al., 2013; Taggart, Sylva, Melhuish, Sammons, & Siraj, 2015; Sammons et al., 2014; Sammons, Toth, & Sylva, 2015) and the quality of the Home Learning Environment (HLE) (e.g. Anders et al., 2013; Melhuish et al., 2008; Skwarchuk, Sowinski, & LeFevre, 2014).

The HLE is a broad term that encompasses parental attitudes towards learning, the availability of home learning resources, as well as the quality and quantity of home experiences that promote learning. Large-scale studies have identified positive relationships between broad indices of the HLE (that include literacy, numeracy and more general learning experiences such as painting or drawing) and both literacy and numeracy skills (e.g. Melhuish et al., 2008; Sammons et al., 2015). However, there is now increasing interest in determining whether specific home numeracy and home literacy experiences have differential relationships with early number and literacy skills (e.g. Anders et al., 2012; Napoli & Purpura, 2018; Skwarchuk et al., 2014).

The Home Literacy Environment

In order to identify the relationships between specific aspects of the HLE and different aspects of children's attainment, theoretical models have been developed to classify different home experiences. Two different but closely related models are commonly used to categorise home literacy experiences. The first is the formal/informal distinction originally described by Sénéchal, Lefevre, Thomas, and Daley (1998) and utilised in a number of later studies (e.g. Hood, Conlon, & Andrews, 2008; Sénéchal & LeFevre, 2002; Skwarchuk et al., 2014). In this model home literacy experiences are classified as either formal, where the primary goal is to teach a child literacy skills, or informal, where the primary goal is to enjoy the meaning conveyed by the text. Shared reading is viewed as the archetypal informal home literacy experience. Formal home literacy experiences are more varied, but are generally considered more didactic experiences (e.g. teaching a child how to read simple words, teaching the sounds associated with particular letters). The second model formulated by Phillips and Lonnigan (2009) classifies home literacy experiences as either supporting outside-in skills, relating to comprehending the meaning of oral and written language, or supporting inside-out skills, which relate to analysing the phonological or orthographic code of oral and written language. In this model, shared reading would be considered an outside-in activity. Other activities such as discussing the narrative of a story or teaching the meaning of words would also be considered outside-in activities. In contrast, teaching word decoding, familiarising a child with the alphabetic code or discussing the phonological aspects of oral language (e.g. identifying rhyming words) would be considered inside-out activities. Largely, there is overlap between these two models where activities that are considered informal are outside-in and activities that are considered formal are inside-out. To avoid ambiguity within the current paper, we use the terms code-focused and meaning-focused to distinguish the two core types of home literacy experiences. Experiences that focus on the phonological and orthographic basis of language are termed code-focused, whereas experiences that focus on the semantics of spoken or written language are termed meaning-focused.

Code- and meaning-focused home literacy experiences make differential contributions to the development of early language and literacy (Phillips & Lonigan, 2009; Sénéchal & LeFevre, 2014). The majority of findings indicate that code-focused experiences enhance emergent literacy (including understanding of the alphabetic code and early reading) (e.g. Hood et al., 2008; Sénéchal & LeFevre, 2002, 2014). There are mixed findings regarding the relationship between code-focused experiences and phonological awareness. A positive relationship has been reported (Foy & Mann, 2003), although this is not always independent of emergent literacy skills (Sénéchal & LeFevre, 2002), as well as studies that have failed to identify a relationship (Hood et al., 2008; Napoli & Purpura, 2018). In contrast, meaning-focused experiences, particularly shared reading, are consistently associated with a stronger vocabulary (Frijters, Barron, & Brunello, 2000; Manolitsis, Georgiou, & Tziraki, 2013; Sénéchal, 2006; Sénéchal & LeFevre, 2002, 2014, however see Puglisi, Hulme, Hamilton, & Snowling, 2017, for arguments that this relationship is correlational but not causal). Within the current study, we explore the extent that code- and meaning-focused home literacy experiences explain individual differences in early number skills.

The Home Numeracy Environment

Studies using indices of the home numeracy environment (that focus on experiences which have a mathematical or numerical component) have generally reported positive associations with children's number skills (Anders et al., 2012; del Río, Susperreguy, Strasser, & Salinas, 2017; Hart et al., 2016; Skwarchuk et al., 2014; Huntsinger, Jose, & Luo, 2016; Sonnenschein, Metzger, & Thompson, 2016; Zippert & Ramani, 2017). However, some null findings have also been reported (e.g. Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000; Missall, Hojnoski, Caskie, & Repasky, 2015). This somewhat mixed pattern of findings may be influenced by the way that the home numeracy experiences are conceptualised and measured. A model of the home numeracy environment that mirrored the formal/informal distinction within the home literacy environment (Sénéchal et al., 1998) was advocated by LeFevre et al. (2010) and Skwarchuk et al. (2014). In this model, experiences with a teaching focus on the formal number system such as teaching number names, practicing counting or completing calculations were classified as formal or direct. Experiences that involve mathematical concepts, but where the focus is primarily enjoyment, were classified as informal or indirect. In the Skwarchuk et al. study, playing number games (e.g. Ludo, Snakes and Ladders) was used as an index of informal numeracy experiences. However, informal number experiences could be viewed more broadly to encompass a range of play-based experiences that involve mathematical or number concepts (e.g. baking, playing shops, sorting shapes). Skwarchuk et al. demonstrated that formal and informal home numeracy experiences were related to different numeracy outcomes. The index of formal numeracy was related to symbolic arithmetic but not to nonsymbolic arithmetic, whereas the index of informal home numeracy experiences was related to nonsymbolic arithmetic. Similarly LeFevre et al. reported that the informal home numeracy experiences were not related to symbolic numeracy measures.

Although the extent that informal home numeracy experiences are included in home numeracy scales may influence the relationships with symbolic early number skills, the difficulty of the home numeracy experiences may also influence the strength of the relationship. It has been argued that the relationship between the home numeracy experiences and early numeracy outcomes is age- and activity-specific (Elliot & Bachman, 2017; Thompson, Napoli, & Purpura, 2017). If the experiences within a home numeracy environment index are too basic for the age of the sample, null results may be more likely. This interpretation could account for some existing mixed findings, as the difficulty of the experiences included in home numeracy environment indices and the age of the participants vary considerably across studies. This argument is also supported by studies that have demonstrated that more advanced home number experiences had a stronger relationship with symbolic arithmetic (del Río, et al., 2017; LeFevre et al., 2010; Ramani, Rowe, Eason, & Leech, 2015; Skwarchuk, 2009; Skwarchuk et al., 2014; Thompson et al., 2017). In summary, the relationship between the home numeracy experiences and *symbolic* early number skills is more robust when the scale focuses on direct experiences that explicitly involve the formal number system and when the experiences are appropriately stretching for the age-group studied.

Cross-domain Influences

Simple home numeracy models hypothesise that number-oriented experiences promote the acquisition of early number skills (del Río et al., 2017; Manolitsis et al., 2013; Sonnenschein et al., 2016). A relationship between home number experiences and number skills would be considered a within-domain relationship. However, an additional role for home literacy experiences supporting early number skills has been suggested (see Anders et al., 2012, and Napoli and Purpura, 2018, for discussions). Language skills have been associated with the development of number skills. For instance, letter knowledge and phonological awareness have been associated with counting and calculation (De Smedt, Taylor, Archibald, & Ansari, 2010; Krajewski & Schneider, 2009b; Koponen, Salmi, Eklund, & Aro, 2013; Purpura et al., 2011; Soto-Calvo et al., 2015). Vocabulary has also been associated with mathematical attainment and early number skills (Moll et al., 2015; Romano, Babchishin, Pagani, & Kohen, 2010) and proposed to support mathematical development through the acquisition and understanding of mathematical vocabulary (Moll et al., 2015; Toll & Van Luit, 2014). Consequently, there is an argument that code-focused home literacy experiences could support early numbers skills via the development of phonological skills or by supporting children's general understanding of verbal-symbolic linkage. In contrast, meaning-focused literacy experiences could support early number skills via vocabulary development. In this scenario shared reading may have a more direct role as exposure to books may increase the likelihood of parents engaging in spontaneous exchanges of not only literacy-related discourse but also of numeracy-related discourse (see Vandermaas-Peeler, Nelson, Bumpass, and Sassine, 2009, and Barnes and Puccioni, 2017, for discussions).

Recent investigations into the relationship between home literacy experiences and early number skills have reported mixed results. Baker's (2014) longitudinal study reported that frequency of literacy-related interactions with two-year-olds was predictive of the children's mathematical achievement at the age of four. Similarly, Anders et al. (2012) found that both indices of the home numeracy environment and the pre-reading home literacy environment of pre-schoolers made unique and independent contributions to their number skills performance two years later. Intriguingly, it was the pre-reading literacy index that had the stronger relationship with numeracy performance. Although Barnes and Puccioni (2017) failed to find a relationship between the frequency of shared reading and mathematics, they did report a relationship between the *quality* of talk associated with shared reading and mathematics attainment in four-year-olds. However, other studies have not reported a positive association between the home literacy environment and early number skills. LeFevre et al. (2010) conducted a cross-cultural study with five-year-old Canadian and Greek children. They found that a composite measure of parental frequency of shared reading and number of children's books in the home was significantly related to Greek children's numeracy performance, although this relationship was not significant for Canadians. Moreover, Segers, Kleemans, and Verhoeven (2015) and LeFevre et al. (2009) found no evidence of a positive relationship between home literacy experiences and early numeracy in young children. Huntsinger et al. (2016) also failed to identify longitudinal associations between the home literacy environment and later mathematics.

It is possible therefore that the relationship between home literacy experiences and early number skills may be influenced by the extent that they are code- or meaning-focused. Napoli and Purpura (2018) found that a single variable of how often parents read storybooks to their child (a meaning-related literacy experience) did not predict maths performance either concurrently or a few months later. Although they did not use regressions to test whether their code-related literacy experiences predicted maths performance or growth, their correlations indicated that code-related literacy experiences had stronger relationships with maths than their meaning-related literacy experiences at both time points. This suggests that code- and meaning-focused home literacy experiences may have differential relationships with early number skills. The current study uses specific indices of code- and meaning-focused home literacy experiences to clarify whether the nature of home literacy experiences influences the relationships with early number skills.

Parental Mathematical Attitudes

Some studies of the HLE have gone beyond examining the frequency of formal and informal learning experiences to examine how parental attributes relate to the frequency of engagement in learning experiences and children's academic outcomes. Links between parental mathematical attitudes and young children's numeracy performance have been previously reported (Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; LeFevre et al., 2010; Skwarchuk et al., 2014; Sonnenschein et al., 2016). There is some evidence suggesting that this relationship is due to parents who hold more positive attitudes towards maths engaging more frequently in numeracy experiences with their children (LeFevre et al., 2010; Sonnenschein et al., 2016). However, parents' mathematical attitudes have also been directly associated with their children's symbolic and nonsymbolic numeracy performance (del Río et al., 2017; LeFevre et al., 2010; Skwarchuk et al., 2014). In the current study, we examine whether parental attitudes towards mathematics are related to their reported frequency of engagement in home number experiences with their children and to their children's early number skills. Potentially, parents who have more positive attitudes to mathematics may engage more frequently in number-related home experiences and therefore support the development of their children's early number skills.

Aim of the Study

The central focus of this study is to explore how home literacy experiences and home numeracy experiences relate to children's early number skills. We used a parental questionnaire to collect information on different aspects of the HLE of three- and four-year-old children. Alongside this, we assessed children's counting, number transcoding and calculation skills. These early number skills were chosen because preschool competence in these areas has been consistently associated with later mathematical attainment (Jordan et al., 2007; Jordan et al., 2009; Krajewski & Schneider, 2009a,b; Martin et al., 2014; Moll et al., 2015; Nguyen et al., 2016; Passolunghi & Lanfranchi, 2012; Purpura et al., 2011; Soto-Calvo et al., 2015; Stock et al., 2009a,b; van Marle et al., 2014; Watts et al., 2014) as well as being core components of the Early Years Curriculum in England (Department for Education, 2013; Testing and Standard Agency, 2017).

Within our HLE questionnaire, we constructed three scales to assess the frequency of home number and literacy experiences. All the items within the home number scale had an explicit focus on number or quantity (e.g. 'Is encouraged to point out or identify numbers in books or the environment'). We chose to focus on experiences with an explicit numerical component rather than informal or indirect experiences, as they have been more consistently associated with symbolic number skills (LeFevre et al., 2010; Swarchuk et al., 2014). The items within the code-focused literacy scale related to the orthographic and phonological basis of language (e.g. 'Is taught the names or sounds of letters or how to 'sound out' words'). The items within the meaning-focused literacy scale related to the meaning of spoken or written language being discussed or shared (e.g. 'Discusses stories with an adult'). We used factor analysis to determine whether these scales, based on theoretical models of the HLE (LeFevre et al., 2010; Phillips & Lonnigan, 2009; Sénéchal et al., 1998; Skwarchuk et al., 2014), were reliable and internally consistent. In addition, we used a book exposure measure as an index of shared reading since this is a core meaning-focused home literacy experience. This measure indexes the frequency of shared reading by assessing parental knowledge of children's book titles. Similar checklists have been successfully utilised in previous HLE research (e.g. Dilnot, Hamilton, Maughan, & Snowling, 2017; Hamilton, 2014; Hamilton, Hayiou-Thomas, Hulme, & Snowling, 2016; Hume, Lonigan, & McQueen, 2015; Puglisi et al., 2017; Skwarchuk et al., 2014; Sénéchal et al., 1998; Sénéchal et al., 2008).

Our study extends the existing literature in two key ways. First, we were able to describe the frequency of home literacy and numeracy experiences in a sample of UK pre-schoolers and examine the relationships between these home learning experiences and early number skills. Analyses of cross-domain relationships between the home literacy environment and number skills have predominantly been conducted with North American and European samples (Anders et al., 2012; Baker, 2014; LeFevre et al., 2009; LeFevre et al., 2010; Napoli & Purpura, 2018; Segers et al., 2015), but an analysis of the relationships between specific home literacy and home numeracy experiences and early number skills has not been conducted within a UK pre-school context. Furthermore, as discussed previously, the extent that code- and meaning-focused home literacy experiences are differentially related to early number skills remains ambiguous. Our study aims to clarify the extent that these different types of home literacy experiences are associated with a range of early number skills. Finally, we examined whether parents who hold more positive attitudes towards mathematics engage more frequently in number-related experiences with their children (LeFevre et al., 2010; Sonnenschein et al., 2016) and whether the children of parents with more positive mathematical attitudes have stronger early number skills (Skwarchuk et al., 2014). The core aims of the study can be summarised in three research questions:

1. Are home number experiences positively related to pre-schoolers' early number skills?
2. Are code- and meaning-focused home literacy experiences differently related to pre-schoolers' early number skills?
3. Are parental mathematical attitudes positively related to pre-schoolers' early number skills?

Methodology

Design

These data presented here are part of a larger dataset from an ongoing longitudinal study examining the relationships between environmental and cognitive factors and later academic attainment. The present analyses focus on the relationships between home learning experiences, parental attitudes towards mathematics and early number skills within a preschool sample. All assessments were completed in the children's final year of preschool (the academic year in which they turned four).

Participants

We recruited 41 Early Years settings, of which 40 had parents who consented for their children to participate. These 40 participating settings were distributed across three counties in the North West of England and were broadly representative of English Early Years provision[2], with 24 settings (60%) being private or voluntary nurseries or preschools (60% nationally), 12 (30%) being nursery classes within a maintained school (31% nationally), three (7.5%) being maintained nursery schools (4% nationally) and one (2.5%) being a nursery class within an independent school (2% nationally).

We received 302 parental consents together with a completed questionnaire; 278 were from parents whose children were within the eligible age-bracket and arrived in time for the children to complete all number skills assessments at their settings in the spring term. Two children withdrew consent at a later stage and two were excluded because they were judged unable to comprehend the tasks following the administration of the practice items. The final sample therefore consisted of 274 parent-child dyads. Of the parents who completed the questionnaire 254 were female.

The postcode deprivation decile for each household was obtained from the English indices of deprivation 2015 online open data of the United Kingdom (Department for Communities and Local Government, http://imd-by-postcode.opendatacommunities.org/). The mean deprivation level was close to the national average (M = 5.42, SD = 3.32). Three respondents did not supply their postcodes.

Parental qualifications were coded according to the UK National Qualification framework (https://www.gov.uk/what-different-qualification-levels-mean/list-of-qualification-levels). This scale levels qualifications from 1 (qualifications equivalent to a lower grade GCSE, typically taken by 16-year-olds) to 8 (doctoral level qualifications). Parental highest level of education was diverse, with a mean which was broadly equivalent to

[2] National figures based on the proportion of 3-year-olds attending different types of preschool provision in England (Whitaker, 2014).

two years of post-secondary education (*M* = 4.75, *SD* = 2.00). Four respondents did not report their qualifications.

The children (146 females) were on average 4:0 (*SD* = 3.63 months) when they completed the number skills assessments. Parents completed the questionnaire on average half a month (two weeks) prior to the children completing the assessments (time lag between questionnaire receipt and assessment *M* = 0.50 months, *SD* = 0.72). Parents were asked to report the ethnicity of their child, which was coded according to the categories used in the 2011 UK Census. A total of 249 (90.9%) of the children were white, 17 (6.2%) were of mixed/multiple ethnic heritage, four (1.5%) were Asian, three (1.1%) were Black and one (0.4) was classified as ‘other’ (a category that includes any ethnicity other than white, mixed/multiple, Asian or Black). Twenty-three children (8.4%) spoke a language in addition to English at home. A range of European, Asian and African languages were reported. Two children could use sign language in addition to spoken English to communicate.

A total of 15 children (5.5%) were described by their parents as having a special educational need or disability (SEND) or as being referred for or undergoing investigations because such a need was suspected. A range of needs were reported including speech and language impairments, autism and physical disabilities. These 15 children were included in the sample as they were judged able to comprehend the tasks and respond appropriately during the practice items. Inclusion of children with SEND in the sample provides a more accurate reflection of the population of children attending mainstream preschools in the UK than would excluding them.

The total number of preschool sessions per week was obtained by adding the number of sessions the child attended at the participating setting and an additional setting (where applicable) per week. A session equates to a half-day attendance (either morning or afternoon). On average children attended approximately six sessions each week (*M* = 5.74, *SD* = 1.65).

Measures

The questionnaire.

The first section of the questionnaire asked about demographic details relating to the parent and family. The remaining sections included the home experiences, book exposure and parental mathematical attitudes items.

Home experiences. Parents were asked to report the frequency on a 6-point Likert scale ranging from *never* to *several times a day* that their child experienced 32 experiences at home. There were eight number experiences, eight meaning-focused literacy experiences and seven code-focused literacy experiences. In addition there were nine non-domain specific filler items that were not analysed in the current study (e.g. ‘Rides a scooter, balance bike or bike’). The different types of item were randomly ordered within the measure. The items utilised in the three core home learning experiences scales are shown in Tables 1 to 3.

Book exposure. This scale consisted of a list of 21 book titles. Six titles were made-up and 15 were real. Respondents were asked to indicate which book titles were real children’s books. They were given three choices; ‘real’, ‘made-up’ and ‘don’t know’. Five of the real titles were sourced from the 100 best-selling children’s books from a large online retailer (amazon.co.uk), five were sourced from the most borrowed children’s authors in UK libraries (https://www.bl.uk/plr/most-borrowed-authors) and five were sourced from the Booktrust 100 best books of the last 100 years (http://www.booktrust.org.uk/books/children/100-best-books/). The number of correctly identified real titles and falsely identified made-up titles was recorded. The items utilised in the book exposure scale are shown in Table 4. Responses to the book title checklist were then used to create a Book exposure variable using the same formula as Skwarchuk et al. (2014), which corrects for guessing [(Story books titles correctly identified - Foils identified as real books) / total number of actual books] x 100). This variable reflects parental familiarity with preschool book titles and is used as an index of shared reading. Six respondents did not complete this section. The mean score was 53.41% (*SD* = 21.63) reflecting that on average parents could correctly identify approximately half of the real book titles. Table 4 displays responses for each item. Real book titles were identified as such more frequently than fictional titles.

Mathematical attitudes. Parents indicated how much they agreed with 20 statements about their thoughts and feelings towards mathematics on a 5-point Likert scale ranging from *strongly agree* to *strongly disagree*. The items were selected from the Attitudes to Mathematics Inventory (Tapia, 1996), excluding those relating to ongoing mathematics education. A higher score indicated more positive attitudes towards mathematics. The descriptive statistics and factor loadings for the items utilised to measure parental attitudes towards mathematics and those included in the mathematical attitudes scales are shown in Table 5.

Data reduction: Home experiences and mathematical attitudes scales. Descriptive statistics for the individual items within the home experiences and mathematical attitudes scales were examined. Items were excluded from further analyses if they suffered from significant ceiling effects and a lack of variability in response (operationalised as a mean item score within one point of the maximum). Further items were removed if they had consistently low inter-item correlations with the remaining items in the scale (operationalised as a coefficients of <.3). The descriptive statistics for the individual items (including those subsequently removed) are shown in Tables 1 to 3 for the home learning experiences items and Table 5 for the parental mathematical attitudes items.

We conducted Exploratory Factor Analysis (EFA) using the Principal Axis Factoring (PAF) method with a Promax rotation and Kaiser normalisation with the remaining items in each of the home experiences scales and the parental mathematics attitudes scales to create the HLE factors. Missing items were replaced with the item mean. The number of missing items is noted in Tables 1 to 3 for the home experiences items and in Table 5 for the mathematical attitudes items.

Three factor analyses were conducted to assess whether the items relating to number, meaning-focused literacy and code-focused literacy experiences formed reliable and internally consistent scales.

Barlett's test of sphericity for the home number experiences was significant χ^2 (15) =405.76, p <.001. Only one factor emerged with an Eigenvalue > 1 (Eigenvalue = 2.91). This factor explained 38.54% of the variance. The Kaiser-Meyer-Olkin (KMO) measure was very good (KMO = .80) confirming the adequacy of the sample. The scale demonstrated acceptable reliability (α = .79). Individual item loadings are shown in Table 1. We refer to this scale as *Number experiences*.

Barlett's test of sphericity for the meaning-focused literacy experiences was significant χ^2 (15) = 347.36, p < .001. Only one factor emerged with an Eigenvalue > 1 (Eigenvalue = 2.77). This explained 35.73 % of the variance. KMO was very good (KMO = .80) confirming the adequacy of the sample. The scale demonstrated acceptable reliability (α = .76). Individual item loadings are shown in Table 2. We refer to this scale as *Meaning-focused literacy experiences*.

Barlett's test of sphericity for the code-focused literacy experiences was significant χ^2 (21) = 556.70, p < .001. KMO was very good (KMO = .82) confirming the adequacy of the sample. Two factors emerged with Eigenvalues > 1. Factor 1 (Eigenvalue = 3.30) explained 40.20% of the variance. Factor 2 (Eigenvalue = 1.07) explained an additional 8.78% of the variance. The reliabilities for factor 1 (α = .76) and factor 2 (α = .74) were acceptable. These two factors were correlated (r = .70). Examining the items that loaded onto factor 1 we noticed that all but one of the experiences explicitly or implicitly referred to the sounds letters make. Furthermore all but one item involved adult-child interaction. We therefore refer to this scale as *Letter-sound interactions.* Examining the items that loaded onto component 2 we noticed that no items explicitly mentioned adult-child interaction and that letter sounds were only mentioned in one item. We therefore refer to this scale as *Letter activities*. Individual item loadings are shown in Table 3.

Barlett's test of sphericity for the parental mathematical attitudes was significant χ^2 (120) = 4000.77, p < .001. KMO was excellent (KMO = .95) confirming the adequacy of the sample. Two factors emerged with Eigenvalues > 1. Factor 1 (Eigenvalue = 10.01) explained 60.66% of the variance. Factor 2 (Eigenvalue = 1.51) explained an additional 7.40% of the variance. The reliabilities for factor 1 (α = .96) and factor 2 (α = .89) were very good. These two factors were correlated (r = .74). The 11 items that loaded heavily onto factor 1 referred to feelings and competence in mathematics and therefore we refer to this scale as *Mathematics feelings and competence*. The five items which loaded heavily onto factor 2 referred to interest and satisfaction and therefore we refer to this scale as *Mathematics interest and satisfaction*. Individual item loadings are shown in Table 5.

Early number skills.

All number skills tasks began with one practice trial for which feedback was provided. Feedback was not provided following the experimental trials, although children's effort was praised and encouragement offered. One point was awarded for each correct response and children were stopped after three consecutive incorrect answers or after three or more incorrect answers within a block (except for the sequential counting where there was no stopping rule). Items for the different number skills tasks are shown in Appendix 1.

Sequential counting. Children were asked to count out loud to a cuddly toy starting from one to as high as they could. The highest number recited in the correct order was recorded.

Give me X. This task was based on classic 'Give me a number' tasks (Fluck & Henderson, 1996; Wynn, 1990). Our task maintained the core elements of the original task. The child was given a larger set of objects (e.g. 10 pigs) and asked to select a smaller set (e.g. 5 pigs). In each item, the child was asked to place the specific number of toy animals requested, on a drawing of a farm and a house (e.g. 'Can you put two ducks in the pond?'). Using the farm set and animals enabled us to maintain the child's interest. To complete the task successfully, the child needed to count the items and understand that the result of these procedures represented the number of items in the set. The task consisted of three blocks of five items. Items in the first block represented magnitudes below ten and children had to select from a box containing 10 items, items in the second block were numbers from 10 to 20 and items in the third block were numbers from 20 to 30. In these latter two blocks children had to select the items from a box containing 35 items. One point was awarded on each trial when the child placed the correct number of items requested.

Counting objects. Children were asked how many animal pictures were presented on a card (e.g. "How many birds are there?"). There were 20 cards with pseudo-randomly distributed pictures of the same animal on each card. The cards were grouped into four blocks each consisting of five items. The first block presented quantities below 10, the second presented quantities from 10 to 19, the third block presented quantities from 20 to 30 and the fourth block presented quantities ranging from 35 to 97. The last count-word spoken by the child was recorded and the item was scored as correct if it matched the number of animals presented on the card.

Numeral recognition. This task consisted of four blocks. In each block children were presented with a card displaying nine different numerals. The numerals were printed on the card in a pseudo-random arrangement rather than the count-word sequence. Each block consisted of five items. For each item, the researcher asked the child to point at a specific number (e.g. "Can you point to number five?"). The card presented in the first block displayed the nine single-digit numerals, the second presented the two-digit numerals from 11 to 19, the third presented nine two-digit numerals from the range 20 to 90, and the fourth block presented three-digit numerals selected from the range 100 and 200.

Numeral reading. Children were asked to name the printed numerals that the researcher pointed at on a sheet of card. Each card displayed five numerals. This task consisted of four blocks each containing five items. The first block presented single-digit numerals, the second presented two-digit numerals below 20, the third presented two-digit numerals above 20 and the fourth block presented three-digit numerals between 100 and 200.

Addition and subtraction. The experimenter presented each problem to the child in the form of a story (e.g. "If you put two horses on the path and you add one more, how many horses would there be?"). Animal toys and a drawing of a farm or a house were available to help the child complete the calculation. The child was asked to provide a verbal response. The last number-word spoken was scored as their response. Items were scored correct only if the child provided the correct number as a final verbal response regardless of their placement of objects.

Both, the addition and subtraction sections, consisted of three blocks each containing four items. In the first block children had to add or subtract one or two to an addend or minuend below five. In the second block, children had to add or subtract two or three to an addend or minuend of four, five or six. In the third block, for additions children had to add three or four to a single-digit addend with the answer always being above 10. For subtractions children had to subtract three or four from a minuend above 10.

Procedure

Ethical approval was granted by the university research ethics panel and written consent was gained from the settings' managers. Copies of the questionnaire, together with a parental information sheet and a consent form were distributed to the parents of pre-schoolers in the participating settings. Parents were given the option of returning the consent form and completed questionnaire in a sealed envelope to the preschool setting (where it was kept securely), or posting it directly to the university. Subsequently, children's early number skills were assessed in the spring term of their preschool year. Immediately prior to assessment, verbal assent was sought from each child. The children completed the early number skills tasks in two sessions, each lasting approximately 10 minutes. The tasks were administered in a quiet area of the preschool setting. The order of tasks in the sessions was fixed. The first session one consisted of numeral recognition, give me X and calculation (addition). The second session two consisted of numeral reading, counting objects, calculation (subtraction) and sequential counting.

The R program (R Core Team, 2014) with the "lavaan" library (Rosseel, 2012) was used to conduct the Confirmatory Factor Analysis (CFA) and Structural Equation Models (SEM). Model fit was assessed using various indexes according to the criteria suggested by Hu and Bentler (1999). We considered the chi-square (χ^2), the comparative fit index (*CFI*), the non-normed fit index (*NNFI*), the standardised root mean square residual (*SRMR*), and the root mean square error of approximation (*RMSEA*) to evaluate model fit.

Results

The Frequency of Home Literacy and Number Experiences

The means across items within each core home learning experiences scale is shown in Tables 1 to 3. We conducted a one-way repeated measures ANOVA to examine if the observed differences across scales were statistically significant. Mauchly's test indicated that the assumption of sphericity had not been met, χ^2 (5) =.78, $p < .001$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .89$). The results showed that there were significant differences in the reported frequency of the different types of home experiences, $F(2.68, 693.50) = 45.82$, $p < .001$. Post-hoc contrasts revealed that Meaning-focused literacy experiences ($M = 3.36$, $SD = .81$) and Letter-sound interactions ($M = 3.24$, $SD = 1.10$) were reported more frequently than Number experiences ($M = 2.85$, $SD = .89$) or Letter activities ($M = 2.48$, $SD = 1.12$). Number experiences were reported significantly more frequently than Letter activities.

Correlation Analyses

Bivariate Pearson product-moment correlations (above diagonal) and partial correlations controlling for age (below diagonal) between the SES indices (postcode deprivation decile and parental qualifications), the number of sessions of preschool attendance per week, the home learning experiences scales, Book exposure, the Mathematical attitudes scales and the early number skills are provided in Table 6. This table also displays key descriptive statistics for the variables. The Number experiences scale, the Letter-sound interactions scale and the Letter activities scale are positively related to all the early number skills (with the exception of sequential counting, addition and subtraction that just fail to reach the traditional level of significance with the letter activities scale). Book exposure is only positively related to sequential counting.

Early Number Skills Preliminary Analyses

We ran a series of CFAs to confirm the factorial structure of sequential counting, cardinal counting (counting objects and give me X), number transcoding (numeral recognition and numeral reading) and calculation (addition and subtraction). In the first CFA, four factors were tested, i.e., sequential counting (measured by sequential counting only), cardinal counting (counting objects and give me X), number transcoding (numeral recognition and numeral reading) and calculation (addition and subtraction). Unfortunately, the fit of this model was poor, $\chi^2(9) = 34.59$, $p < .001$, *RMSEA* = .11, *SRMR* = .03, *CFI* = .97, *NNFI* = .93, *AIC* = 8495, and thus we opted to test alternative models. In the second CFA, we included sequential counting together with the other two counting measures (i.e. counting objects and give me X). This three-factor structure also had a poor fit, $\chi^2(11) = 42.43$, $p < .001$, *RMSEA* = .11, *SRMR* = .04, *CFI* = .96, *NNFI* = .93, *AIC* = 8499. These results were probably influenced by sequential counting's high levels of skewness and kurtosis (see Table 6). We therefore decided to exclude sequential counting from the third CFA. The fit of this model was considerably better compared to previous models, $\chi^2(6) = 16.40$, $p = .012$, *RMSEA* = .09, *SRMR* = .03, *CFI* = .99, *NNFI* = .96, *AIC* = 6630 and was therefore retained for further scrutiny (see Figure 1 where the final CFA is illustrated as part of the SEM).

Structural Equation Models: The Relationships Between Home Learning Experiences and Early Number Skills

We used SEMs to examine the extent that the home learning experiences scales predicted variance in the three early number skills factors that emerged from our final CFA (i.e. counting, number transcoding and calculation). To reduce the number of variables we included as potential predictors only those variables that were statistically significant correlates of the number skills measures included in our final CFA. On this basis, five predictors were included in the first model (postcode deprivation decile, number experiences, letter-sound interactions, letter activities and mathematics interest and satisfaction). In this first model, the predictors were entered simultaneously and all paths were included. The fit of this model was good, $\chi^2(21) = 30.07$, $p = .091$, *RMSEA* = .04, *SRMR* = .03, *CFI* = .99, *NNFI* = .97, *AIC* = 6616, but only the paths between letter-sound interactions and the three early number skills were statistically significant. The path between home number experiences and number transcoding approached conventional levels of significance ($p = .053$). This model is illustrated in appendix 2. In our second model, postcode deprivation decile, letter activities and mathematics interest and satisfaction were excluded from the analysis (as they had no significant paths to the outcome variables in our first model) and the paths from number experiences to counting and calculation were also dropped (since they were not significant in the first model). We continued to include the path between home number experiences and number transcoding. The fit of this second model (illustrated in appendix 3) was good, $\chi^2(14) = 21.64$, $p = .09$, *RMSEA* = .05, *SRMR* = .03, *CFI* = .99, *NNFI* = .98, *AIC* = 6605. All paths were statistically significant, except for the path from number experiences to number transcoding, which no longer approached significance ($p = .20$). Finally, we created a third and final model dropping the non-significant path between number experiences and number transcoding. The overall fit was adequate ($\chi^2(9) = 20.07$, $p = .02$, *RMSEA* = .07, *SRMR* = .03, *CFI* = .98, *NNFI* = .96, *AIC* = 6604). All the paths between letter-sound interactions and the early number skills were statistically significant. In terms of the Effect Size, the variance in the early number skills explained by our predictors in the final model was modest (counting = 14%, number transcoding = 11% and calculation = 12%). This final model is illustrated in figure 1.

[Insert Figure 1 about here]

Discussion

The frequency of pre-schoolers' letter-sound interactions explained modest but nevertheless statistically significant variance in three key early number skills (counting, number transcoding and calculation). Consistent with previous findings (Anders et al., 2012; Skwarchuk et al., 2014; Huntsinger et al., 2016) home number experiences were correlated with our measures of these early number skills. However, within the SEM they could not explain a statistically significant unique portion of the variance. The findings were not consistent with meaning-focused home literacy experiences supporting pre-schoolers' counting, number transcoding or calculation. With the exception of a significant association between book exposure and sequential counting, the correlations between the early number skills measures and both the meaning-focused literacy experiences and book exposure measures were not statistically significant. Our findings therefore suggest that code-, but *not* meaning-focused home literacy experiences may support the development of early counting, number transcoding and calculation.

Describing Home Learning Experiences

Consistent with previous research (e.g. Blevins-Knabe et al., 2000; LeFevre et al., 2009; Missal et al., 2015; Skwarchuk et al., 2009), we found that parental reports of how often they engage in numeracy and literacy experiences with their 3-and-4-year-olds at home is very variable. Some parents reported never engaging in these experiences whilst others reported doing so several times a day. Also aligning with previous research (Anders et al., 2012; Blevins-Knabe et al., 2000; LeFevre et al., 2009; Skwarchuk et al., 2014), parents reported engaging more often in home literacy experiences (both meaning-focused and letter-sound interactions) than in number experiences. Letter activities was an exception to this pattern, being less frequently reported than home number experiences. The experiences within the Letter activities scale were reported the least frequently. Furthermore, our SEM analyses indicated that although letter-sound interactions had statistically significant independent relationships with the number skills, letter activities did not. This fractionation of the code-focused literacy experiences scale illustrates the importance of testing theoretical *a priori* assumptions about items cohering onto a single construct. The retention of significant paths between letter-sound interactions and number skills, but not between letter activities and number skills, also highlights how subtle differences in the nature of items within scales can alter their relationships with other variables and ultimately our conclusions about that construct's place in development.

Within- And Cross-domain Relationships Between Home Learning Experiences And Early Number Skills

The number experiences and letter-sound interactions scales that focused on the formal number system and the phonological and orthographic basis of language respectively, were consistently associated with all of the early number skills. In contrast, meaning-focused home literacy experiences were not related to any of the early number skills and book exposure was only related to sequential counting. Our results are consistent with code- rather than meaning-focused home experiences being related to the acquisition of formal early number skills. Interestingly, within our SEM, letter-sound interactions predicted significant variance in children's counting, number transcoding and calculation. In contrast, number experiences could not predict significant unique variance in the early number skills. Such a pattern of a stronger association between indices of the home literacy environment and early number skills than between indices of the home numeracy environment and early number skills has been reported previously in pre-schoolers (see Anders et al., 2012). The finding that letter-sound interactions are related to early number skills supports theoretical models of the home learning environment that encompass cross-domain influences (i.e. models that suggest literacy focused experiences can support numeracy, see Anders et al., 2012, and Napoli and

Purpura, 2018, for discussions) and furthermore suggest that such cross-domain may be underpinned by experiences that focus on phonology and its links with symbols.

There are at least three potential explanations for the relationship between letter-sound interactions and children's early number skills. The first is that these code-focused home literacy experiences support the development of early number skills by supporting children's phonological skills or their understanding of verbal-symbol linkage. Systematic phonics teaching has been established as supporting the development of children's early word decoding skills (see Castles, Rastle, & Nation, 2018 for a review) with more recent studies suggesting that formal or code-focussed home literacy experiences support early word decoding to a greater extent than shared reading (e. g. Puglisi et al., 2017; Sénéchal & LeFevre, 2002). A language-based interpretation of our findings would widen the impact of code-focused home literacy activities beyond early word decoding to also impact on early number skills. This explanation is substantiated by evidence that both phonological skills and letter knowledge have been associated with the development of number skills (De Smedt et al., 2010; Krajewski & Schneider, 2009b; Koponen et al., 2013; Purpura et al., 2011; Soto-Calvo et al., 2015), and also by reports indicating associations between code-focused home literacy experiences and alphabetic and phonological skills[3] (Foy & Mann, 2003; Sénéchal & LeFevre, 2002).

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[3] We note that many studies do not find that code-focused home literacy experiences are related to phonological skills i*ndependently* of alphabetic knowledge and emergent literacy. We view this as reflective of the bi-directional relationship between phonological skills and alphabetic knowledge (see Morais and Kolinsky, 2005, and Suortti and Lipponen, 2016) and would anticipate any influence on phonological awareness to occur in tandem with alphabetic knowledge.

Although a language-based explanation for the relationship between letter-sound interactions and early number skills is parsimonious, a second explanation is also viable. It could be that the level of difficulty of the items within the home experiences variables rather than the focus of activity (e.g. numbers, letter-sound links) underpins the relationship with early number skills. Such difficulty-focused account of the relationship between home learning experiences and attainment have been suggested by Thompson et al. (2016) and by Elliot and Bachman (2017). It may be that the items in our letter-sound interactions scale were more challenging than in our number experiences scale. In Skwarchuk et al. (2014), a Principal Component Analysis of the number experiences items resulted in the creation of two factors, basic and advanced home numeracy experiences. It was the advanced factor that was related to children’s formal number skills. If the level of difficulty underpins the relationships between home learning experiences and number skills, including more challenging items in our number experiences scale may have strengthened its relationships with counting, number transcoding and calculation. As our study is correlational, a third explanation is also plausible. Letter-sound interactions may be a correlate, but not a cause, of preschool number skill development. Whether letter-sound interactions have a causal influence on number skills development and whether such influence is underpinned by the development of phonological skills must await the availability of longitudinal data.

Parental Mathematical Attitudes

Our parental mathematics attitudes scales showed good levels of variability and internal consistency. Both scales were also positively related to parental qualifications levels. Similar findings relating SES indices with parental numeracy attitudes have been reported previously (Skwarchuk et al., 2014). However, in our study parental attitudes were not related to the frequency of preschool home number experiences and there was only a single significant correlation between the mathematics interest and satisfaction scale and children’s subtractions skills. This relationship did not remain significant within the SEM and there were no other significant bivariate correlations between the number skills and the mathematics attitudes scales. Previous studies that have identified significant associations between attitudes and home number experiences (e.g. del Rio et al., 2017; Skwarchuk et al., 2014) have utilised measures that index parents attitudes towards *children'*s mathematics learning rather than general attitudes towards mathematics such as the scale utilised in the current study. It may be that general mathematical attitudes are less influential in parents' engagement with home number experiences.

Limitations And Further Work

The current study provides a description of the frequency of home number and literacy experiences in a representative sample of English pre-schoolers and identifies the relationships between home number and home literacy experiences and children's early number skills. It succeeds in clarifying the extent that code- and meaning-focused home literacy experiences are associated with early number skills. Furthermore, the findings highlight the need to include home literacy measures that index the frequency of letter-sound interactions in future studies that examine the influence of the preschool home learning environment on children's mathematics development. It was these home literacy experiences, not shared reading or meaning-focused experiences, that were related to pre-schoolers' early number skills.

The findings of this study are valuable, but the limitations should be acknowledged. First, although statistically significant, the proportion of the variance in early number skills explained by letter-sound interactions was modest. The inclusion of a wider range of predictors may not only enable a greater proportion of the variance to be explained, but would also allow the potential role of unmeasured variables to be explored. Variables outside the measurement model could underpin the relationships described. For example, children with more advanced executive or language abilities may have better early number skills and may prime their parents to engage more frequently in code-focused home literacy experiences. To clarify the nature of the relationships observed, further studies, including data on the language and executive skills are required.

Second, in common with the vast majority of studies within the HLE field (e.g. Huntsinger et al., 2016; LeFevre et al., 2009; LeFevre et al., 2010; Napoli & Purpura, 2018; Skwarchuk et al., 2014; Sonnenschein et al., 2016) we used parental reports to index the HLE. Parental reports can be criticised in terms of the accuracy with which parents can retrospectively recall the experiences that they engage in with their children and also in terms of the possibility of a social desirability bias in reporting. Diary studies could be utilised to reduce the influence of recall accuracy, although the issue of social desirability remains. Diary studies also require very high levels of commitment from participants and in consequence may bias the samples obtained. Further observation studies, where parents are observed interacting with books, toys, numbers and print with their children would enrich our understanding of the nature of parent-child learning interactions, but this will not elucidate whether the *frequency* of such interactions influences child outcomes. It is only by triangulating the findings of studies using varying methodologies (questionnaire, diary and observation) that we can further our understanding of how the nature and frequency of specific home learning experiences influence pre-schoolers' numeracy development.

Third, although our sample is representative in terms of settings attended and home geographical area deprivation, the sample is not diverse in terms of ethnicity. Given previous indications that the link between the HLE and attainment varies across cultures (see Cankaya & LeFevre, 2016 for a review), further investigations need to examine the relationships within different ethnic groups within the UK.

Finally, we acknowledge that the range of attainment measures used could be widened. We focused on symbolic early number skills, which are key outcomes of the English Early Years curriculum (Department for Education, 2013; Testing and Standards Agency, 2017) as well as robust predictors of later mathematics (Jordan et al., 2007; Jordan et al., 2009; Krajewski & Schneider, 2009a,b; Martin et al., 2014; Moll et al., 2015; Nguyen et al., 2016; Passolunghi & Lanfranchi, 2012; Purpura et al., 2011; Soto-Calvo et al., 2015; Stock et al., 2009a,b; van Marle et al., 2014; Watts et al., 2014). The number skills assessed in the current study have a strong verbal component. Although these skills are crucial aspects of early number development, we acknowledge that nonverbal (e.g. ordering numerals, using number lines) and non-symbolic number skills (e.g. nonverbal calculation) are also important aspects of children's early mathematical development. Such nonverbal and non-symbolic skills may have weaker relationships with code-focused home literacy experiences. Further studies need to build on the work of Skwarchuk et al. (2014) to examine the extent the home learning experiences predict nonverbal early number skills. Furthermore, some recent findings suggest that the home numeracy experiences have positive effects on literacy outcomes (Huntsinger et al., 2016; Napoli & Purpura, 2018). We did not measure early literacy skills so were unable to examine these potential cross-domain relationships.

Conclusions

Revisiting our stated research questions, we can conclude that preschool home number experiences are related to preschool early number skills, however, these relationships are *not* independent of the relationships between early number skills and home letter and sound interactions. According to our findings, code-and meaning-focused literacy experiences are differently related to preschoolers early number skills; letter and sound interactions (an aspect of code-focused home literacy experiences) had consistent, independent relationships with all of the early number skills within the study. In contrast, meaning-focused home literacy experiences, including shared reading, were largely unrelated to early number skills (a relationship between sequential counting and shared reading being the only exception). Similarly, the relationships between parental mathematical attitudes and early number skills were largely insignificant. Together these findings suggest that of the aspects of the preschool home learning environment studied, letter-sound interactions have the most robust, independent relationships with counting, number transcoding and calculation.

The present work highlights that not all home literacy experiences are comparable in their relationships with children's early number skills. Although the correlational nature of the present study necessitates a cautious interpretation, our findings are more consistent with letter-sound interactions in the preschool period supporting early number skills rather than shared reading or meaning-focused literacy interactions.

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Appendix 1: Number Skills Items

Number reading

Block 1: 2, 4, 7, 5, 9

Block 2: 11, 14, 19, 12, 13

Block 3: 22, 57, 41, 36, 65

Block 4: 103, 159, 178, 126, 191

Number Recognition

Block 1: Numbers on the card [1-9] Target numbers the child is asked to identify - 2, 4, 7, 5, 9

Block 2: Numbers on the card [11-19] Target numbers the child is asked to identify - 11, 14, 19, 12, 13

Block 3: Numbers on the card [22, 36, 41, 57, 65, 73, 84, 99] Target numbers the child is asked to identify - 22, 57, 41, 36, 65

Block 4: Numbers on the card [103, 117, 126, 134, 145, 159, 162, 178, 191] Target numbers the child is asked to identify - 103, 159, 178, 126, 191

Counting objects

Block 1: 2, 3, 5, 6, 8

Block 2: 10, 11, 14, 16, 18

Block 3: 20, 23, 24, 26, 30

Block 4: 35, 42, 51, 66, 97

Give me x

Block 1: 2, 3, 5, 6, 8 [Presented with 10 objects to select the correct number from]

Block 2: 10, 11, 14, 16, 18 [Presented with 35 objects to select the correct number from]

Block 3: 20, 23, 24, 26, 30 [Presented with 35 objects to select the correct number from]

Addition

Block 1: 2+1, 3+1, 4+1, 4+2

Block 2: 5+2, 4+3, 6+2, 6+3

Block 3: 8+3, 9+3, 8+4, 9+4

Subtraction

Block 1: 2-1, 3-1, 4-1, 4-2

Block 2: 5-2, 4-3, 6-2, 6-3

Block 3: 11-3, 12-3, 12-4, 13-4

Table 1

Descriptive Statistics and Factor Loadings for Exploratory Factor Analysis, using the principal axis factoring method, of the Home Number Experiences Items

Item	Mean	SD	Missing Responses	Factor loading
Is encouraged to point out or identify numbers in books or the environment (e.g. "What number is on the bus? Can you see a number 8?")	3.72	1.32	2	.74
Is taught the names of numbers (e.g. "This is number 8")	3.43	1.21	2	.67
Writes or traces numbers	2.32	1.46	2	.64
Completes number activities in magazines or workbooks	1.73	1.33	3	.59
Plays games that involve number cards, dice or a number spinner	2.07	1.25	1	.54
Discusses numbers or quantity with an adult (e.g. "How many blocks are there?", "Who has more sandwiches?")	3.81	1.18	4	.51
Recites numbers in order [a]	4.17	1.01	1	
Sings number songs (e.g. *Ten Little Monkeys*, *This Old Man*) [b]	3.47	1.26	2	
Number experiences [c]	3.08	0.83		

Notes. N = 274 [a] Item excluded from the analyses due to lack of variability in response. [b] Item excluded from EFA due to low inter-item correlations within the scale. [c] The mean response to the items contained in the number scale.

Table 2

Descriptive Statistics and Factor Loadings for Exploratory Factor Analysis, using the principal axis factoring method, of the Home Meaning-focused Literacy Experiences Items

Item	Mean	SD	Missing Responses	Factor loading
Discusses stories with an adult (e.g. “What do you think happens next? Do you think the bunny is frightened?”)	3.70	1.08	3	.70
Is encouraged to point out or identify pictures in books (e.g. “Can you point to the elephant?”)	3.88	1.07	2	.65
Is encouraged to choose books that interest them to look at with an adult	3.78	1.03	1	.63
Is encouraged to use books to follow-up interests or experiences they have (e.g. looking at a space book because that had talked about space at preschool)	2.24	1.35	3	.58
Discusses with an adult how things work or what they mean (e.g. “Why do you think the ice lolly is melting?”, “Nocturnal animals sleep in the day”)	3.62	1.42	4	.51
Looks at factual books (e.g. books about animals, space or transport)	2.90	1.27	1	.49
Has stories read to them [a]	4.14	0.78	0	
Makes up songs, stories or rhymes [b]	3.72	1.41	3	
Meaning-focused literacy experiences[c]	3.50	0.74		

Notes. N = 274. [a] Item excluded from the analyses due to lack of variability in scores. [b] Item excluded from EFA due to low inter-item correlations within the scale. [c] The mean response to the items contained in the meaning-focused literacy scale.

Table 3

Descriptive Statistics and Factor Loadings for Exploratory Factor Analysis, using the principal axis factoring method, of the Home Code-focused Literacy Experiences Items

Item	Mean	SD	Missing Responses	Factor 1 loading	Factor 2 loading
Is prompted to identify letters in books or the environment (e.g. "Can you see a's' on the sign?", "What letter does the word cat begin with?")	3.21	1.50	1	.82	
Talks about letter sounds with an adult (e.g. "What sound does snake start with?", "Can you think of any other words starting with 's'"?	3.28	1.40	2	.82	
Is taught the names or sounds of letters or how to 'sound out' words	3.64	1.32	0	.52	.17
Forms or traces letters or writes their name	2.78	1.53	3	.40	.16
Plays with puzzles or games involving letters	2.68	1.30	1		.79
Sings or recites the alphabet	2.93	1.51	4		.67
Completes activities involving letters or sounds in magazines or workbooks	1.89	1.33	4		.62
Letter-sound interactions [a]	3.24	1.10			
Letter activities [b]	2.50	1.14			

Notes. N= 274 [a] The mean response to the items contained in the letter-sound interactions scale (factor 1). [b] The mean response to the items contained in the letter activities scale (factor 2).

Table 4

Parents' Responses to the Items in the Book Exposure Measure

Item	Identified as Real (%)
Real titles	
The very hungry caterpillar [a]	251 (91.6)
Kipper [b]	227 (82.8)
Dear zoo [a]	211 (77.0)
That's not my monkey [b]	202 (73.7)
Aliens love underpants [b]	195 (71.2)
The snail and the whale [a]	193 (70.4)
Giraffes can't dance [a]	172 (62.8)
Maisy's bedtime [b]	161 (58.8)
Not now, Bernard [c]	149 (54.4)
Each peach, pear, plum [a]	129 (47.1)
Princess Smartypants [c]	105 (38.3)
Dogger [c]	89 (32.5)
Gorilla [c]	68 (24.8)
Would you rather... [c]	66 (24.1)
Oscar got the blame [b]	57 (20.8)
Made-up titles	
Grandmother Windmill	7 (2.6)
Belinda Brown takes charge	15 (5.5)
The peg dolly	19 (6.9)
Sally-Anne drives the van	19 (6.9)
What's after bedtime?	25 (9.1)
The wand that wouldn't work	43 (15.7)

Notes. n = 268, six parents did not complete this section of the questionnaire. Percentages are provided in brackets. Sources: [a] Amazon best-selling book titles; [b] Most borrowed authors; [c] Booktrust 100 best books.

Table 5

Descriptive Statistics and Factor Loadings for Exploratory Factor Analysis, using the principal axis factoring method, of the Parental Mathematical Attitudes Items

Item	Mean	SD	Missing Responses	Factor 1 loading	Factor 2 loading
It makes me nervous to even think about having to do a mathematics problem [a]	3.75	1.13	3	.98	-.15
Mathematics makes me feel uncomfortable [a]	3.63	1.14	3	.93	
I feel a sense of insecurity when attempting mathematics	3.59	1.07	5	.85	-.15
Mathematics does not scare me at all	3.39	1.14	3	.84	
My mind goes blank and I am unable to think clearly when working with mathematics [a]	3.46	1.15	4	.81	
When I hear the word mathematics, I have a feeling of dislike [a]	3.64	1.21	3	.81	
I have a lot of self-confidence when it comes to mathematics	3.10	1.14	3	.77	.13
I am able to solve mathematics problems without too much difficulty	3.47	1.00	3	.76	
I believe I am good at solving math problems	3.31	1.07	3	.69	.22
I learn mathematics easily	3.15	1.10	5	.63	.25
I am confident that I could learn advanced mathematics	3.04	1.23	3	.62	.23
Mathematics is a very interesting subject	3.55	0.89	3	-.24	1.04
I really like mathematics	3.26	1.01	4	.19	.73
Mathematics is dull and boring [a]	3.74	0.87	5		.70
The challenge of mathematics appeals to me	3.39	1.02	3	.24	.68
I get a great deal of satisfaction out of solving a mathematics problem	3.78	1.01	5		.61
Mathematics is a very worthwhile and necessary subject [b]	4.76	0.50	2		
Mathematics helps develop the mind and teaches a person to think [b]	4.41	0.66	4		
Mathematics is important in everyday life [b]	4.56	0.57	3		
Mathematics is one of the most important subjects for people to study [b]	4.16	0.80	3		
Mathematics feelings and competence	3.42	0.96			
Mathematics interest and satisfaction	3.55	0.80			

Notes. *N* = 274. Items adapted from Attitudes towards mathematics inventory, by M. Tapia, 1996, Paper presented at the Annual Meeting of the Mid-South Educational Research Foundation. Tucaloosa, AL, November 6-8. Reprinted with author's permission. [a] Reversed scored items. [b] Item excluded from PCA due to lack of variability in response.

Table 6

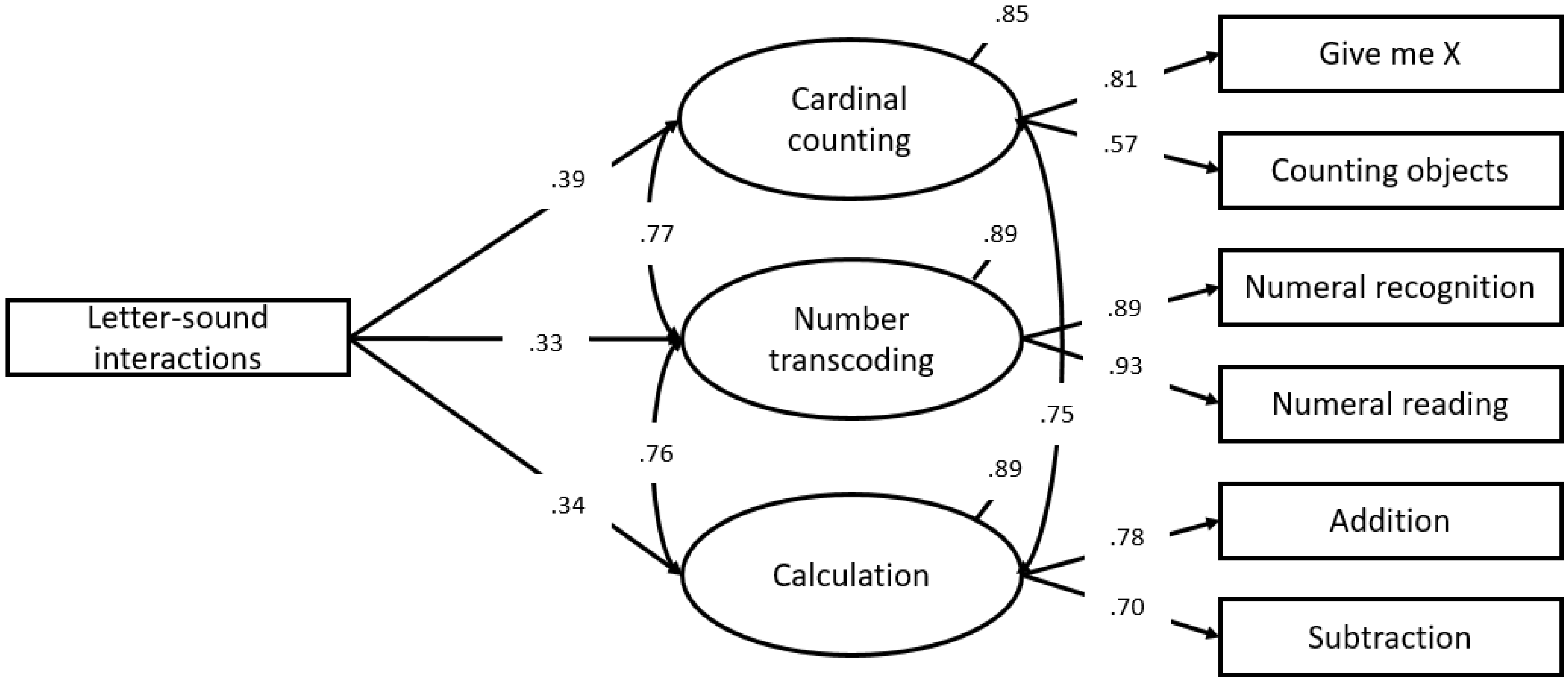
Descriptive Statistics and Correlations. Bivariate Correlations Shown Above the Diagonal, Partial Correlations Controlling for Age Shown Below Diagonal

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1. Age (months)	-	**-.12**	-.12	-.02	.06	-.09	.11	.06	-.07	.03	.04	**.19**	**.24**	**.22**	**.23**	**.26**	**.29**	**.17**
2. Postcode deprivation decile		-	**.42**	.04	-.03	.01	.02	-.11	**.19**	.09	.06	.09	**.13**	.02	.10	**.14**	.07	.05
3. Parental qualifications		**.41**	-	**.19**	-.01	.08	.01	**-.16**	**.21**	**.18**	**.18**	.01	.08	.04	.10	.09	.06	.08
4. No. Sessions		.04	**.19**	-	-.05	.05	.05	.02	-.02	.07	.01	.06	.10	.03	.08	.07	.08	.00
5. Number exp.		-.02	-.01	-.05	-	**.51**	**.73**	**.72**	**.17**	.00	.06	**.18**	**.25**	**.24**	**.29**	**.27**	**.18**	**.18**
6. Meaning-focus		.00	.07	.05	**.52**	-	**.50**	**.42**	**.14**	-.07	-.02	-.01	.06	.06	-.01	-.06	-.02	.06
7. Letter sound int.		.03	.02	.05	**.73**	**.52**	-	**.70**	**.18**	-.04	.00	**.22**	**.31**	**.25**	**.32**	**.29**	**.25**	**.25**
8. Letter activities		-.10	**-.15**	.02	**.72**	**.43**	**.70**	-	.03	-.02	-.03	.11	**.22**	**.19**	**.19**	**.13**	.12	.12
9. Book exposure		**.19**	**.20**	-.02	**.17**	**.14**	**.19**	.03	-	.02	.07	**.13**	.07	.11	.07	.08	.01	.06
10. Maths F&C		.10	**.19**	.07	-.01	-.08	-.07	-.03	.03	-	**.74**	.08	.09	.08	.06	.11	.06	.08
11. Maths I&S		.07	**.18**	.00	.07	-.02	-.02	-.03	.07	**.74**	-	.04	.11	.03	.09	.08	.02	**.12**
12. Seq. counting		.12	.03	.07	**.17**	.01	**.21**	.10	**.14**	.07	.02	-	**.45**	**.37**	**.42**	**.59**	**.45**	**.37**
13. Give me X		**.17**	.11	.11	**.24**	.09	**.29**	**.21**	.09	.08	.11	**.43**	-	**.45**	**.58**	**.58**	**.46**	**.51**
14. Count objects		.05	.07	.03	**.23**	.08	**.24**	**.18**	**.13**	.08	.03	**.35**	**.42**	-	**.41**	**.44**	**.28**	**.32**
15. Numeral rec.		**.14**	**.13**	.08	**.29**	.01	**.30**	**.18**	.09	.05	.10	**.39**	**.55**	**.37**	-	**.82**	**.55**	**.46**
16. Numeral read.		**.18**	**.13**	.08	**.26**	-.04	**.28**	**.12**	.10	.11	.08	**.57**	**.56**	**.40**	**.81**	-	**.60**	**.47**
17. Addition		.12	.10	.09	**.17**	.00	**.23**	.10	.03	.05	.00	**.42**	**.42**	**.23**	**.52**	**.57**	-	**.54**
18. Subtraction		.08	.10	.01	**.17**	.08	**.24**	.11	.07	.07	**.12**	**.35**	**.49**	**.29**	**.43**	**.45**	**.52**	-
M	48.31	5.42	4.75	5.74	0.00	0.00	0.00	0.00	53.41	0.00	0.00	16.57	3.17	5.14	6.41	5.07	1.69	2.23
SD	3.63	3.32	2.00	1.65	0.89	0.88	0.91	0.89	21.63	0.98	0.96	14.23	2.47	2.72	5.32	3.99	2.25	2.23
ZSkewness	-0.74	-0.63	-2.68	7.28	-1.76	-3.70	-4.09	-1.41	-2.80	-2.13	0.17	27.09	6.67	4.60	5.71	7.28	12.47	9.61
ZKurtosis	-3.91	-5.04	-4.25	3.61	-0.50	0.66	0.07	-0.01	-0.31	-1.91	-1.16	76.64	1.92	1.92	-1.22	4.96	13.04	6.59
Minimum	41	1	0	2	-2.55	-2.67	-2.62	-2.30	0	-2.55	-2.64	0	0	0	0	0	0	0
Maximum	55	10	8	10	1.99	1.70	1.54	1.99	100	1.62	1.85	110	11	14	20	20	12	10
Maximum Possible	-	10	8	10	-	-	-	-	100	-	-	-	15	20	20	20	12	12

Notes. N = 274, except for correlations with Postcode deprivation (n =271), Parental qualification (n =270), Number of sessions (n =273) and Book exposure (n =268). Cases excluded pairwise. No. Sessions = Number of pre-school sessions; Number exp.= Number experiences, Meaning-focus= Meaning-focused literacy experiences, Letter sound int. = Letter-sound interactions, Maths F&C = Mathematics feelings and competence, Maths I&S = Mathematics interest and satisfaction, Seq. counting = Sequential counting, Count objects = Counting objects, Numeral recog. = Numeral recognition, Numeral read. = Numeral reading.
Significant correlations in bold. Values above .123 $p < .05$, values above .150 $p < .01$, values above .195 $p < .001$.

Figure 1.

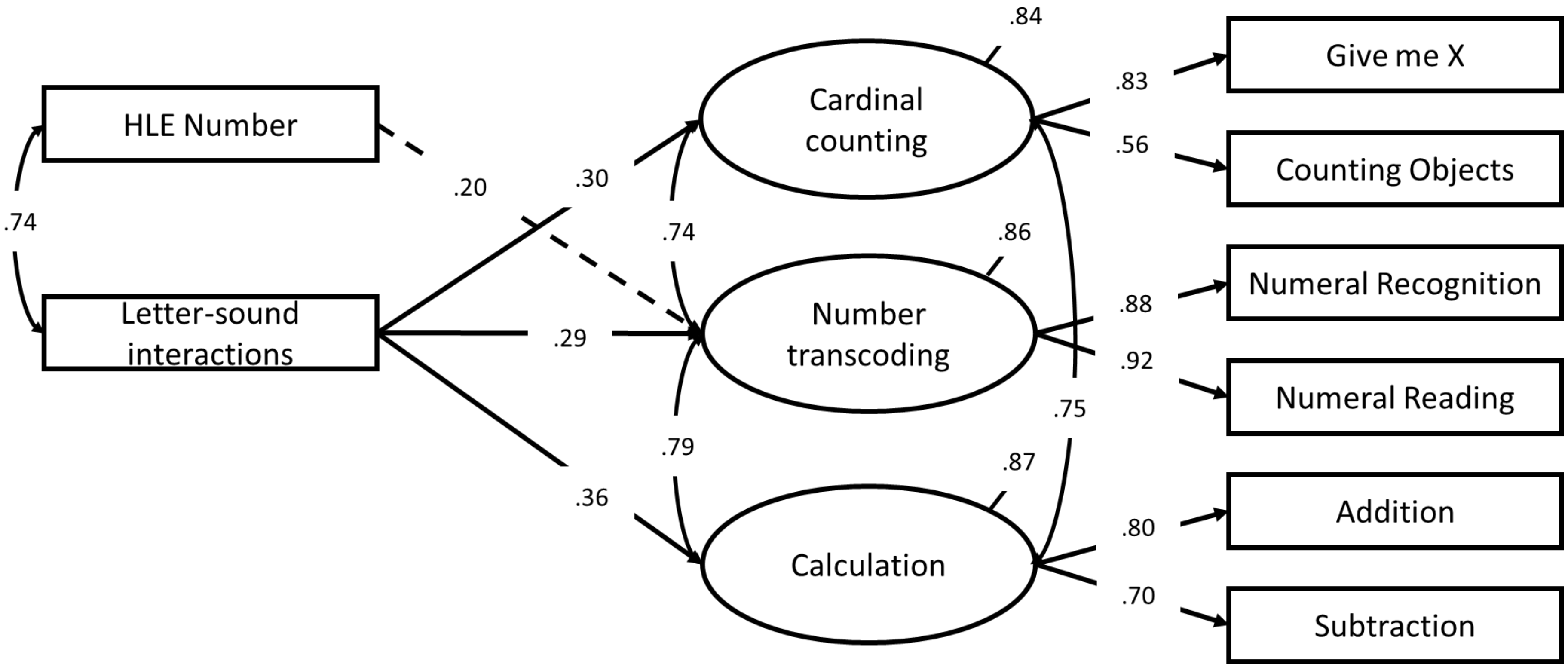
Final model: The Relationships between Home Letter-sound Interactions and the Early Number Skills



Notes. $n = 271$, three participants were excluded as they did not report their postcode and postcode deprivation which was included in the first full model. All paths are statistically significant, ($p < .001$). The fit of this model is adequate.

Appendix 2.

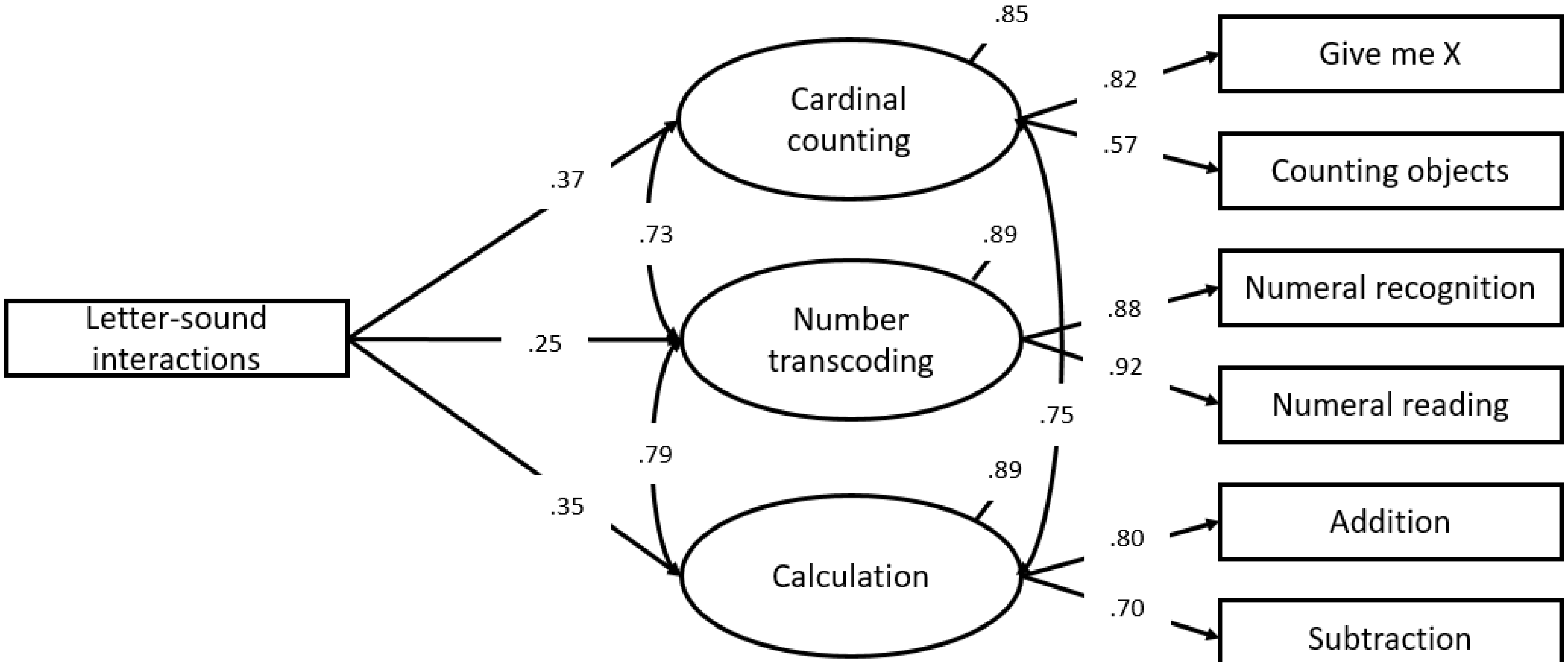
Model 1: The Relationships between the Home Learning Environment and the Early Number Skills



Notes. Postcode deprivation decile, letter activities and mathematics interest and satisfaction were also entered as predictors, but are not illustrated as they did not predict any of the number skills at a statistically significant level. All illustrated paths from letter-sound interactions are statistically significant ($p < .01$). The path between home number experiences and number transcoding (dashed line), approached conventional levels of significance ($p = .053$). $n = 271$, three participants were excluded as they did not report their postcode.

Appendix 3.

Model 2: The Relationships between the Home Learning Experiences and the Early Number Skills



Notes. A path between home number experiences and number transcoding was also tested. However, it did not reach statistical significance so is not illustrated. All illustrated paths from letter-sound interactions are statistically significant (path to number transcoding $p < .01$, all others $p < .001$). $n = 271$, three participants were excluded as they did not report their postcode and postcode deprivation was included in the first full model.