Responsive Home Numeracy as Children Progress from Kindergarten through Grade 1

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This study has been financed by the Academy of Finland (#296082 to Gintautas Silinskas).

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Abstract

The aim of the present study was to investigate longitudinal associations between formal home numeracy activities and children's arithmetic fluency skills. Children were followed during the transition from the end of kindergarten (T1; M_{age} = 6.87 years) to the beginning of Grade 1 (T2), and again at the end of the Grade 1 (T3). Participants were Lithuanian children (n = 341) and their parents. At each time point, parents reported the frequency of the formal home numeracy activities they engaged in with their children; the children completed addition and subtraction tasks at the same three time points. Using a cross-lagged analysis, we found that parents adjusted the frequency of their home numeracy activities in response to children's arithmetic performance. The frequency of home numeracy activities, however, did not predict changes in arithmetic skills. Finally, maternal education was found to be related to children's arithmetic skills rather than to home numeracy activities.

Keywords: *home numeracy, numeracy activities, math skills, numeracy, arithmetic fluency*

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When most children enter formal schooling in Grade 1, they are able to recognize and write some numbers and make simple calculations (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Duncan et al., 2007; Silinskas, Leppänen, Aunola, Parrila, & Nurmi, 2010). These early numeracy skills are predictive of later mathematical skills and become quite stable across school years (Aunola et al., 2004; Duncan et al., 2007; Geary, 2011; Lyons, Price, Vaessen, Blomert, & Ansari, 2014; Watts, Duncan, Siegler, & Davis-Kean, 2014). Although the development of math skills can be attributed, in part, to the children's math learning environment in kindergarten and primary school, children's home numeracy environment (HNE) is also related to the growth in math-related skills (Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2009; Manolitsis, Georgiou, & Tziraki, 2013; Niklas & Schneider, 2014; Skwarchuk, Sowinski, & LeFevre, 2014; Susperreguy, Douglas, Xu, Molina-Rojas, & LeFevre, 2018). However, the link between the home numeracy environment and children's mathematical skills has primarily been tested concurrently or retrospectively. That is, parental reports on home numeracy practices are typically assessed once (usually before or during kindergarten; Anders et al., 2012; Manolitsis et al., 2013; Melhuish et al., 2008) and the children's math skills are then assessed at the same time and/or a later time point. Conclusions are limited to describing a snapshot of the relations or inferring that the home numeracy practices at Time 1 have an ongoing influence on mathematical skills later on. We address this fundamental limitation. Further, researchers have mainly focused on young children and have not investigated these associations as children move from kindergarten to primary school. Finally, the home numeracy literature is predominantly centered on children in North America or Western Europe. There is a clear need to extend the home numeracy literature to different cultural environments and educational settings before broader generalizations across countries can be made. Therefore, the goal of this study was to investigate the longitudinal associations between home numeracy activities and children's arithmetic skills in the Lithuanian cultural

environment. We examined the reciprocal associations between parental formal home numeracy practices and children's arithmetic skills across the transition from the end of kindergarten to beginning of Grade 1 and then at the end of Grade 1.

Home Numeracy Activities and Math Acquisition in Kindergarten and Grade 1

Children are exposed to a variety of home activities that promote their early academic skills. The influence of home literacy activities on children's literacy skills has been well established; in contrast, home numeracy research is still in its infancy (Elliott & Bachman, 2018). Based on the previous research, Skwarchuk et al. (2014) developed the Home Numeracy Model. In this model, formal home numeracy activities (e.g., teaching children simple sums, printing numbers, weighing and measuring, or doing mental math) were related to children's early symbol knowledge (e.g., counting, ordinal knowledge, digit naming), whereas informal home numeracy activities (e.g., exposure to number games) were related to children's non-symbolic math skills (e.g., object addition).

The distinction between informal and formal categories of home numeracy activities however has not always been supported due to challenges in obtaining convincing construct validity (see Elliott & Bachman, 2018, for a review). Moreover, both informal and formal home numeracy activities have predicted the same math skills, raising a question of predictive validity with later math performance (Elliott & Bachman, 2018; Huntsinger, Jose, & Luo, 2016; LeFevre at al., 2009; Susperreguy et al., 2018). Consequently, some researchers have used an overall score of the home numeracy activities, mixing the formal and informal, or they chose to investigate one category of home numeracy activities (Elliott & Backman, 2018a). However, Susperreguy et al. (2018) found that both types of home activities uniquely predicted children's performance, suggesting that home activities should not be averaged. In the present study we focused on one type of parental home numeracy activity—formal home numeracy activities—because these consistently show relations with children's symbolic number knowledge.

The present study was focused on children's formal math skills during the transition from kindergarten to Grade 1. Materials were designed based on the guidelines of the Lithuanian kindergarten curriculum (LR Ministry of Education, Science and Sports, 2014, 2019) and results of previous studies in other countries (LeFevre et al., 2009; Lerkkanen et al., 2006–2019; Skwarchuk et al., 2014). Consequently, symbolic number knowledge and formal aspects of the home numeracy environment were the focus of the current longitudinal investigation.

The strength of the links between home numeracy activities and children's math outcomes varies as a function of child age and developmental stage. For example, in a review by Dunst et al. (2017), these links were stronger among preschoolers (i.e., aged 3 to 4 years) than among kindergarteners or grade school students (i.e., 5 years and older). Nevertheless, positive links are often found between home numeracy activities and the early math skills of kindergarten-aged children (Blevins-Knabe & Musun-Miller, 1996; LeFevre et al., 2009; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; Niklas & Schneider, 2014). For instance, parental reports on their formal numeracy activities related to kindergarten children's applied problem-solving skills (Del Rio, Susperreguy, Strasser, & Salinas, 2017), verbal counting (Manolitsis et al., 2013), symbolic number knowledge (Skwarchuk et al., 2014), and arithmetic skills (LeFevre et al., 2009). For children in Grades 1 and 2 (i.e., ages 6 and 7 years), formal numeracy activities were positively related to arithmetic fluency (LeFevre et al., 2009) whereas in other studies with primary school students, the home numeracy environment was not related to children's math skills (DeFlorio & Beliakoff, 2015; Missall, Hojnoski, Caskie, & Repasky, 2015). In a few other studies among primary school children, researchers reported negative associations (Ciping, Silinskas, Wei, & Georgiou, 2015; Silinskas et al., 2010). In summary, the relations between home numeracy activities and math-related skills depend on children's age and the type of skills being assessed (Dunst et al., 2017).

In the current longitudinal investigation, we first tested children at the end of kindergarten (aged 6–7), before the transition from kindergarten to Grade 1 (Time 1). They were subsequently tested during the transition (i.e., early in Grade 1; Time 2), and at the end of Grade 1 (Time 3). Children start to learn formal math operations during this time. Further, because parental involvement in formal home numeracy activities before primary school may enhance children's symbolic math skills, such as arithmetic fluency, we focused on assessing formal home numeracy activities. Multiple studies have shown that formal home numeracy activities are related to children's numerical development in this stage of education (LeFevre et al., 2009; Lerkkanen et al., 2006–2019; Skwarchuk et al., 2014).

The Role of Children's Skills in Parental Home Numeracy Activities

Although researchers have often assumed that parental activities promote children's academic skills, children's characteristics (e.g., skills and interests) can also evoke parental responses (Scarr & McCartney, 1983; Silinskas et al., 2015). For example, among school-aged children, a child's academic skills and achievement can influence their parents' academic involvement (Ciping et al., 2015; Levin et al., 1997; Pomerantz & Eaton, 2001; Silinskas et al., 2012). Most research on the direction of influence, however, has been conducted in the domain of reading/literacy. For example, exploring the influence of children's reading skills on parental activities, Sénéchal and LeFevre (2014) found that parents whose children had poor reading skills in Grade 1 reported more teaching activities in Grade 2. In contrast, parents whose children had stronger reading skills in Grade 1 reported fewer teaching activities in Grade 2. Thus, parent's home literacy practices were influenced by the child's previous literacy skills. The effect of children's emergent numeracy skills on parental home numeracy practices, however, has rarely been examined, especially among students transitioning from kindergarten to Grade 1 (see for exceptions, Ciping et al., 2015; Silinskas et al., 2010). Consequently, exploring the direction of these influences was among the main aims of the present study.

To investigate the reciprocal associations between parent-initiated home numeracy activities and children's arithmetic skills, longitudinal analyses need to be performed where both parental activities and math skills are followed across time. To our knowledge, only two studies have investigated the cross-lagged associations between the home numeracy environment and children's math skills among kindergarten and Grade 1 children (Ciping et al., 2015; Silinskas et al., 2010). Silinskas et al. (2010) assessed how often Finnish parents taught their children to recognize numbers and to make simple calculations. Children were tested at the end of kindergarten and at the end of Grade 1. The authors found that, for kindergarten students, the association between mothers' reports of formal home numeracy activities and children's math performance were positive even after controlling for mothers' SES and maternal reports of their own learning difficulties in math. However, in Grade 1 students, the association became negative. Parents did fewer home numeracy activities with more-skilled children than with less-skilled children. Similarly, for Chinese children, Ciping et al., (2015) found that children's math skills in Grade 1 were negatively related to parents' reports of formal numeracy activities in Grade 2 (i.e., teaching simple calculations and solving math problems).

One explanation for the differences in reported home numeracy activities before and after Grade 1 could be that children are not exposed to systematic math instruction in kindergarten, and, thus, parental teaching could play a significant role in promoting math skills. However, children in Grade 1 are exposed to systematic math instruction, and therefore parental teaching may be less important. An alternative explanation for grade-related differences is that parents in Grade 1 may become more sensitive to their children's needs and adapt the frequency of their home numeracy activities in response to their children's math skills. In the two previously mentioned studies, Silinskas et al. (2010) measured associations between home numeracy activities and math performance during kindergarten and contrasted those to the associations across Grade 1, whereas Ciping et al. (2015) assessed associations

across Grade 1 and Grade 2. Further, these studies also occurred in different countries and so the different relational patterns may reflect educational differences.

Consequently, in the present longitudinal investigation, we assessed children's arithmetic fluency skills and maternal home numeracy activities on three occasions and applied statistical methods that allowed testing the reciprocity of the longitudinal associations controlling for the previous levels of the same constructs across all three measurement points (i.e., end of kindergarten and the beginning and the end of Grade 1). This approach provides information about the reciprocal relations between home numeracy activities and children's arithmetic skills across the transition from kindergarten to formal learning in Grade 1.

Learning Math in the Lithuanian Educational System

In Lithuania, children start kindergarten at the age of six (i.e., on the first of September of the calendar year when children turn six), and thus they are somewhat older than kindergarten children in many other countries. One year of kindergarten education became compulsory in 2016 (LR Ministry of Education, Science and Sports, 2019). The aim of kindergarten education in Lithuania is to ensure the optimal development of children and to prepare them to learn in primary school. Kindergarten education strategies in Lithuania are child-oriented and seek to develop children's personal and social development rather than formally teaching academic skills. According to the guidelines for kindergarten education, children should become familiar with measuring, comparing and grouping objects, counting forwards to 20 and backwards from 10, adding and subtracting objects, and recognizing some numbers and mathematical signs (LR Ministry of Education, Science and Sports, 2014). Although the guidelines provide examples of what children can be exposed to, there are no formal academic expectations. After kindergarten, children enter Grade 1. The curriculum for Grade 1 focuses on recognizing and writing numbers and making simple calculations (adding and subtracting quantities up to 10). Student gains in mathematics are encouraged by the availability of tasks at multiple levels of difficulty and by encouraging their motivation to

learn math. The measured math-related skills and parental home numeracy activities in the present study were chosen to reflect the kindergarten and Grade 1 curricular expectations in Lithuania.

The Present Study

The aim of the present study was to investigate cross-lagged longitudinal associations between home numeracy activities and children's arithmetic skills across the transition from kindergarten to Grade 1 and later in Grade 1. At each time point, we asked parents to report how frequently they engaged in formal home numeracy activities with their children and we tested children on their arithmetic skills. By investigating these longitudinal associations in a sample of Lithuanian children and their parents, this study adds to the body of literature cross-culturally. This information will be helpful for parents and professionals that are interested in facilitating children's arithmetic skill development from kindergarten through Grade 1.

We examined the following research questions:

1. To what extent does the frequency of home numeracy activities longitudinally relate to the development of children's arithmetic skills? Based on previous literature (LeFevre et al., 2010; Skwarchuk et al., 2014; Susperreguy et al., 2018), we expected that home numeracy activities in kindergarten would positively relate to the children's arithmetic skills across time. As previous literature provided mixed results concerning this association in Grade 1, we did not set specific hypotheses for the relation from home numeracy activities to arithmetic skills after entering Grade 1.
2. To what extent do children's arithmetic skills predict the frequency with which parents engage in home numeracy activities? Based on the previous literature (Ciping et al., 2015; Levin et al., 1997; Pomerantz & Eaton, 2001; Silinskas et al., 2012), we expected negative paths between children's arithmetic skill and home numeracy activities.

In previous research, maternal education was often related to children's arithmetic skills (Anders et al., 2012; LeFevre et al., 2009; Melhuish et al., 2008) and to the frequency

with which parents engage in home numeracy activities (Aunio & Niemivirta, 2010; DeFlorio & Beliakoff, 2014; Saxe et al., 1987; Tutge & Doucet, 2004; Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). Consequently, the models of the present study controlled for the influence of maternal education.

Method

Participants and Procedure

The participants came from a longitudinal study *"Blinded"* (*Authors*, 2017–2018), which followed approximately 300 Lithuanian children during their transition from kindergarten to Grade 1. This longitudinal study was approved by the *[blinded]* Institutional Ethics Committee, as project # *[blinded]*. Children and their parents were recruited from six schools: three smaller schools in the rural/province parts of the country (around 33.5% of our study participants) and three schools in the capital and the largest city—Vilnius (around 66.5% of study participants). All six principals that we approached gave us permission to conduct the study at their schools. In all participating schools, the kindergarten classes—compulsory one-year preparation for Grade 1—were in the same building as the future primary school. Parents gave written consent for their own participation and for their children's participation in the study across all three time points. The consent form indicated that parents could request information on their child's math skills. Eleven parents requested this information. However, information was not provided until all data collection (T1, T2, and T3) was completed. Thus, it is unlikely that information provided to parents accounts for the trends in the data.

The language of instruction at all schools was Lithuanian. Furthermore, 89.6% of children spoke only Lithuanian at home, whereas 7.4% spoke a combination of Lithuanian, and Russian or Polish, 2.0% spoke only Russian and 0.5% spoke only Polish at home. The language profile of this sample is fairly representative of the overall population: According to Statistics Lithuania (2014), the native languages of a minority of people are Russian (5%) or

Polish (6%). Taken together, the sample was highly homogeneous in ethnic and cultural background, which is typical of the school population in Lithuania. In terms of parental education (Statistics Lithuania, 2007), our sample was comprised of well-educated mothers, with 61.4% reporting that they had completed a university degree, 23.7% completed college or polytechnics, 10.1% completed high school, and only 4.8% had lower than high school education.

Children. The children were followed across three time points: the end of kindergarten (T1; April–May, 2017; n = 229; 116 girls; M_{age} = 6.79 years, SD = .47, range 6.08–7.33), the beginning of Grade 1 (T2; October–November, 2017; n = 337; 178 girls; M_{age} = 7.30, SD = .38, range 6.17–8.00), and the end of Grade 1 (T3; April–May; n = 341; 180 girls; M_{age} = 7.77, SD = .46, range 7.08–8.5). A total of 90.5% of the participating children had attended preschool before entering kindergarten. Children were tested individually at each time point by professional school psychologists. Because school psychologists were employed by the schools that children were attending, they administered the tests in the psychologist's work rooms during school hours. School psychologists had 1–2 months to assess the children.

A total of 38 children dropped out of the study between the first and second measurement points because they either moved or changed schools. However, the sample size in Grade 1 increased substantially by 146 children. The increase in the sample size between T1 and T2 was due an influx of new Grade 1 students who had attended different kindergartens. Missing data analyses did not detect any systematic differences between children who dropped out or joined the study between T1 and T2 on any of the study variables. Across Grade 1 (T2 and T3), we did not recruit new participants, however, four new child reports became available at T3 (reports of the children who were absent from school at T2). Analyses showed that these five students did not differ from the rest of students with respect to any variables of the present study.

Parents. Of the 395 parents who allowed their children to participate in the study, a total of 245 filled in questionnaires in the spring of kindergarten (T1), 349 at the beginning of Grade 1 (T2), and 318 at the end of Grade 1 (T3). Questionnaires were completed by either mothers (92.2%), fathers (4.9%), mothers and fathers together (1.6%), or other guardians (1.2%; e.g., grandmother, foster care professional). The parents' ages ranged from 23 to 60 (M = 35.38, SD = 5.46). A total of 79.6% of the children were from families with two parents; 4.5% of the children were from families where the mother or father was living with his or her new spouse and their children; 11.0% of the children were living with a single mother; and 4.9% of parents reported that children were living with "other" (e.g., grandparents, in foster care). A total of 25.7% of children were the only children in their families (singletons); 56.7% had one sibling; 13.9% had two siblings; 2.9% had three siblings; and 0.8% had four siblings.

A total of 60 parents dropped out of the study between the first and second measurement points because their children started attending different schools. However, 164 parents joined the study in Grade 1 because their children joined the participating classrooms. We did not recruit new participants from T2 to T3 but 31 parents dropped out of the study during this time. Missing data analyses showed no systematic differences between the parents who had joined the study at the beginning of Grade 1 and those whose data were available from their children's kindergarten year on any of the study variables. In addition, attrition analysis compared parents who dropped out from the study at any measurement point with the ones who remained. There were slight tendencies amongst lower-educated parents and parents whose children were not doing well in arithmetic to drop out ($p < .10$), but we did not find any significant differences between the parents who dropped out and the parents who remained in the study.

Measures

All study measures were developed based on the measures used in the First Steps study (Lerkkanen et al., 2006–2019). Psychometric properties of all study variables are presented in Table 1; reliabilities of the scales are presented on the diagonal of Table 2.

Parental Questionnaire (T1, T2, and T3)

Home numeracy activities. Based on the work of LeFevre et al. (LeFevre et al., 2009; Skwarchuk et al., 2014) and Lerkkanen et al. (2006–2019), and following the guidelines of the Lithuanian national curriculum for kindergartens and primary school (LR Ministry of Education, Science and Sports, 2014, 2019), four questions were developed to assess parent's formal home numeracy activities. At each time point, the home numeracy activities were measured by four identical questions (i.e., How often do you teach your child …to recognize numbers, to write numbers, to compare quantities, and to conduct simple calculations). Concerning the item "compare quantities", to make it clearer for parents what exactly we were referring to, they were provided with examples that roughly translated into "more than", "less than", and "equal to". The questions targeted both current and retrospective frequency of maternal home numeracy activities (e.g., *during this school year [from September]; since Christmas*; see Table 1 for the exact items). Parents reported the frequency with which they engaged in these formal home numeracy activities with their child on a six-point scale (0 = *not anymore because my child has mastered the skill*, 1 = *never*, 2 = *rarely*, 3 = *sometimes*, 4 = *often*, 5 = *very often*). If parents stated that they were no longer engaging in these activities because their child had mastered that skill, their response was coded as a missing value, thus making the scale range from 1 to 5. The exact number of the responses per item (*n*) is presented in Table 1. Principal component analysis with varimax rotation revealed that all four items loaded on one factor. Cronbach's alphas were .90 (T1), .90 (T2), and .92 (T3).

Children's Tests (T1, T2, and T3)

The arithmetic fluency measure was the sum of two individually timed tests: addition and subtraction. Internal consistency between addition and subtraction scores was acceptable;

Cronbach's α comparing addition and subtraction scores were .78 (T1), .76 (T2), and .75 (T3). Similar tasks were used in other studies (Aunola & Räsänen, 2007; Lerkkanen et al., 2006–2019). At the piloting stage, children were also tested on basic math concepts (e.g., naming cardinal numbers, identifying ordinal numbers, seriation of numbers) and verbal counting (e.g., up to 30). Because children scored at ceiling-level on math concepts and counting in the pilot testing, we did not gather these data in the current study.

Addition. Children responded orally to written addition questions. To avoid a ceiling effect, the number and difficulty of items increased at each measurement point: T1 had nine questions, T2 had 20 questions, and T3 had 23 questions. For instance, at T3, eight of the questions were single-digit addition; 12 questions included addition of one two-digit number and one single-digit number; and three questions included addition of two two-digit numbers. Within each time point, the questions were ordered in increasing difficulty. Scoring was the total number of correct responses in one minute. Based on our sample, Cronbach's alphas were .83 (T1), .90 (T2), and .93 (T3).

Subtraction. Children responded orally to written subtraction questions. To avoid a ceiling effect, the number of items and difficulty of questions increased at each measurement point: T1 had nine questions, T2 had 20 questions, and T3 had 23 questions. For instance, at T3, six questions included subtracting a single digit from a two-digit number; 15 questions included subtracting a single digit number from a two-digit number; and two questions included subtracting a two-digit number from a two-digit number. Within each time point, the questions were ordered in increasing difficulty. Scoring was the total number of correct responses in one minute. Based on our sample, Cronbach's alphas were .88 (T1), .83 (T2), and .86 (T3).

Analysis Strategy

The main goal of this study was to examine the extent to which the frequency of engaging in home numeracy activities predicted children's arithmetic fluency skills, and the

extent to which children's arithmetic fluency skills predicted home numeracy activities. To achieve this aim, we started by estimating the longitudinal measurement model of the home numeracy activities across time. We specified the home numeracy latent construct by four identical indicators across three time points. We specified correlations of the same items across time and allowed latent constructs to correlate. Further, we constructed a cross-lagged model. The model included cross-lagged longitudinal paths between latent constructs of the home numeracy activities and sum scores of children's arithmetic fluency across each subsequent time point. Also, concurrent associations were estimated. Finally, we added maternal education as a control variable in our model to predict all of the study variables.

The missing data analysis was performed using Little's (1988) Missing Completely at Random (*MCAR*) test. Non-significant test results indicate that the data are MCAR (Missing Completely at Random), whereas significant results would indicate that data are not MCAR. Little's MCAR test results, χ^2 (1698) = 1762.46, p = .135, suggested data to be MCAR. As a result, the models were estimated using full maximum likelihood estimation, which uses all available information to estimate the model. Apart from the descriptive and correlational statistics, the path analyses were performed using M*plus* (Version 8; Muthén & Muthén, 1998–2017). Model fit was examined using a combination of the comparative fit index (*CFI*), root mean square error of approximation (*RMSEA*), and standardized root mean square residual (*SRMR*). A CFI value above .95, RMSEA value below .06, and SRMR value below .08 indicate a good model fit (Hu & Bentler, 1999). A CFI value above .90, and RMSEA and SRMR values below .10 indicate acceptable fit (Kline, 2015). We also calculated 95% confidence intervals for RMSEA. If the confidence interval does not span zero, then it indicates that the model fit is good. Finally, chi-square values were reported and a Satorra-Bentler test (Satorra & Bentler, 2010) was employed to compare the models.

Results

Descriptive Analyses

Descriptive information on all study variables and individual items is presented in Table 1. Parents completed surveys when their children were at the end of kindergarten (T1), at the start of Grade 1 (T2, 6 months later) and at the end of Grade 1 (T3, 6 months later). At each testing point, parents reported how frequently they taught their child to recognize and to write numbers, to compare quantities, and to make simple calculations. By the third testing point, approximately two thirds of parents (n = 240) reported that their children already recognized numbers; these children had significantly higher arithmetic skills, $t(339) = 3.15$, $p = .002$, $d = .38$. Similarly, by the third testing point, approximately two thirds of parents (n = 238) reported that their children already knew how to write numbers; again, these children had significantly higher arithmetic skills, $t(339) = 2.55$, $p = .01$, $d = .36$. These findings suggest that parent reports accurately reflect children's performance. At the end of Grade 1 (T3), children were close to 8 years of age and thus had likely mastered these skills.

For more complex skills, such as calculating (n = 243) and comparing quantities (n = 229), 80–90% of parents continued to practice these skills up to the end of Grade 1 (T3). The children of parents who reported that their child already knew how to perform simple calculations had significantly higher arithmetic skills than the children of parents who continued to practice simple calculations, $t(339) = 2.05$, $p = .04$, $d = .24$. In contrast, the children of parents who reported that their child already knew how to compare quantities did not have significantly different arithmetic skills than the children of parents who continued to practice quantity comparison, $t(339) = -0.82$, $p = .41$, $d = .09$.

Correlational Analyses

Correlations among the home numeracy environment, children's arithmetic skills, and control variables are presented in Table 2. Parent reports of home activities at T1 were not related to children's math skills at T1, that is, prior to formal schooling. However, the frequency of home numeracy activities at T2 and T3 were negatively related to children's arithmetic performance: Fewer activities related to better math performance. As anticipated,

mother's education was positively related to children's arithmetic performance at all three time points. Concerning the correlations between maternal education and parental home numeracy activities, once children began formal schooling in Grade 1, parent education was negatively related to home activities. That is, the lower the mother's education was, the more home numeracy activities parents reported at the beginning and the end of Grade 1. Finally, child age was not related to any of the study variables, perhaps because all the participating children were of similar age, born in the same year. Child gender showed only a few significant associations with arithmetic fluency at the beginning and the end of Grade 1. According to a recent meta-analysis, the correlation between home numeracy activities and numeracy skills does not differ for girls and boys (Dunst et al., 2017). Consequently, both child age and gender were excluded from further analyses.

Cross-Lagged Relations between Home Numeracy Activities and Arithmetic Fluency

Longitudinal measurement model. First, confirmatory factor analysis (CFA) was performed to test the factor loadings for each type of home numeracy activity on the latent constructs at each time point. The model had good fit to the data, $\chi^2(45) = 88.35$, $p < .001$, *RMSEA* = .049, [.034, .065], *CFI* = .96, *SRMR* = .069. The factor loadings for each type of home numeracy activity were relatively high (ranging between .64 to .95; see detailed information on factor loadings in Figure 1).

Structural equation model. Next, we examined the structural equation model without the control variable (i.e., mother's education). The model had acceptable fit, $\chi^2(76) = 160.73$, $p < .001$, *RMSEA* = .052, [.041, .064], *CFI* = .95, *SRMR* = .092. Finally, we added mother's education as the control variable by specifying mother's education as a predictor variable of all of the home numeracy outcomes and arithmetic outcomes at each time point (see Figure 1). The final model had an acceptable fit, $\chi^2(76) = 165.74$, $p < .001$, *RMSEA* = .047, [.037, .058], *CFI* = .95, *SRMR* = .086. As presented in Figure 1, the results showed that, after controlling

for mother's education, both home numeracy activities and arithmetic fluency were stable across the three time points. We found that the cross-lagged paths from arithmetic fluency at T1 to home numeracy activities at T2 and arithmetic fluency at T2 to home numeracy activities at T3 were significant. These results indicated that the poorer children's arithmetic skills at T1 and T2, the more parents engaged in home numeracy activities at T2 and T3, respectively. In addition, mother's education was not related to the frequency of home numeracy activities at any of the measurement points. In contrast, mother's education positively predicted children's arithmetic fluency at T1 and T3 (Figure 1).

Stability across time points. To test if our main results are dependent on timing of measurements, we tested if the paths across T1 and T2 were equivalent to the same paths across T2 and T3. Thus, we employed the Satorra–Bentler scaled chi-square difference test (Satorra & Bentler, 2010) to compare the freely estimated model with the model where the T1–T2 path was constrained to be equal to the corresponding path at T2–T3. The results showed, first, that the stability path of home numeracy activities across transition from kindergarten to Grade 1 (T1–T2) is weaker than the same stability path across Grade 1 (T2–T3), $\Delta\chi^2(1) = 7.12$, $p = .008$. Second, the cross-lagged path from arithmetic fluency to home numeracy activities during the transition (T1–T2) was significantly stronger than the same cross-lagged path across Grade 1 (T2–T3), $\Delta\chi^2(1) = 60.91$, $p < .001$, suggesting that parents were especially sensitive/responsive to children's arithmetic skills during the transition to formal schooling. We did not find any other differences between the paths across T1–T2 versus the paths across T2–T3.

The Moderating Role of Children's Skill Level in the Relation between Home Numeracy Activities and Children's Arithmetic Fluency

To better understand our main results, we further investigated in what way children's skill level moderates the previously found associations and mean-level differences of home numeracy activities. First, we ran a freely estimated multi-group model to determine if

children's skill level moderated the associations found in our final model without controls. Median split of the arithmetic fluency skills at the end of Grade 1 (T3) was used for identifying two groups—low (n = 171) and high (n = 170) achievers. We used median split to identify two groups because models with a larger number of groups (i.e., smaller group sizes) would not converge. The model (Figure 2) had an acceptable fit, $\chi^2(164) = 250.468$, $p < .001$, *RMSEA* = .056, [.041, .069], *CFI* = .942, *SRMR* = .098. The results showed that arithmetic fluency was a predictor of the home numeracy environment for children with lower skills across the transition to Grade 1 ($\beta = -.42$, *SE* = .08, $p < .001$) and across Grade 1 ($\beta = -.20$, *SE* = .08, $p = .02$), whereas the same association for children with good skills were weaker or non-significant. In addition, the home numeracy environment at the beginning of Grade 1 negatively predicted the development of children's arithmetic skill ($\beta = -.18$, *SE* = .07, $p = .01$), but only for the children with lower skills.

Second, to clarify the patterns of negative associations between parental home numeracy activities and children's arithmetic skills in Grade 1, we investigated the mean level differences across time for children with different levels of arithmetic fluency skills. In particular, similar to the analyses in the domain of home literacy (Sénéchal & LeFevre, 2014), we investigated mean changes in parental frequency of home numeracy activities dependent on children's arithmetic fluency skills. Participants who were missing either the home numeracy activity rating or the arithmetic skill outcome at T3 were excluded from the analyses. The sample was divided into three groups based on children's arithmetic skills at the end of Grade 1 (T3). The arithmetic skill groups were labelled as poor (< 25th percentile), average (25th to 75th percentile) and high (> 75th percentile). Subsequently, we analyzed sum scores of parents' reported frequencies of home numeracy activities in a 3 (Time: T1, T2, T3) by 3 (Arithmetic skill level: poor, average, high) mixed ANOVA, with arithmetic skill level as a between-subject variable and time as a within-subject variable. Reported statistics are Greenhouse-Geisser corrected where appropriate.

We found significant main effects of home numeracy activities by time, $F(1.84, 621.46) = 22.55$, $p < .001$, $\eta_p^2 = .06$, and arithmetic skill level, $F(2, 338) = 6.26$, $p = .002$, $\eta_p^2 = .04$. The main effects were qualified by a significant time by arithmetic skill level interaction, $F(3.68, 621.46) = 2.86$, $p = .03$, $\eta_p^2 = .02$. Post-hoc Bonferroni contrasts were calculated. As shown in Figure 3, at T1, parents reported similar frequencies of home numeracy activities across skill levels. However, at T2 and T3, after children entered Grade 1, the patterns began to change. Specifically, at T2, parents of children with poor arithmetic skills reported engaging in home numeracy activities more frequently than parents of children with average arithmetic skills ($\Delta M = 1.71$, *S.E.* = .62, $p = .02$) and high arithmetic skills ($\Delta M = 2.79$, *S.E.* = .73, $p < .001$). The same pattern was observed at T3 (poor–average: $\Delta M = 1.45$, *S.E.* = .55, $p = .03$; poor–high: $\Delta M = 2.29$, *S.E.* = .65, $p = .001$).

When examining the patterns across levels, for children with poor arithmetic skills, the frequency with which parents engaged children in home numeracy activities significantly increased from T1 to T2 ($\Delta M = –3.38$, *S.E.* = .67, $p < .001$) and significantly decreased from T2 to T3 ($\Delta M = 1.98$, *S.E.* = .51, $p < .001$). Similar patterns were observed for children with average arithmetic skills (T1 to T2: $\Delta M = –1.83$, *S.E.* = .46, $p < .001$; T2 to T3: $\Delta M = 1.83$, *S.E.* = .46, $p < .001$). For children with high arithmetic skills, there was no significant difference in the frequency with which parents engaged children in home numeracy activities from T1 to T2, but there was a significant decrease in frequency from T2 to T3 ($\Delta M = 1.48$, *S.E.* = .52, $p = .02$). Overall, parents tended to increase the frequency with which they engaged in home numeracy activities from T1 to T2 (except for parents of children with high arithmetic skills) and decrease the frequency from T2 to T3. However, parents of children with poor arithmetic skills engaged in home numeracy activities significantly more at T2 and T3 than parents of other children, possibly increasing their frequency of home numeracy activities based on their child's difficulties in math.

Sensitivity Analysis

We conducted sensitivity analyses to make sure that the way we treated our home numeracy variables did not influence the results we obtained. To this end, we ran the same models with the home numeracy variables where the category "not anymore" was not coded as missing, where the categories "not anymore" and "never" were combined, and where the category "not anymore" formed a dichotomous external control variable. In all of these cases, the same trend of results was obtained, suggesting robustness of the findings irrespective of which response scale for the home numeracy activities was used. Moreover, as more than 100 new parent–child dyads joined the study in Grade 1, we ran sensitivity analyses only for the participants who participated in all three measurement points. These analyses, again, did not reveal any substantial differences from the results reported.

Discussion

We investigated the cross-lagged associations between formal home numeracy activities and children's arithmetic skills in a sample of Lithuanian children from the end of kindergarten to the end of Grade 1. Importantly, although previous studies suggested that parental home numeracy activities at home predict children's math skills (LeFevre et al., 2009; Manolitsis et al., 2013; Melhuish et al., 2008), we also considered testing the opposite direction of association, that is, from children's skills to parental home numeracy activities. Consequently, in the present study, we found that poor arithmetic skills at the end of kindergarten and beginning of Grade 1 predicted increased frequency of parental engagement in formal home numeracy activities; no predictive relations from formal home numeracy activities to children's math skills were found. Taken together, the results suggest that parents of first graders are responsive to their children's level of math skills across Grade 1, especially at the beginning of Grade 1 and especially among children with lower arithmetic fluency skills.

Responsive Home Numeracy and Children's Arithmetic Skills

In line with the findings of previous studies that assessed the role of home numeracy activities after children had been exposed to formal math instruction (Ciping et al., 2015; Silinskas et al., 2010), we found negative longitudinal associations between children's arithmetic skills in kindergarten and Grade 1 and subsequent parental home numeracy activities at the beginning and the end of Grade 1. Lithuanian parents reported engaging more frequently in teaching their child to recognize and write numbers, compare quantities, and make simple calculations when children had poorer arithmetic skills. Interestingly, most previous studies that assessed home numeracy activities in kindergarten reported positive concurrent correlations with math-related skills (LeFevre at al., 2010), and longitudinal studies reported the switch from positive relations in kindergarten to negative relations in Grade 1 (Silinskas et al., 2010). In contrast, the present study found no relation in kindergarten and negative relations already at the beginning of Grade 1 and again at the end of Grade 1. Taken together, the results suggest that the time when home numeracy activities are assessed determines the direction of the relationship with children's math skills. That is, upon entering Grade 1, more frequent engagement in home numeracy activities is a reaction to poor children's arithmetic fluency skills. This association depends on child's skill level and if they need support from parents. Note that the children in our study were about one year older than kindergarten children in many other studies (e.g., LeFevre et al., 2010). However, similar negative associations were obtained between math skills and teaching of math in Grade 1 among Finnish children (Silinskas et al., 2010), and Chinese children across Grades 1 and 2 (Ciping et al., 2015). Similarly, negative associations were obtained between reading skills and teaching of reading in Grade 1 for Canadian children (Sénéchal & LeFevre, 2014).

Our findings should not be interpreted as an indication that parents lose their ability to engage effectively in their children's math learning; rather, parents are there to assist their children when they notice their children are struggling with arithmetic (Blevins-Knabe & Musun-Miller, 1996). It is also possible that, in Grade 1, teachers provide explicit feedback to

parents regarding their children's progress in learning math (e.g., through report cards or parent–teacher meetings). This feedback may subsequently encourage parents to engage more frequently in home numeracy activities if their child is struggling (Green et al., 2007). If parents are responsive to teachers' feedback, then they would benefit from precise instructions on what and how to teach math at home. However, how and to what extent math-related activities can be incorporated into existing family practices remains a question for future research.

Parents' own math skills may also influence the home numeracy environment. Silinskas et al. (2010) found that mothers who reported engaging more in direct teaching of math in Grade 1 also experienced struggles with math themselves. In particular, the authors found that the more mothers reported that they previously had or currently have troubles in calculation or math, the more they taught their children math in Grade 1 (but not kindergarten). Similarly, literature on math anxiety provides support for another explanation. In particular, mathematical anxiety is related to one's own performance in math and to lower enjoyment of math, lower confidence in math, lower motivation in math, and overall more negative attitudes towards math (Dowker, Sarkar, & Looi, 2016; Hembree, 1990). For instance, John, Nelson, Klenczar, and Robnett (2020) found that a person's memory of early math experiences can affect their emotions and motivation towards math, and their choice to pursue math in the future, even years after the experience has occurred. Furthermore, studies on parental involvement in children's math homework showed that children learned less math over the school year and developed math anxiety themselves when their parents who were high in math anxiety frequently helped with math homework (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Also, parents higher in math anxiety reported more negative emotional experience/interactions (e.g., frustration, conflict, stress) while helping their children with math homework in Grades 1–6 (DiStefano, O'Brien, Storozuk, Ramirez, & Maloney, 2020). Taken together, the higher frequency of teaching math might reflect parents'

own experiences with acquiring math and their worries that their children may experience the same challenges with math that they had (Berkowitz et al., 2016). Thus, parents may increase their formal home numeracy activities it Grade 1 because they want to protect their children from failure in mathematics. The effectiveness of increased teaching, however, may depend on the parents' own skills (Silinskas et al., 2010) and their anxiety about mathematics (Maloney et al., 2015).

Finally, it is possible that when parents report that their children invite them to be involved (e.g., by explicitly asking to play math games, to create math tasks, to solve math exercises together), parents are more likely to become involved in academic-related activities at home (Green et al., 2007; Hoover-Dempsey & Sandler, 1995). Also, apart from direct invitations from their children, parents may be responsive to the characteristics of their children, such as low performance, low motivation to learn math, or distractive behavior in learning situations, and increase the frequency of the home numeracy activities accordingly (Silinskas et al., 2015). Thus, it is possible that certain child characteristics may have an "evocative impact" on their parents' responses in academic contexts (Scarr & McCartney, 1983; Rutter, 1997; Nurmi, 2012; Silinskas et al., 2015). In the context of early reading, Sénéchal and LeFevre (2014) characterized parents as providing a responsive home environment for their Grade 1 children.

Parental Reports of Frequency of Home Numeracy Activities and their Concurrent and Longitudinal Relations to Arithmetic Skills

Parental reports of the frequency of their home numeracy activities in kindergarten (T1) were not concurrently related and did not longitudinally predict their children's arithmetic skills. This finding is in contrast to many previous studies where positive links were found between parents' reports of home numeracy experiences and early numeracy skills among children in preschool and kindergarten (Kleemans et al., 2012; LeFevre, Polyzoi, et al., 2010; LeFevre et al., 2009; Manolitsis et al., 2013; Niklas, Cohrssen, & Tayler, 2016; Niklas

& Schneider, 2014; Pan et al., 2006; Silinskas et al., 2010; Skwarchuk et al., 2014). One explanation for the non-significant association between arithmetic skill and home numeracy in kindergarten is that, because learning to count and calculate are not explicit goals of the kindergarten curriculum in Lithuania, parents do not monitor those skills in their children. In contrast, when children start Grade 1, parents start to pay attention to their children's math skills, and, consequently, readapt the frequency of their home numeracy activities to the level of children's math skill. This explanation may be specific to the culture in Lithuania in which kindergarten has only recently become mandatory. A second possible explanation for our results is that parental beliefs about the importance of kindergarten education may be directly related to their expectations for children's skills and, consequently, to the frequency of engagement in formal home numeracy activities. To explore this interesting possibility, however, further research is necessary in which parents' expectations are assessed. A third possibility is that the lack of significant correlations between the home numeracy activities at the end of kindergarten (T1) and concurrent math skills is specific to how the home numeracy environment was measured in the present study. In particular, the findings of the present study might differ for informal home numeracy activities compared to formal home numeracy. However, given that we did not measure informal home numeracy activities we cannot evaluate how formal and informal activities may relate to children's math skills. Thus, future research should consider both formal and informal home numeracy activities when predicting the development of children's math skills.

We did not find significant paths from parents' reports of home numeracy activities in kindergarten to children's arithmetic skills in Grade 1. This finding is consistent with some previous literature for the relations across kindergarten and Grade 1 where the results are often mixed; the pattern of results may be contingent on the time of measurement and on the specificity of math outcomes. Contrary to our results, Manolitsis et al. (2013) found that formal home literacy activities in kindergarten were related to math fluency at the end of

Grade 1. However, the authors measured formal numeracy at the beginning of kindergarten, and we measured it at the end of kindergarten. Also, the authors reported that formal home numeracy was related to math fluency skills indirectly, through early math skills, such as math concepts and counting in kindergarten, whereas we considered only the direct links to arithmetic fluency.

Lack of prediction from home numeracy activities in kindergarten to arithmetic fluency skills in Grade 1 may have a few explanations. First, it is possible that the direct effect of home numeracy activities is relatively time limited. Lack of relations also may suggest that school experiences/school instruction is more important in children's learning math at school than at home. That is, as children are exposed to numeracy instruction in Grade 1, the effect of home numeracy reduces or fades out. Research from home literacy seems to support this claim (Manolitsis et al., 2011; Silinskas et al., 2012). Second, we used home numeracy questions and tested children on the skills that were appropriate for the age and stage of the children in transition from kindergarten to Grade 1 (LR Ministry of Education, Science and Sports, 2014). By the end of Grade 1, the activities that we asked about may have been irrelevant because children's skills were more advanced. Thus, assessing more advanced formal numeracy activities (e.g., operations with two-digit numbers, learning fractions, multiplication) might have shown stronger and positive relations to the children's math outcomes. Dunst et al. (2017) found that positive correlations among home numeracy activities and early math skills were stronger among young children and most of the research has been with preschool or kindergarten children (Elliot & Bachman, 2018). This pattern suggests that assessed home numeracy activities need to be the ones that the children have not already mastered. Investigating a wider range of home numeracy activities that capture the evolving skills of children across grades is important to advance work in this field.

A second reason for a lack of relation between home numeracy activities and children's skills in Grade 1 might be due to educational factors specific to Lithuania. In

Lithuania, systematic instruction about math is not included in guidelines for kindergarten education, and children are not assigned any homework to enhance math-related skills. Thus, parents may be unaware of the level of children's math skills, teachers' goals for children's math learning, or home practices that could enhance math skills. Children in the current sample were in a pre-instructional setting at Time 1 and thus the home activities selected by their parents may reflect their personal beliefs about appropriate math activities and their knowledge of their children's interest and skills, rather than an understanding of the skills that are important for Grade 1 (Lukie, Skwarchuk, LeFevre, & Sowinski, 2014).

Third, children in the present study were somewhat older than in most other studies on home numeracy, transitioning to formal schooling (Grade 1) at the age of 6 to 7, approximately one year later than in most countries. Therefore, home numeracy activities before kindergarten year possibly promoted their math skill development. Perhaps assessing the relations from home numeracy activities for younger children or assessing the association between home numeracy activities and children's math skills across a larger period of time would make the gains more obvious (Thompson et al., 2017).

Limitations

The current study had several limitations. First, although we used longitudinal data gathered every six months (spanning from the end of kindergarten to the end of Grade 1), we cannot make causal claims about the relation of influence. Experimental and intervention studies are needed to support such claims (Berkowitz et al., 2015; Niklas et al., 2016). Second, parental reports were used to measure the frequency of home literacy activities. This methodology may be subject to social desirability biases and to parents' individual interpretations of the questions (Elliot & Bachman, 2018). Third, we measured only formal numeracy activities (i.e., not informal activities); this choice was based on previous work in which formal numeracy activities were associated with symbolic number knowledge and math fluency (LeFevre, Polyzoi, et al., 2010; Manolitsis et al., 2013; Skwarchuk et al., 2014). Also,

our choice was based on the guidelines of the Lithuanian national curriculum for kindergarten and primary school education (LR Ministry of Education, Science and Sports, 2014, 2019), which are focused on symbolic number skills. Thus, we do not know whether informal numeracy practices might predict children's math outcomes nor do we know if more advanced formal numeracy activities (e.g., learning fractions, multiplication, operations with two-digit numbers) would relate to the children's math outcomes.

Fourth, we assessed a limited range of numeracy activities, measuring the frequency of only four types of formal home numeracy activities. This set may not capture the richness of home numeracy activities or the quality of interaction between parents and children during those activities (Sénéchal et al., 2017). In future, researchers should assess a wider range of both formal and informal home numeracy activities and use a wider range of methods for gathering data, such as observations (Levine, Ratliff, Huttenlocher, & Cannon, 2012; Vandermaas-Peeler, Boomgarden, Finn, & Pittard, 2012), audio recordings of parents' number talk (Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010), or intensive data gathering approaches (e.g., collecting diary data).

Fifth, we did not assess children's arithmetic fluency or other basic math skills at the beginning of kindergarten. We also did not assess other math-related skills. In order to better understand our longitudinal findings, it would be useful to assess skills at the start of kindergarten. In addition, a greater variety of math-related skills would have provided a more comprehensive picture of the relations between home numeracy activities and children's arithmetic skills.

Sixth, because math achievement is heritable (Kovas et al., 2007, 2013), information about parents' math knowledge and attitudes may be important in fully describing the home numeracy environment. In the present study, influences of the home numeracy activities could have been confounded with heritable influences because the parents and children in the

present study not only shared a home environment but were also biologically related to one another.

Conclusions

The current study adds to the literature on home numeracy in the following ways. First, it provides longitudinal evidence for the relation between home numeracy activities and children's arithmetic skills across the transition from kindergarten to Grade 1 and during Grade 1. Second, the results were based on a large sample size that allowed testing the hypothesized relations employing complex statistical approaches. Furthermore, the current study provided evidence from a new cultural environment—Lithuania—a country in the north eastern part of Europe where children start learning formal arithmetic in Grade 1, at the age of 7. The results of the current study extend the Home Numeracy Model by showing that if children's arithmetic skills are low, parents respond by increasing the frequency of home numeracy activities. Parents were especially reactive/sensitive at the very beginning of their children's school career, during the first half of Grade 1. Moreover, parents of children with low math skills were especially responsive to their children's math skill level, increasing the frequency of their home numeracy activities. Overall, the findings suggest that the links between the home numeracy environment and children's math skills must be viewed within a developmental framework where the relations between parents' home activities and children's skills shift from being non-significant in kindergarten to being negative in early primary school.

These findings have important practical implications. Parental home numeracy activities in kindergarten were not significantly related to children's math skills. Starting in Grade 1, parents of poor achievers increased the frequency of their home numeracy activities, but these actions did not show benefits for the development of children's arithmetic skill. Instead, they appeared to be reactive to children's level of numeracy skill. Taken together, these findings suggest that more research is needed on the reciprocal relations between home

numeracy experiences and children's early skills. Further, along with other studies in which parents' own skills and attitudes influence children's learning, the way parents engage in numeracy activities with their children requires a closer look in the future research. Given that parents can often be responsive to the invitations for involvement or characteristics of their children (especially for low achievers and starting at the very beginning of Grade 1), a practical implication of our findings would suggest that teachers and educators should communicate their instructional goals to parents and provide the concrete means by which parents could help to achieve these goals.

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Table 1

Descriptive Statistics of All Study Variables

Variables	*n*	*M*	*SD*	Range		Skewness
				Potential	Actual	
Parent Questionnaire (end of kindergarten; Time 1)[1]						
Mean score of Home Numeracy Activities T1	236	3.13	.93	1–5	1–5	.25
During kindergarten (from September), my child and I were learning to recognize numbers	156	3.40	1.01	1–5	1–5	.19
During kindergarten (from September), my child and I were learning to write numbers	188	3.18	1.02	1–5	1–5	.18
During kindergarten (from September), my child and I were learning to calculate	222	3.39	.97	1–5	1–5	.16
During kindergarten (from September), my child and I were learning to compare quantities	207	2.81	1.13	1–5	1–5	.17
Parent Questionnaire (beginning of Grade 1; Time 2)[1]						
Mean score of Home Numeracy Activities T2	308	3.11	1.05	1–5	1–5	.16
During this school year (from September), my child and I are learning to recognize numbers	146	3.47	1.18	1–5	1–5	.20
During this school year (from September), my child and I are learning to write numbers	229	3.35	1.14	1–5	1–5	.16
During this school year (from September), my child and I are learning to calculate	267	3.55	1.07	1–5	1–5	.15
During this school year (from September), my child and I are learning to compare quantities	264	2.73	1.19	1–5	1–5	.15
Parent Questionnaire (end of Grade 1; Time 3)[1]						
Mean score of Home Numeracy Activities T3	271	2.92	.96	1–5	1–5	.38
During this school year (from Christmas), my child and I are learning to recognize numbers	103	3.25	1.23	1–5	1–5	.24
During this school year (from Christmas), my child and I are learning to write numbers	105	3.18	1.29	1–5	1–5	.24
During this school year (from Christmas), my child and I are	243	3.27	1.05	1–5	1–5	.16

learning to calculate						
During this school year (from Christmas), my child and I are learning to compare quantities	229	2.76	.98	1–5	1–5	.16
Arithmetic Fluency (end of kindergarten; Time 1)						
Sum score of Arithmetic	229	8.43	4.82	0–18	0–18	.10
Addition	229	3.67	2.47	0–9	0–9	.69
Subtraction	229	4.76	2.86	0–9	0–9	–.43
Arithmetic Fluency (beginning of Grade 1; Time 2)						
Sum score of Arithmetic	337	12.86	6.73	0–40	0–35	.98
Addition	337	5.71	4.24	0–20	0–20	1.29
Subtraction	337	7.16	3.19	0–20	0–16	–.07
Arithmetic Fluency (end of Grade 1; Time 3)						
Sum score of Arithmetic	341	19.91	8.62	0–46	0–42	.27
Addition	341	9.91	5.78	0–23	0–23	.37
Subtraction	341	10.00	3.61	0–23	0–20	–.19
Control variable						
Maternal Education	399	4.59	.89	1–5	1–5	–1.33

[1] Survey responses were: 0 = not anymore, because the child has acquired the skill, 1 = never, 2 = rarely, 3 = once or twice a week, 4 = several days a week, and 5 = every day. "Not anymore" responses were recoded as missing data, so they are not included in the mean scores. Note that the sample size (*n*) is provided for each individual item, excluding responses of "not anymore".

Table 2

Correlations amongst Parent Factors, Child Performance, and Control Variables

	1	2	3	4	5	6	7	8	9
1. Child Age									
2. Child gender (0 = girl, 1 = boy)	.06								
3. Maternal education	.08	–.04							
4. Arithmetic fluency (T1)	–.14	.11	.31**	*.78*					
5. Arithmetic fluency (T2)	–.11	.16**	.20**	.77**	*.76*				
6. Arithmetic fluency (T3)	–.00	.17**	.25**	.74**	.77**	*.75*			
7. Home Numeracy Activities (T1)	–.01	.03	–.05	.09	.03	.02	*.90*		
8. Home Numeracy Activities (T2)	.01	.04	–.19**	–.29**	–.21**	–.23**	.35**	*.90*	
9. Home Numeracy Activities (T3)	.03	.06	–.17**	–.26**	–.28**	–.26**	.47**	.46**	*.92*

Note. Reliabilities (Cronbach's alpha) are shown on the diagonal (*italicized*).

* $p < .05$, ** $p < .01$

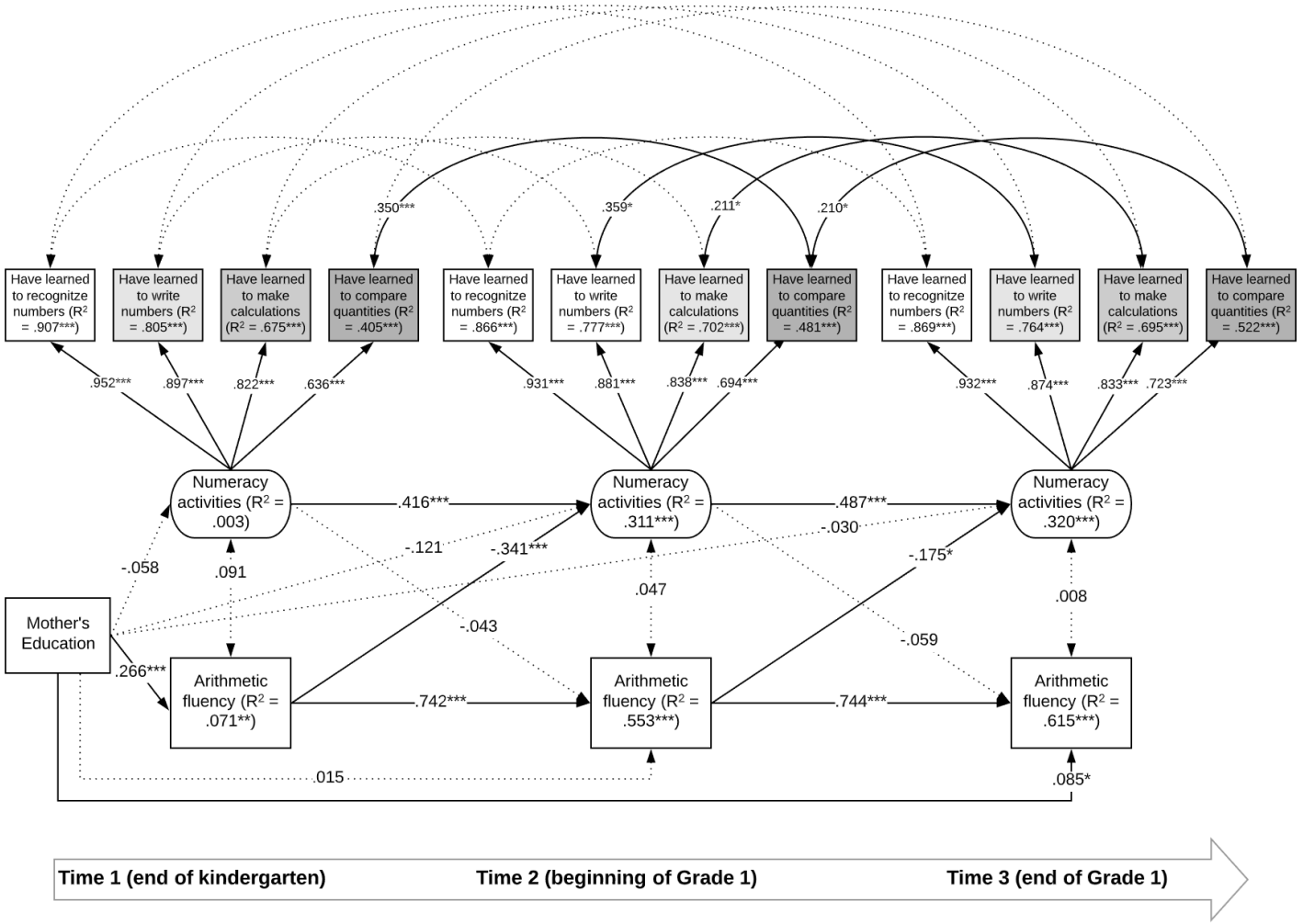

Figure 1. Home numeracy activities and arithmetic fluency skills across kindergarten (Time 1) and Grade 1 (Time 2 and Time 3). All coefficients are standardized. Dotted lines represent non-significant associations. * $p < .05$, ** $p < .01$, *** $p < .001$

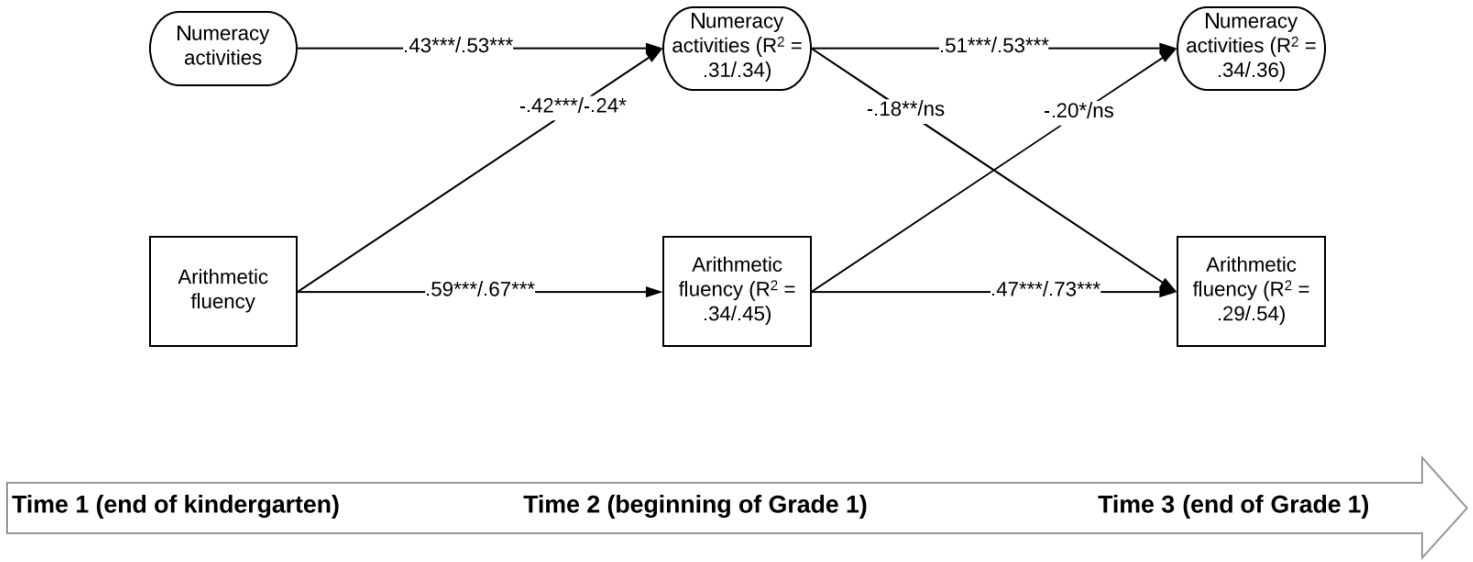

Figure 2. Home numeracy activities and arithmetic fluency skills for children with low arithmetic fluency skills at the end of Grade 1 (the first coefficient) and children with high arithmetic fluency skills at the end of Grade 1 (the second coefficient). All coefficients are standardized. Only significant paths are shown (n = 170/n = 171).

^{ns} $p > .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

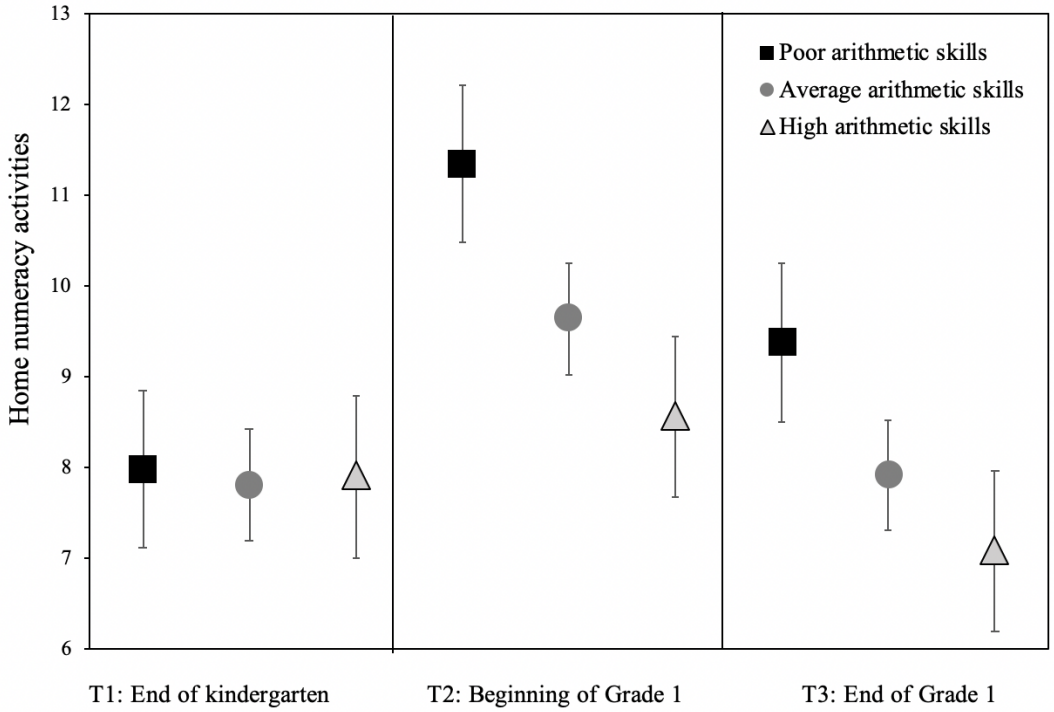

Figure 3. Means of the sum score of the frequency of parental home numeracy activities (with 95% inferential confidence intervals) across time in three groups of children with different levels of arithmetic skills.