Article type : Paper

Parents' early book reading to children:

Relation to children's later language and literacy outcomes controlling for other parent language input

Ö. Ece Demir-Lira, Lauren R. Applebaum, Susan Goldin-Meadow, & Susan C. Levine

University of Chicago

Author Note

Ö. Ece Demir-Lira is now in the Department of Psychological & Brain Sciences at the University of Iowa.

Lauren R. Applebaum is now at the Museum of Science and Industry Chicago.

Address correspondence to: Ö. Ece Demir-Lira, Department of Psychological & Brain Sciences, The University of Iowa, W316B Seashore Hall, Iowa City, Iowa 52242-1407; email: ece-demirlira@uiowa.edu

Research Highlights

- The quantity of parent language provided during naturally occurring parent-child book reading interactions between child ages 1 and 2.5 years predicts elementary school language and literacy outcomes, controlling for other talk parents provide their children outside of book reading interactions, family socioeconomic status, and children's own early language skill.
- The particular child outcomes significantly predicted by the language parents provide during parent-child book reading utterances include children's elementary school receptive vocabulary, reading comprehension and internal motivation to read, but not children's reading decoding, external motivation to read, or math skill.

  The linguistic complexity of parent language during book reading interactions is more sophisticated than parent language outside book reading interactions in terms of both vocabulary diversity and syntactic complexity.

Abstract

It is widely believed that reading to preschool children promotes their language and literacy skills. Yet, whether early parent-child book reading is an index of generally rich linguistic input or a unique predictor of later outcomes remains unclear. To address this question, we asked whether naturally occurring parent-child book reading interactions between 1 and 2.5 years-of-age predict elementary school language and literacy outcomes, controlling for the quantity of other talk parents provide their children, family socioeconomic status, and children's own early language skill. We find that the quantity of parent-child book reading interactions predicts children's later receptive vocabulary, reading comprehension, and internal motivation to read (but not decoding, external motivation to read, or math skill), controlling for these other factors. Importantly, we also find that parent language that occurs during book reading interactions is more sophisticated than parent language outside book reading interactions in terms of vocabulary diversity and syntactic complexity.

Keywords: book reading, language input, language, literacy

Parents' early book reading to children: Relation to children's later language and literacy outcomes controlling for other parent language input

Researchers, practitioners and parents agree that parent-child shared book reading provides an important foundation for children's later language and literacy outcomes (e.g., Bus, van IJzendoorn, & Pellegrini, 1995; Debaryshe, 2008; Mol & Bus, 2011; Payne, Whitehurst, & Angell, 1994; Sénéchal & Lefevre, 2002; Sénéchal, Lefevre, Thomas, & Daley, 1998). For example, a meta-analysis by Bus, van IJzendoorn and Pellegrini (1995) reported an overall effect size of d=0.59 (a medium sized effect) for the relation between early book reading and later oral language and reading measures.

Surprisingly, however, important questions remain regarding the magnitude of this relation and its specificity. In terms of magnitude, another meta-analysis by Scarborough and Dobrich (1994) reported that only 8% of the variation in a general measure of early literacy-related skills and early reading is accounted for by early book reading interactions. Moreover, when other factors, such as SES, were taken into account, the predictive power of book reading disappeared. In terms of specificity, it is not known whether early book reading is a marker of higher socioeconomic status, rich language input in general, or a unique predictor of later language and literacy outcomes. Prior studies that have reported positive effects of early book reading have primarily relied on parent questionnaires that ask about frequency of book reading (Payne, Whitehurst & Angell, 1994; Senechal & LeFevre, 2002) or on observations of parent-child book reading interactions around books provided by researchers in laboratory studies (e.g. Bus, Leseman, & Keultjes, 2000; Hoff-Ginsberg, 1991). Thus, these studies did not control for SES or the language parents provide to children outside of the book reading context, even though we know that parent SES and early language input more generally are strong predictors of children's later language and literacy skills (e.g. Hart & Risley, 1995; Hoff, 2003).

Moreover, the book reading episodes elicited by the books that were provided to parents may not have reflected those that actually occur in the home environment. In the current study, when examining relations between parental input around books and children's outcomes, we control for parent socioeconomic status as well as parent input outside of book reading interactions. Further, we base our analyses on our coding of book and non-book interactions that occur naturalistically in the early home environment.

We first ask whether parent language in the context of book reading when children are 1 to 2.5 years of age predicts children's later language and literacy outcomes, controlling for parent language input outside of the book reading context as well as children's early language skills and parent socioeconomic background. To address this question, we videotaped naturally occurring parent-child interactions in the home, which captured language within and outside of book reading contexts. This approach contrasts with existing questionnaire and laboratory studies examining the relation of book reading to later child outcomes (e.g. Hoff-Ginsberg, 1991; Payne, Whitehurst & Angell, 1994; Senechal & LeFevre, 2002). Laboratory studies might not be valid reflections of the nature of parent-child book reading interactions because of demand characteristics on the parent, and because they do not capture the frequency of these interactions in the home (e.g. Hindman, Connor, Jewkes, & Morrison, 2008). Questionnaires might also fail to accurately capture this information, again because of demand characteristics on the parent and also limitations of parent memory. Moreover, no questionnaire or laboratory study examining parent-child book reading interactions has also captured non-book reading language interactions in the same parent-child dyads, which constitutes, by far, the majority of the language children receive from their parents.

Second, we consider the possibility that early book reading is more important for certain language and literacy outcomes than for others. Notably, early book reading may predict later oral language skills and reading comprehension, but not reading decoding skills simply because book reading interactions rarely include explicit instruction that would aid decoding (de Jong & Leseman, 2001; Evans, Williamson, & Pursoo, 2008; Robins & Treiman, 2009). Indeed, although the benefit of early parent-child book reading for children's vocabulary is consistently-reported (Biemiller & Boote, 2006; Dickinson & Smith, 1994; Hassinger-Das, Ridge, Parker, Golinkoff, Hirsh-Pasek, & Dickinson, 2016), existing research is inconsistent with respect to question of whether early parent-child book reading predicts later reading decoding skill (de Jong & Leseman, 2001; Sénéchal et al., 1998; Senechal & LeFevre, 2002). Intervention studies also support a stronger relation between book reading and children's vocabulary than between book reading and emergent literacy skills, such as phonological or print awareness skills (Lefebvre, Trudeau & Sutton, 2011; Toub et al., 2018; Wasik, Hindman, & Snell, 2016). Moreover, existing studies tend to focus on earlier grades, typically second grade or earlier, when reading decoding and reading comprehension might be difficult to differentiate (Gough, Hoover, & Peterson, 1996; Sénéchal et al., 1998). Thus, it is possible that early parent-child book reading interactions will predict later reading comprehension more strongly than reading decoding if reading decoding and comprehension are assessed later during the elementary school years. In addition, because existing studies have not relied on naturalistic parent-child reading interactions, we know little about whether the ways in which parents read books to their young children differ, and whether these variations make a difference in terms of predicting later language and reading outcomes for the child. Here we explore this question about the quality of book reading interactions by coding the kinds of linguistic input parents provide in the book reading context, noting

whether the parent reads the text, labels or describes the pictures in the book, and/or extends the topic of the book.

Third, in addition to assessing whether early parent-child book reading interactions predict children's later language and reading skills, we examine whether early book reading interactions predict the child's later motivation to read and perception of their reading competence. Intrinsic motivation is present when individuals engage in an activity for its own sake, whereas extrinsic motivation is present when individuals engage in an activity to obtain an external reward such as a good grade or praise (Wigfield & Guthrie, 1997). Concurrent relations between parent-child book reading and children's interest in books have been reported (Morrow, 1983). However, no existing studies, to our knowledge, have asked whether children's early positive interactions with their parents around books also influence how enjoyable children find reading later on. Reading motivation is an important variable in that it has cascading effects on children's own reading frequency, which in turn influence children's later reading and language outcomes (Baker, Scher, & Mackler, 1997; Wigfield & Guthrie, 1997).

Finally, we examine whether parent language during book reading, on average, contains greater vocabulary diversity and/or syntactic complexity than parent language to children outside of the book reading context. This possibility is supported by a recent corpus analysis suggesting that the language in popular children's books is richer than the language parents provide during naturalistic interactions that are part of the CHILDES database (Montag, Jones, & Smith, 2015). Similarly, prior studies showed that, when asked to interact with their children in different contexts, parents produce richer language (longer sentences and more diverse and sophisticated vocabulary) around books than at meal time or while dressing (Hoff-Ginsberg, 1991; Weizman and Snow, 2001). However, these studies did not

examine naturalistic parent-child book reading interactions, and thus do not provide direct information about whether the language that naturally occurs during book reading is more complex than the language that occurs outside of the context of book reading. Moreover, these studies did not examine the relation between language provided in and outside of the context of book reading and child language and literacy outcomes. Here, we compare: (1) the language parents provide children during naturalistic book reading interactions that is present in the texts of the books; (2) the language parents provide children during naturalistic book reading interactions that does not appear in the texts; and (3) the language parents provide children in non-book reading contexts.

In sum, we ask three main questions: (1) How does the quantity of parent language during book reading relate to children's later language and literacy outcomes, controlling for the quantity of parent language outside of the book reading context and family SES. Further, we control for the quantity of child language during book reading interactions and children's early language skills as assessed by a standardized measure. We hypothesize that quantity of parent language during book reading will predict children's language and literacy outcomes, controlling for these variables. (2) Does the relation of quantity of parent language during book reading differentially predict children's language and literacy outcomes? We predict that by 4th grade, the relation of early book reading to skills that require language comprehension will be stronger than the relation of early book reading to skills that tap reading decoding (3) Is the linguistic complexity of parent language during book reading interactions higher than that during non-book reading interactions? Based on the prior literature (Montag et al., 2015), we hypothesize that this will be the case for vocabulary diversity and for the first time ask whether this is also the case for syntactic complexity. We also compare the linguistic complexity of the parent language during book reading and during non-book reading with the linguistic complexity of the written text of the book.

Method

Participants

Fifty-five parent-child dyads (25 of the children were girls) participated in the current study, which is part of a larger longitudinal study on language development[1] (Goldin-Meadow, Levine, Hedges, Huttenlocher, Raudenbush & Small, 2014). Forty-nine of the primary caregivers were mothers, 1 was a father, and the remaining 4 families shared caregiver responsibility between parents (1 family did not provide primary caregiver information). Families were recruited through direct mailing sent to approximately 5,000 families living in targeted zip codes and advertisements placed in a free, monthly parent magazine. Parents were then interviewed to obtain information on their demographic characteristics. Families were recruited until a sample of 65 families that was representative (based on race/ethnicity and income) of the greater Chicago area, as reported in the 2000 US census was created. One exception was that only families where English was the primary language spoken in the home were included. Caregivers provided race and ethnicity information. They reported that 39 children were White, 10 were African-American, and 5 were of mixed race (1 family did not respond). Additionally, 6 of these children were reported to be Hispanic. Parent education was coded on an ordinal scale (10 = less than high school degree, 12 = high school degree, 14 = some college or associates degree, 16 = college degree, 18 = more than college). In this sample, average parent education was 15.9 years (*SD* = 2.04, Median = 16 years, Range = 10 – 18 years) and average family income was $61,636 (*SD* = $31,177, Median = $62,500. Range = $7,500 – $100,000). Because income and education were significantly correlated, $r_s = .44$, $p < .001$, we combined the two measures into a composite score of socioeconomic status (SES) using Principal Components Analysis (PCA). The first principal component weighted education and

[1] Sixty-four families participated in the original study. Nine families dropped out before their children started school and thus were excluded from the current study.

income positively and equally. This component accounted for approximately 71 percent of the original variance in income and education.

Procedure

The data coded for this study are part of a larger longitudinal study examining the relation of parent input to children's language development. We coded videotapes of parents interacting with their children for approximately 90-minutes during home visits that occurred every 4 months between child ages 14 to 58 months of age. For the purposes of this study, we transcribed four visits (at child ages 14, 18, 26 and 30 months). Parents were asked to go about their normal activities during the visits. The activities we observed frequently included toy play, book reading, and eating meals and snacks. For the current study, outcome measures came from measures administered during visits that occurred when children were in 2nd through 4th grade. All of these measures are described below.

Parent measures

Socioeconomic Status (SES). As described above, SES of each family was indexed by a composite factor score that combines parental education and income information.

Parent book and non-book reading utterances (child ages 14 to 30 months). All parent and child language from four videotaped home visits was transcribed, and all utterances that occurred within and outside of the book reading context were coded for the purpose of this study. The unit of transcription for these data was the utterance. An utterance was delimited by a pause, a change in conversational turn, or a change in intonational pattern. For reliability, a second coder transcribed 20% of the data. The two coders were considered reliable when at least 95% of their transcriptions matched on utterances (percent agreement). Inconsistencies

were resolved through discussions. Coded transcripts included all dictionary words, onomatopoeic words (e.g. meow) and evaluative sounds (e.g. whoops, uh-oh).

We further coded parent-child book reading interactions that occurred during these sessions. A book reading episode began when the parent and child both focused on a book and was considered to have ended at the point when 10 consecutive utterances spoken by the parent were not relevant to the book. A second coder transcribed 20% of the book reading episodes and established reliability on identification and categorization of book reading utterances (reliability was 92%, n=24, agreement between coders, Kappa = .92). The total number of book reading utterances for a given caregiver is the combined total of the book utterances described below. We also calculated total number of non-book parent utterances. Two of the parent-child dyads missed a session.

Parent talk during parent-child book reading interactions took many forms. We divided the talk into the following seven categories: *reading the text, labeling or describing a picture, extending the topic, print-related talk, behavioral directives, conversational utterances,* and *comments*. *Reading the text* captured all utterances read directly from the text of the book. Parents did not read the books from start to the end verbatim and frequently recast certain sentences in their own words. Thus, unlike Montag et al. (2015), our *reading the text* measure is not exclusively the verbatim text of the book, but rather parent utterances that came from the book, including minor recasts (e.g. "He is taking a break", instead of "He was taking a break"). *Labeling or describing a picture* included providing labels and asking questions relevant to the book (e.g. "That's a ball," "Where is the elephant?"). This category also included descriptions focusing on attributes including but not limited to shape (e.g. "This is a round one"), color (e.g. "This one is red") or number (e.g. "Walrus has two tusks"). *Extending the topic* consisted of utterances that connected the topic of the book to the child's own experiences (e.g., "Do you

remember the last time we went to the zoo?" when reading a book about animals in a zoo). Predictions, evaluations, and inferences about the story were also included in this category (e.g. "What are they going to do next?" "Why is she sad?"). *Print-related utterances* included all talk about letter-sound correspondences (e.g., "These are all words that sound alike"), spelling (e.g., "How do you spell dog?"), and letter names (e.g., "This is L"). *Behavioral directives* included utterances aiming to direct the child's behavior or attention around the book ("Sit down"). *Comments* included utterances about the child, parent, or the book ("You are a good listener", "I like this book"). *Conversational utterances* included agreement ("Yes"), disagreement ("No), requests for clarification and prompts ("What?"). Irrelevant utterances that were not about the book reading activity ("We will eat after this") constituted 7% of the book utterances and were excluded from the analyses described below. These categories were identified on the basis of the previous literature focusing on book reading interactions (Bus, Leseman, & Keultjes, 2000; Dale, Crain-Thoreson, Notari-Syverson, & Cole, 1996; Reese and Cox, 1999), and on the basis of the kinds of talk surrounding book reading that we observed in the current dataset.

In order to examine whether the linguistic complexity of book reading utterances differed from the complexity of non-book reading utterances, we analyzed vocabulary diversity and syntactic complexity of both types of utterances over time, using growth modeling. We measured vocabulary diversity using word type-token ratios of all of the book and non-book reading utterances. We measured syntactic complexity for all utterances that occurred in book reading contexts and non-book reading contexts with mean length of utterances in words (MLU), as well as number of unique verbs (verb types) per utterance. Tokens and types were tallied automatically by a program written specifically for this project. All dictionary words, onomatopoeic words (e.g. meow), and evaluative sounds (e.g., whoops, uh-oh) were included when counting word tokens. Additional criteria were used to decide what constituted a word type. In particular, morphologically inflected variants of words (e.g., run, running) were

considered a single type. Words produced in imitation and words that were produced while reading were included when counting word tokens and types, and later separated in our analyses of language within and outside of the book reading context.

The literature suggests that type-token ratio is heavily influenced by total amount of talk; type-token ratios of language samples of different sizes (e.g., different numbers of tokens or utterances) should thus not be compared (Hess, Sefton & Landry, 1986). As described below, book reading utterances (included parents' reading of the text of the book and their utterances surrounding the book) constituted a small proportion of the overall utterances parents produced. We took several measures to decrease the influence of different number of utterances produced during and outside of book reading interactions. In order to equate book and non-book talk for amount so that we could meaningfully compare type-token ratios in these contexts, for each session and each parent, we randomly selected 10 samples from non-book reading utterances that were matched in length to that parent's book utterances. We then compared the average word type to word token ratio (type-token ratio) in the non-book and book utterance samples for each parent. Because our measure of type-token ratio takes the relation between type-token ratio and word tokens in the sample into account, the measure closely resembles other vocabulary diversity measures in the literature, such as D, which accounts for sample size when calculating type-token ratio (Richards & Malvern, 1988). In calculating the type-token ratio, we used the Mass index of lexical diversity which is influenced by text length to a lesser extent than other measures in the field (McCarthy & Jarvis, 2010). The two syntactic complexity measures described above (MLU in words and number of unique verbs per utterance) have been widely used to assess parental language input in the literature and have been shown to reliably predict children's outcomes (Hoff-Ginsberg, 1991; Gopnik, Choi, & Baumberger, 1996; Pancsofar & Vernon-Feagans, 2006; Rowe & Goldin-Meadow, 2009; Rowe, Coker & Pan, 2004; Vigil, Hodges, & Klee, 2005; Rowe, Levine, Fisher, & Goldin-Meadow, 2009).

Because these measures have not been found to be influenced by sample size in the same way as type/token ratios, we used the entire sample of non-book related utterances to calculate these measures and compared them to the measures derived from book related utterances.

Child measures

Child book reading utterances (child ages 14 to 30 months). Child book reading utterances were identified using the same criteria we used for parent book reading utterances, as described above.

Child non-book reading utterances (child age 14 to 30 months). As a measure of children's overall language production, we calculated the total number of non-book child utterances.

Standardized and unstandardized outcome measures. The following tests were administered to children between 2nd and 4th grades to assess their receptive vocabulary, reading decoding, reading comprehension, mathematics problem solving, and reading motivation (three measures: internal motivation to read, external motivation to read, perceived reading competence). Not all children completed all assessments. This was because they missed the particular visit when a measure was administered or the measure was not administered due to experimenter error or child fatiguing during the visit.

Receptive vocabulary. During 2nd grade, children were administered the Peabody Picture Vocabulary Test (PPVT-3, Dunn & Dunn, 2007), a standardized test that measures receptive vocabulary skill. Standardized scores were used (n=53/55).

Reading comprehension. The Comprehension subtest from Gates-MacGinitie (MacGinitie, 2000) administered at the beginning and end of 3rd grade served as our reading comprehension measure. This subtest measures children's ability to silently read and understand different types of prose as assessed by comprehension questions that followed each passage. W scores, averaged across the two sessions, served as our measure of children's reading comprehension achievement (n=52/55).

Reading decoding. At the beginning and end of 3rd grade, children completed the Letter Word Identification subtest and the Word Attack subtests of the Woodcock-Johnson Tests of Achievement (WJ-III, Woodcock, McGrew, & Mather, 2001). The Letter Word Identification subtest measures word reading skills and the Word Attack subtest measures skill in applying phonic and structural analysis skills to the reading of non-words. The two subtests constituted the Basic Reading Skills Cluster, which served as our decoding measure. W scores on these two subtests, averaged across the two sessions, served as our measure of children's reading decoding achievement (n= 52/55).

Mathematics problem solving. The Applied Problems subtest of the Woodcock-Johnson Tests of Achievement were given to children in the middle of 3rd grade and Calculation subtest was given at the end of 3rd grade (WJ-III, Woodcock, McGrew, & Mather, 2001). The Applied Problems subtest consists of math word problems and the Calculation consists of number-fact problems. W scores on each of these tasks were used as measures of math achievement (Calculation subtest n = 49/55, Applied Problems subtest n = 47/55).

Reading motivation. Reading motivation was assessed in the beginning of 4th grade through a questionnaire that probed the child's attitudes towards reading. Questions used to measure reading motivation were based on the Wigfield and Guthrie (1997) questionnaire, and assessed children's reading motivation with three sets of questions (see Appendix 1 for questionnaire, Cronbach's alpha = .72): (1) Questions assessing internal motivation asked whether the child reads books for internal reward or personal pleasure (Cronbach's alpha= .77) (2) Questions assessing external motivation measured whether the child reads books for external rewards, such as good grades or praise (Cronbach's alpha = .50). (3) Questions assessing perceived reading competence measured the child's perceptions of his/her reading performance (Cronbach's alpha = .70) (n = 52/55).

Analytical approach

In this paper, we hypothesize that quantity of parent's book utterances between 14 and 30 months will predict children's outcomes, controlling for parent SES, quantity of parent non-book utterances, quantity of child book and non-book utterances. To test this hypothesis, we took a two-step approach. In the first step, to examine quantity of parent book utterances over the 2 years we focus on, we built a two-level hierarchical linear model (HLM, Raudenbush, Bryk, Cheong & Congdon 2000) of change in parent book utterances between 14 and 30 months. To account for the contribution of overall parent talk and children's own language skills, we also built parallel models for quantity of parent non-book, child book and child non-book utterances. We then extracted the parameters of these two-level models defining change in the quantity of parent and child book and non-book utterances.

In the second step, we built prediction models where we examined how parameters that describe change in the quantity of parent and child book and non-book utterances related to children's outcomes in school years. Specifically, in our prediction models, we examined how parameters that define the change in quantity of parent and child utterances relate to child outcomes, controlling for parent SES, and quantity of parent non-book, child book and child non-book utterances in a multivariate HLM. Below, we first describe the two-level model describing parent- and child-specific change and then we describe our prediction model.

The two-level models for parent-and child-specific change in book and non-book utterances:

First, we used HLM to examine the number of book and non-book utterances produced by parents and children between 14 and 30 months. This statistical model has two levels: a Level-1 model that accounts for variation in repeated measures within each individual; and a Level-2 model that represents variation between individuals. We built four parallel models, one for each category of utterances: parent book, parent non-book, child book, and child non-book utterances. We use parent book utterances to describe our analytical approach, which also applies to other three utterance categories. At Level-1 (within parents), we represent the trajectory of parents' book utterances as a quadratic model. For each parent *i* at time *t,* we have:

$$Y_{ti} = \pi_{0i} + \pi_{1i}(a_{ti-} - 22) + \pi_{2i}(a_{ti-} - 22)^2 + e_{ti}\,,\ e_{ti} \sim N(0, \sigma_t^2)$$

In this equation, a_{ti} is the age of the child *i* at visit time *t,* π_{0i} is parent *i*'s status at child age 22 months (age was centered at 22 months, since it is the middle time point between 14 and 30 months), corresponding to average number of book utterances at 22 months. π_{1i} is the parent's linear change in book utterances (velocity) at child age 22 months of age, and π_{2i} is the parent's acceleration in book utterances at child age 22 months. The residual e_{ti} is the portion of parent *i*'s book utterances at child age *t* not predicted by child age.

At Level-2 (between parents), we examined whether parents' status (intercept centered at 22 months) and linear change (velocity) of book utterances are predicted by SES. This provides a between-person model for each variable, in which there is a separate equation for each Level 1 coefficient, $\pi_{pi,}$ where p = 0, 1, 2:

$$\pi_{pi} = \beta_{p0} + \beta_{p1}*(SES_i) + r_{pi}, \quad p = 0, 1$$

In this equation, π_{pi} is the pth growth parameter from the Level 1 model, β_{p0} and β_{p1} are linear regression coefficients, and r_{pi} is a random effect. We allow random effects to be correlated within parents but not between parents.

Our goal is to examine how parents' SES status, velocity and acceleration of various utterance types at child age 22 months predict later child outcomes controlling for background characteristics such as SES, as well as parameters for change in parent non-book, child book, and child non-book utterances. Thus, in the next step, we compute empirical Bayes posterior means for these parameters by estimating the two-level models described above and outputting empirical Bayes coefficients for these parameters in parent-level and child-level files. For further details on this analytical approach, please see Rowe, Raudenbush & Goldin-Meadow (2012). We next describe how we use these parameters to predict children's outcomes using multivariate hierarchical linear modeling.

The prediction model:

Second, we use multivariate hierarchical linear modeling to examine children's outcome measures. Whereas in standard application of multivariate measures, missing values are not allowed, HLM allows analysis of incomplete data, specifically multivariate HLM allows the study of multivariate outcomes with missing data. In this case, at level 1 (within children), we have:

$$Y_{ti} = \pi_{ti}(\text{child outcome}) + e_{ti}$$

In this equation, there is no intercept, and π_{ti} is an indicator for child *i*'s outcome measure *t*. The residual e_{ti} is the portion of child *i*'s performance not predicted by the measures.

At level 2 (between children), we examined whether children's performance on an outcome measure was predicted by quantity of parent book utterances. We also included parent SES, quantity of parent non-book, child book and child non-book utterances as controls. As described above, here we use empirical Bayes (EB) estimates of parent book utterances, parent non-book utterances, child book utterances, child non-book utterances computed from the models described in the previous section. Thus, we create a between-person model, in which there is a separate equation for each Level 1 coefficient, π_{pi}:

$$\pi_{pi} = \beta_{p0} + \beta_{p1}*(SES_i) + \beta_{p2}*(\textit{parent book utt EB}_i) + \beta_{p3}*(\textit{parent non-book utt EB}_i) + \beta_{p4}*(\textit{child book utt EB}_i) + \beta_{p5}*(\textit{child non-book utt EB}_i) + r_{pi,,} \quad p = 0, 1, 2, 3, 4, 5$$

Here where π_{pi} is the pth parameter from the Level 1 model, β_{p0}, β_{p1}, β_{p2}, β_{p4} and β_{p5} are linear regression coefficients, and r_{pi} is a random effect.

Linguistic complexity analyses:

We used HLM to examine the linguistic complexity of book and non-book utterances produced by parents and children between 14 and 30 months. Using the approach described above, we built parallel models for parent book and non-book utterance type-token ratio, MLU and verbs per utterances. We then compared EB estimates from these models to compare linguistic complexity across book and non-book utterances. Following these, we built parallel models differentiating book *reading the text* utterances and other book utterances.

Results

Quantity of parent book and non-book reading utterances

Seven children did not have any parent-child book reading episodes during any of the sessions. Parents of children who did not read books to their children had significantly lower income ($t(53) = 2.61$, $p = .02$) and fewer years of education ($t(53) = 3.38$, $p < .01$) than those who read books to their children during at least one session. In addition, children who did not have parent-child book reading episodes had marginally significantly lower PPVT scores ($t(51) = 1.84$, $p = .07$) and reading comprehension scores ($t(50) = 1.69$, $p = .09$) than their peers. There were no other significant differences between those who were read to vs. not read to on the other assessments we administered (all *p*'s >= .10). Because we had no information about early reading interactions for these 7 participants, we excluded them from our remaining analyses, leaving 48 participants.

On average, the remaining 48 parent-child dyads read books during 2.3 of the 4 sessions (*SD* = 0.82, Median = 2, *Range* = 1-4), had 5.3 book reading episodes (*SD* = 3.7, *Range* = 1-17), and read 6.5 books (*SD* = 5.6, *Range* = 1-33). When averaged across the four sessions, the average number of utterances parents produced during book reading episodes at each observation session was 96 (*SD* = 91, Range = 5 – 459), compared to 963 utterances outside of book reading episodes (*SD* = 329, Range = 283 – 1710). Thus, on average, book reading utterances constituted only 9% of the overall talk children heard from their caregivers (*SD* = .07, Range = .01 to .25). Table 1 represents the number of book utterances parents produced at each session.

When averaged across the four sessions, the number of book reading utterances was significantly correlated with other book reading measures: number of home visits with book episodes (r = .65, p < .01), overall number of book reading episodes across sessions (r = .82, p < .01), and overall number of books read across sessions, including repeated readings of the same book (r = .77, p < .01). Similarly, the number of non-book reading utterances was correlated with other measures of parental input, such as the number of word tokens outside book reading interactions (r = .74, p < .01). In all subsequent analyses, the number of book reading utterances and the number of non-book reading utterances were used as our measures of quantity of parent input.

Table 2 presents correlations between parent book reading utterances and parent non-book reading utterances, correlations between child book reading utterances and child non-book reading utterances, and the relation of all of these variables to SES**.** Here we present the numbers averaged across the four sessions (with the exception of the two participants who were missing a session, in which case the average was calculated over three sessions). The average number of parent book utterances was correlated with the average number of parent utterances outside of book reading interactions, and the number of parent book reading utterances was correlated with parent SES. Similarly, the average number of child utterances in the book reading context was correlated with the average number of child utterances outside of the book reading context. However, neither was correlated with SES. Finally, the number of parent book utterances was significantly correlated with the number of child book reading utterances. Several other correlations were positive but did not reach significance.

Types of parent book reading utterances

Per session, parents produced an average of 31 book reading utterances describing the pictures (*SD* = 31, *Range* = .25 – 127), 23 utterances that involved reading the text (SD = 24, Range = 0-94), 9 utterances that involved extending the topic of the book (*SD* = 11.62, *Range* = 0- 44), 1 print-related utterance (*SD* = 3, *Range* = 0-12), 12 behavioral directives (*SD* = 12, Range = 0 – 69), 3 comments (*SD*= 3.41, Range = 0 – 16), and 17 conversational utterances (*SD* = 2, Range = .5 – 133). The different types of book reading utterances were significantly correlated, controlling for overall non-book talk (see Table 3). Moreover, a factor analysis showed that all of the different types of book reading utterances loaded onto one factor, which explained 70% of the variance. Because of the high collinearity of the different types of parent book reading utterances, our main analyses focus on the average number of parent book utterances over all categories as a predictor of children's later outcomes, without distinguishing among the different types (Table 1). We present exploratory analyses examining the relation between specific book utterance types and children's later outcomes in Supplementary Materials.

Predicting child language and literacy from number of early parent book reading utterances

Our results are presented in two steps. In the first step, we use individual growth modeling (employing HLM; Raudenbush, Bryk, Cheong & Congdon 2000) to model parents' book utterances between 14 and 30 months, parent non-book utterances, as well as child book and non-book utterances. We also incorporate SES as a predictor in that change. Table 4 presents a taxonomy of models investigating these relations. Second, we use empirical Bayes estimated parameters from these models to predict children's outcomes.

The two-level models for parent-and child-specific change in book and non-book utterances. To obtain the best fitting Level 1, or within-person, model for parent book reading utterances, we examined empirical plots of all parents' book utterances between 14 and 30 months. We fit a quadratic growth model to the data because it had a lower goodness-of-fit statistic (-2 log likelihood) than a linear model and because the plot of this model best mirrored the plot of the empirical data. Age was centered at 22 months, the midpoint of the data. We looked at fixed effects with robust standard errors. We included SES as Level 2 predictors in these four models. Model 1 in Table 4 is the quadratic growth model for parent book utterances. This model shows that at 22 months, parents have an estimated 136.9 book utterances, with an estimated decrease of 3.9 utterances per month at child age 22 months. The significant quadratic term indicates that, over time, the monthly rate of decrease itself decreases. SES does not have a significant effect on intercept, linear change, or acceleration (Model 1).

We built parallel models for parent non-book, child book and child non-book utterances. We fit a linear growth model to parent non-book utterances because it had a lower goodness-of-fit statistic (-2 log likelihood) than a quadratic model and because the plot of the linear model best mirrored the plot of the empirical data. This model shows that at 22 months, parents have an estimated 961.9 non-book utterances. The linear change was not significant. SES had a trending effect on the intercept of number of non-book utterances, and its effect on linear change was not significant (Model 2).

We fit quadratic growth models to the data on child book utterances (Model 3) and child non-book utterances (Model 4) because they had a lower goodness-of-fit statistic (-2 log likelihood) than linear models and because the plot of the quadratic model best mirrored the plot of the empirical data. Model 3 shows that children have an estimated 28.1 book utterances at 22 months, with an estimated increase of 1.3 utterances per month. Quadratic change is

significant and negative, suggesting that the linear increase in book reading utterances decreases over time. SES does not have a significant effect on the intercept or quadratic change, but has a marginal positive effect on the linear change (Model 3). Model 4 shows that children have an estimated 341.3 non-book utterances at 22 months, with an estimated increase of 35.5 utterances per month. Quadratic change was not significant. SES did not have a significant effect on the intercept or quadratic change, but it had a marginally significant positive effect on the linear change (Model 4). Finally, we outputted empirical Bayes coefficients for the parameters (e.g. intercept of parent book utterances) described above in parent-level and child-level files.

Predicting later child outcomes. Our goal is to examine how parents' status, velocity and acceleration of various utterance types at child age 22 months predict later child outcomes controlling for background characteristics such as SES, as well as parameters for change in parent non-book, child book, and child non-book utterances. For this, we use empirical Bayes estimated growth rates from the growth models described above. However, collinearity is too high and our sample size is too small to include all of the parameters as predictors of children's outcomes. We have three empirical Bayes estimated growth parameters per model for the models describing change in parent book, child book and child non-book utterances (intercept, linear change and quadratic change). Additionally, we have two empirical Bayes estimated growth parameters for the models describing change in parent non-book utterances (intercept, linear change). To determine which aspects of growth (intercept, linear change, quadratic change) are most related to children's outcomes, we conducted preliminary analyses.

Selection of variables. First, we only considered empirical Bayes estimated parameters that significantly varied across individuals as indicated by random effects (Table 4). These parameters included intercept for all four measures, linear change for child book and non-book utterances and quadratic change for child book-utterances. Second, as expected, parameters

from a single model were highly correlated with each other. For example, child book intercept was significantly and highly correlated with linear change (r = .88) and quadratic change (r = -.89). Similarly, intercept for child non-book utterances was significantly and highly correlated with linear change (r = .89) and quadratic change (r = -.88). Thus, we only included intercept for parent book, parent non-book, child book and child non-book utterances in our prediction models. Prediction models including slopes for parent book, parent non-book, child book and child non-book revealed results parallel to the those including- the slower was the decrease in parent book utterances with child age, the higher was children's performance on the measures discussed above, with the strength of the relations of slope being slightly weaker than relations of intercept.

Finally, we ran a series of first-order partial correlations to examine the relations between parent book utterances and child outcomes, controlling for parental SES. These correlations showed that the intercept of parent book utterances was significantly related to decoding, reading comprehension, vocabulary, math word problems and internal motivation, but not to calculation, external motivation or perceived reading competence. It should be noted that the lack of significant relations to external motivation could be due to the low reliability of this sub-scale. Thus, in the models below, we only considered relations to the former set of outcomes. We did not further examine relations to calculation or external motivation. Table 5 lists these correlations as well as correlations with parent non-book, child book and child non-book utterances.

Predictive models. The steps above enabled us to narrow down the predictors we include in our prediction models. We next examined how the predictors identified above (parent SES, parent book reading utterances, parent non-book reading utterances, child book reading utterances, child non-book utterances) related to children's outcomes. These models are presented in Table 6. In the first model (Model 1), we started with parent SES, as well as

parent book and parent non-book utterances as predictors of children's outcomes. Parent SES was included as a measure of socio-economic background and non-book utterances were included as a measure of overall parental talkativeness. We included parent variables first because the main question of interest is on the role of parental input. We then included child variables to make sure that parents would predict even after we account for children's own language skill which could elicit parental input. In terms of children's outcomes, we included child measures that showed a significant first-order correlation with parent book utterances as identified above. These included decoding, reading comprehension, vocabulary, math word problems and internal motivation to read. The ordering of the variables did not change the results.

This first model (Model 1) showed that parental SES is a significant predictor of child reading comprehension, vocabulary and math word problem performance. Controlling for SES and parent non-book utterances, parent book utterances significantly predicted later reading comprehension, vocabulary, internal motivation to read, and performance on math word problems, but not reading decoding. A one standard deviation increase in the intercept of parent book utterances was associated with a 1.8 point (.05 standard deviations) increase in reading comprehension, a 4 point (.28 standard deviations) increase in vocabulary, a 3.6 point (.21 standard deviations) increase in math word problems performance, and a 7.8 point (3.7 standard deviations) increase in internal motivation to read. Further, HLM's multivariate hypothesis testing revealed that the estimate for the effect of parent book utterances on decoding is significantly different than reading comprehension, $\chi 2=5.83$, $p =.01$, vocabulary, $\chi 2=6.75$, $p <.01$, math word problems, $\chi 2=4.06$, $p =.04$, and internal motivation to read, $\chi 2=8.32$, $p <. 01$.

Further, in this model, controlling for both SES and parent book utterances, parent non-book utterances did not significantly predict any of the child outcomes (Model 1). We also tested whether an interaction term between SES and parent book utterances would improve Model 1,

and found that this was not the case, $\chi 2 = 4.704$, $p > .50$ and the interaction term did not significantly predict any of the other outcomes, all p's >.05. Thus, the interaction term was excluded from subsequent models.

In the next model (Model 2), we added child non-book and book utterances as Level 2 predictors. Child non-book utterances significantly predicted child reading comprehension, vocabulary performance and math word problems performance (Model 2). Surprisingly, child book utterances significantly and negatively predicted vocabulary performance. This should be interpreted cautiously as child book utterances were significantly and highly correlated with parent book utterances ($r = .55$, $p < .001$) which may lead to collinearity (Model 2). In addition, because children's language during non-book interactions provides a broader sample of their spontaneous language in a wider range of settings, these utterances might significantly correlate with their vocabulary performance. More importantly for our purposes, controlling for SES, parent non-book utterances, child non-book utterances, and child book utterances, parent book utterances remained as a significant predictor of reading comprehension, internal motivation, vocabulary and math word problems performance.

Linguistic complexity of book reading compared to non-book reading utterances. We next examined whether the linguistic complexity of parent book reading utterances differed from that of their non-book reading utterances, even though parent book reading utterances constituted a relatively small part (9%) of the child's overall linguistic input. As described earlier, we used type-token ratio on samples that were matched in specific ways (see Methods) as a measure of vocabulary diversity, and we used MLU and number of verb types per utterance as measures of syntactic complexity.

We first built linear growth models for parent non-book and book utterance type-token ratio, MLU and verb types per utterances. We then divided the book utterances to address the question of whether possible differences between book and non-book utterances are due to the

text of the books being more complex than other talk, and/or to the parents' language around the books being more complex than other talk. To examine this question, we compared the complexity of the book text, the complexity of parent talk around the book, and the complexity of parent utterances produced outside the book reading interactions.

To obtain the best fitting Level 1, or within-person, model for these utterances, we examined empirical plots of all measures between 14 and 30 months. For all measures, we fit a linear growth models to the data of all measures because they had a lower goodness-of-fit statistic (-2 log likelihood) than linear models and because the plot of these model best mirrored the plots of the empirical data. Age was centered at 22 months, the midpoint of the data. We looked at fixed effects with robust standard errors. Descriptive statistics for linguistic complexity and detailed information on these models are provided in the Supplementary Materials.

Next, we outputted empirical Bayes coefficients for the parameters (e.g. intercept of parent book utterance type-token ratio) in parent-level files as described above. Using these coefficients, we first compared type-token ratio, mean length of utterance in words (MLU) and number of verbs per utterance in non-book versus book utterances. Paired samples t-tests revealed that book utterances were significantly higher on these three measures than non-book utterances (type-token ratio: $t(47) = 7.88$, $p < .001$, MLU: $t(47) = 4.08$, $p < .001$, verbs per utterance: $t(47) = 3.14$, $p = .003$). We then compared type-token ratio, MLU and number of verbs per utterance in non-book, reading the text and other book utterances using repeated measures ANOVAs. This analysis revealed a main effect of utterance type on type-token ratio, $F(2,86) = 255.12$, $p < .001$, where type-token ratio of book text utterances was significantly higher than other book utterances ($p = .001$), which was higher than non-book utterances ($p < .001$). ANOVA on MLU similarly revealed a main effect of utterance, $F(2,86) = 145.69$, $p < .001$. Paralleling these findings, MLU of text utterances was significantly higher than MLU of other book utterances ($p < .001$), which was higher than non-book utterances ($p < .001$). Finally,

ANOVA on the number of verb types per utterance ($F(2,86) = 111.21$, $p < .001$ also revealed a main effect of utterance type. We again found evidence of more complex utterances (more verb types per utterance) in text than in other book utterances ($p < .001$), and more complex utterances in other book utterances than in non-book utterances ($p = .002$).

Discussion

Parent-child book reading interactions are considered to be one of the most important and valuable preschool experiences, and are widely believed to support children's later language and reading outcomes (e.g., Bus, van IJzendoorn, & Pellegrini, 1995; Debaryshe, 2008; Mol & Bus, 2011; Payne, Whitehurst, & Angell, 1994; Sénéchal & Lefevre, 2002; Sénéchal, Lefevre, Thomas, & Daley, 1998). Surprisingly, many questions remain about the specificity and underlying mechanism of how early parent-child book reading interactions support later language and literacy outcomes, some of which are addressed in the current study. Notably, we demonstrated, for the first time, that the quantity of parent book reading predicts important child language and literacy outcomes, controlling for parent language input outside of the book reading context, the child's own contribution to book reading interactions, overall child talk, and parent socioeconomic background. Further, we found that parent language during book reading contains greater vocabulary diversity and syntactic complexity than parents' language outside of the book reading context.

Our findings are consistent with many prior studies reporting positive relations between early parent-child book reading and later child language and literacy outcomes (e.g., Bus, van IJzendoorn, & Pellegrini, 1995; Debaryshe, 2008; Mol & Bus, 2011; Payne, Whitehurst, & Angell, 1994; Sénéchal & Lefevre, 2002; Sénéchal, Lefevre, Thomas, & Daley, 1998). Importantly, our findings move the existing literature forward in multiple ways. We found specific relations between early parent-child book reading utterances and certain later child

outcomes, showing that early parent book reading utterances predicted children's later receptive vocabulary, reading comprehension, and internal motivation to read even when controlling for early parent language input outside of the context of book reading, children's own language contributions to book reading interactions, and parent socioeconomic background. In view of the relation between early reading and later vocabulary knowledge, we also observed a relation between early reading and children's performance on math word problems, which is to be expected given that these math problems involve language comprehension. By also showing that these relations were specific––that is, that early book reading interactions did not significantly predict reading decoding, performance on math calculation problems or external motivation to read––we provide evidence that early book reading interactions are not merely a general marker of positive input in the early home environment. Below, we discuss potential reasons for the relations we found.

An important finding that emerged from our analyses is that naturally occurring parent-child book interactions included greater parent vocabulary diversity and syntactic complexity than naturally occurring parent-child interactions that did not involve books, with these measures obtained from the same set of parents at the same time points. Given that written language affords complex words and syntactic constructions that are not common in daily language (Westby, 1991), it is not surprising that we found that the linguistic complexity of the book texts exceeded the complexity of the spoken language use around the books and outside of book interactions. This finding adds to the findings of Montag et al. (2015), who compared vocabulary diversity in the text of common children's books to vocabulary diversity in parent speech in CHILDES. Another recent study using parent-reported activity logs showed that book-reading interactions include a higher number of conversational turns and parent word count compared to non-book interactions (Gilkerson, Richards, & Topping, 2017). Our unique contribution is that because of the nature of our data, which consisted of naturalistic parent-child interactions, we also were able to examine parent language *around* book reading (e.g., extending the topic, describing the pictures), not just their reading of the text of the books.

Analyzing this aspect of parent language revealed that greater parent linguistic complexity was not confined to the text of the books. Parents brought up a diverse set of topics around the books, described the pictures in their own words, recast the text utterances, and frequently related the book content to children's own experiences. The content of the books may have encouraged parents to use a richer vocabulary when discussing books with their children, compared to both their daily language outside of book reading interactions and their reading of the text within the books. Our small sample size did not allow us to examine whether the greater parent linguistic complexity that characterized early book reading interactions provides a possible mechanism to explain the power of early parent-child reading interactions in predicting child language and literacy development. Future studies with larger sample sizes should examine whether the predictive power of book utterances might be in part due to their linguistic complexity, aspects of language that are known to positively predict children's language and literacy outcomes (e.g., Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Rowe, 2012). Overall, books might present an ecologically-valid way to elicit rich input from parents.

We did not find a significant relation between parent language provided during book reading and later child reading decoding skills or child calculation skills. The differential relations were also confirmed by the fact that the estimate for the effect of parent book utterances on decoding was significantly lower than reading comprehension, vocabulary, math word problems, and internal motivation. While we must be cautious in interpreting non-statistically significant correlations, the lack of a significant relation is consistent with reports in the literature of weaker relations between early book reading and decoding than between early book reading and reading comprehension and vocabulary (de Jong & Leseman, 2001; Sénéchal et al., 1998; Senechal & LeFevre, 2002). Moreover, our findings are not surprising given that both our results and the prior literature suggest that parents rarely engage in print-related talk in the context of early book reading, the type of talk that has been found to support later reading decoding. Interactions other than book reading that focus on phonological features or decoding

skills, such as writing interactions or nursery rhymes, might more strongly predict children's decoding skills (Evans, Williamson, & Pursoo, 2008; Robins & Treiman, 2009). Overall, the current study suggests that, in the age range we focused on, parents rarely use book interactions to focus on print or phonological aspects of language. Relations of book-reading to oral language and reading comprehension might be especially stronger in later elementary school years where reading comprehension increasingly depends on individual differences in oral language skills and to a lesser degree individual differences in decoding skills (Chall & Jacobs, 2003).

Our findings showed that early book reading not only predicts children's later reading comprehension skill, but also their later motivation to read for enjoyment. Prior studies have found contemporaneous relations between reading to young children and children's interest in reading (Baker, Scher, & Mackler, 1997; Morrow, 1983). For example, Morrow (1983) found that kindergarten children who are read to daily are more interested in books. Extending these findings, we found that early parent-child interactions around books during the second and third years of life was related to children's internal, but not external, motivation in 4th grade––a longitudinal relation that to our knowledge has not been identified in previous research. The relation between early parent-child book reading interactions and internal motivation to read may be due to these early interactions initiating a snowball effect, such that children who are read to more early in life become interested in books earlier on, enjoy reading more, develop stronger language skills, and later read more themselves, thus exhibiting greater internal motivation to read (Baker et al., 1997; Wigfield & Guthrie, 1997). This kind of virtuous cycle provides a potential mechanism for how early book reading can contribute to the breadth of children's vocabulary knowledge, as well as their language and reading comprehension skills. Future studies with larger samples could test these hypotheses through longitudinal structural equation modelling or path analyses.

By videotaping and coding naturally occurring parent-child book reading interactions, we were able to obtain detailed information about the different kinds of language parents provided during book reading, which ranged from reading the text to describing the pictures to extending the text to directing children's attention and behavior. All parents produced each of these different types of utterances and the quantities of these different types of utterances were highly correlated with each other, making it difficult to examine the relation between a specific kind of a parent book utterance and children's later outcomes. Our exploratory analyses, however, revealed that parents' utterances extending the topic of the book and their utterances describing and labeling the book pictures might be particularly important in predicting a variety of outcomes including the development of young children's receptive vocabulary, reading comprehension, and internal motivation to read (see Supplementary Materials for a further discussion of these results). The kind of parent talk that would be most important to later outcomes might differ as children get older and gain more language skills. To gain finer grained and causal evidence about the role of different inputs in the development of children's later language and literacy skills, we need studies that examine and experimentally manipulate parent input around books for children of different ages.

Importantly, observing naturally occurring book reading activities has enabled us to assess both the frequency and the nature of naturally-occurring book reading interactions, without the memory limitations that characterize parent questionnaires or the artificiality of observations of book reading in experimental settings. In addition, observing naturally occurring book reading interactions allowed us to measure not only the frequency, but also the nature of parents' book reading talk, including their reading of the text of the books and their talk around the books. Moreover, the fact that we found a significant relation between early book reading and certain later language and literacy skills suggests that we identified meaningful variability among parents.

Our study provides new information about how and why early book reading supports later language and literacy skills. Nevertheless, it has some limitations. First, the study is correlational and thus cannot provide causal evidence for the role of book reading in later child outcomes the way that an experimental study can. However, our study does serve to identify promising hypotheses that can be explored in experimental studies. Second, we measured book reading episodes during four home visits that typically occurred during the daytime. Thus, we might have missed book reading episodes that occurred at bedtime or at other non-visit times. Third, parents might act differently when they are not being observed than when they know that they are being observed and recorded. Although we believe that the frequency and duration of our visits (and the positive long-term relations we find) mitigate this concern, we cannot, of course, be certain. Other dimensions of parent-child interactions, such as general parental responsiveness, also contribute to academic outcomes. Our inclusion of parental SES and parental overall talk account for the variability in such aspects, as parental SES is correlated with responsiveness (Evans, 2004). Further, parental language input and responsiveness has been argued to relate to later outcomes via independent pathways (Wade, Jenkins, Venkadasalam, Binnoon-Erez, & Ganea, 2018). Finally, our sample only included families where English was the primary language spoken at home, which limits the generalizability of our findings. Future work should expand explore book-reading interactions in multi-language family settings.

In sum, our results show positive relations between early parent child book reading and children's later language and literacy outcomes, controlling for non-book parent language, child language skills, and parent SES. We also found that parent language during early book reading interactions was linguistically more complex than parent language during non-book reading interactions provides a possible mechanism for these relations. Thus, our findings offer a potential explanation for the success that interventions encouraging parent-child book reading have had in increasing language skills and school achievement (e.g., Mendelsohn et al., 2001; Whitehurst et al., 1994). Overall, changing parents' talk in the context of book reading

interactions may, in the end, be easier than changing their spontaneous talk more globally, and may carry important long-term consequences for children's achievement.

Acknowledgements

This research was supported by P01HD40605 from NICHD to Susan C. Levine and Susan Goldin-Meadow. We thank participating families and children; Katherine Petty for help in earlier phases of the project; Chicago Language Developmental Project research assistants for help in collecting and transcribing the data; and Kristi Schonwald, Jodi Khan, and Jason Voigt for administrative and technical assistance.

References

Aram, D., & Shapira, R. (2012). Parent-child shared book reading and children's language, literacy, and empathy. *Rivista Italiana Di Educazione Familiare*, *2*, 55-65.

Baker, L., Scher, D., & Mackler, K. (1997). Home and family influences on motivations for reading. *Educational Psychologist*, *32*(2), 69-82.

Biemiller, A., & Boote, C. (2006). An effective method for building meaning vocabulary in primary grades. *Journal of Educational Psychology*, *98*(1), 44.

Bus, A. G., Leseman, P. P., & Keultjes, P. (2000). Joint book reading across cultures: A comparison of Surinamese-Dutch, Turkish-Dutch, and Dutch parent-child dyads. *Journal of Literacy Research*, *32*(1), 53-76.

Bus, A.G., Van Ijzendoorn, M.H., & Pellegrini, A.D. (1995). Joint book reading makes for success in learning to read: A meta-analysis on intergenerational transmission of literacy. *Review of Educational Research*, *65*(1), 1-21.

Chall, J. S., & Jacobs, V. A. (2003). The classic study on poor children's fourth-grade slump. *American Educator, 27*(1), 14-15.

Cumming, G., & Finch, S. (2005). Inference by eye: Confidence intervals and how to read pictures of data. *American Psychologist, 60*(2), 170.

Cunningham, A.E., & Stanovich, K.E. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology, 33*(6), 934.

Dale, P. S., Crain-Thoreson, C., Notari-Syverson, A., & Cole, K. (1996). Parent-child book reading as an intervention technique for young children with language delays. *Topics in Early Childhood Special Education, 16*(2), 213-235.

de Jong, P.F., & Leseman, P.P. (2001). Lasting effects of home literacy on reading achievement in school. *Journal of School Psychology, 39*(5), 389-414.

Debaryshe, B.D. (2008). Joint picture-book reading correlates of early oral language skill. *Journal of Child Language, 20*(2), 455-61.

Dickinson, D.K., Golinkoff, R.M., & Hirsh-Pasek, K. (2010). Speaking out for language why language is central to reading development. *Educational Researcher, 39*(4), 305-310.

Dickinson, D. K., & Smith, M. W. (1994). Long-term effects of preschool teachers' book readings on low-income children's vocabulary and story comprehension. *Reading Research Quarterly*, 105-122.

Dunn, L.M., & Dunn, D.M. (2007). *Peabody picture vocabulary test (PPVT-4)*. Minneapolis: Pearson Assessments.

Evans, G. W. (2004). The environment of childhood poverty. *American psychologist, 59*(2), 77.

Evans, M.A., Williamson, K., & Pursoo, T. (2008). Preschoolers' attention to print during shared book reading. *Scientific Studies of Reading*, *12*(1), 106-129.

Gilkerson, J., Richards, J. A., & Topping, K. J. (2017). The impact of book reading in the early years on parent–child language interaction. *Journal of Early Childhood Literacy*, *17*(1), 92-110.

Goldin-Meadow, S., Levine, S.C., Hedges, L. V., Huttenlocher, J., Raudenbush, S., & Small, S. (2014).

New evidence about language and cognitive development based on a longitudinal study: Hypotheses for intervention, American Psychologist, 69(6), 588-599.

Gopnik, A., Choi, S. & Baumberger, T. (1996). Cross-linguistic differences in early semantic and cognitive development. *Cognitive Development, 11*(2), 197 - 227.

Gough, P.B., Hoover, W.A., & Peterson, C.L. (1996). Some observations on a simple view of reading. In C. Cornoldi & J. Oakhill (Eds.), *Reading comprehension difficulties* (pp. 1-13). Mahwah, NJ: Erlbaum.

Haden, C.A., Reese, E., & Fivush, R. (1996). Mothers' extratextual comments during storybook reading: Stylistic differences over time and across texts. *Discourse Processes*, *21*(2), 135-169.

Hart, B., & Risley, T.R. (1995). *Meaningful differences in the everyday experience of young American children*. Paul H Brookes Publishing.

Hassinger-Das, B., Ridge, K., Parker, A., Golinkoff, R. M., Hirsh-Pasek, K., & Dickinson, D. K. (2016). Building Vocabulary Knowledge in Preschoolers Through Shared Book Reading and Gameplay. *Mind, Brain, and Education*.

Hess, C. W., Sefton, K. M., & Landry, R. G. (1986). Sample size and type-token ratios for oral language of preschool children. *Journal of Speech, Language, and Hearing Research*, *29*(1), 129-134.

Hindman, A.H., Connor, C.M., Jewkes, A.M., & Morrison, F.J. (2008). Untangling the effects of shared book reading: Multiple factors and their associations with preschool literacy outcomes, *23*, 330-350.

Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child Development*, *74*(5), 1368-78.

Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *Child development*, *62*(4), 782-796.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology*, *27*(2), 236.

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive Psychology*, *45*(3), 337-374.

Lefebvre, P., Trudeau, N., & Sutton, A. (2011). Enhancing vocabulary, print awareness and phonological awareness through shared storybook reading with low-income preschoolers. *Journal of Early Childhood Literacy*, *11*(4), 453-479.

Levine, S.C., Ratliff, K., Cannon, J. & Huttenlocher, J. (2012) Early puzzle play: A predictor of preschoolers' mental rotation skill. *Developmental Psychology, 48,* 530-42.

Levine, S.C., Suriyakham, L.W., Rowe, M.L., Huttenlocher, J., & Gunderson, E.A. (2010). What counts in the development of young children's number knowledge? *Developmental Psychology*, *46*(5), 1309-19.

McCarthy, P. M., & Jarvis, S. (2010). MTLD, vocd-D, and HD-D: A validation study of sophisticated approaches to lexical diversity assessment. *Behavior Research Methods*, *42*(2), 381-392.

MacGinitie, W.H. (2000). *Gates-MacGinitie reading tests*. Itasca: Riverside

Mendelsohn, A.L., Mogilner, L.N., Dreyer, B.P., Forman, J.A., Weinstein, S.C., Broderick, M., Cheng, K.J., Magloire T., Moore T., & Napier, C. (2001). The impact of a clinic-based literacy intervention on language development in inner-city preschool children. *Pediatrics*, *107*(1), 130-134.

Mol, S. E., & Bus, A. G. (2011). To read or not to read: a meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, *137*(2), 267.

Montag, J. L., Jones, M. N., & Smith, L. B. (2015). The Words Children Hear Picture Books and the Statistics for Language Learning. *Psychological Science*, 0956797615594361.

Morrow, M. L. (1983). Home and school correlates of early interest in literature. *The Journal of Educational Research*, *76*(4), 221-230.

Pancsofar, N., & Vernon-Feagans, L. (2006). Mother and father language input to young children: Contributions to later language development. *Journal of Applied Developmental Psychology*, *27*(6), 571-587.

Payne, A.C., Whitehurst, G.J., & Angell, A.L. (1994). The role of home literacy environment in the development of language ability in preschool children from low-income families. *Early Childhood Research Quarterly*, *9*(3-4), 427-440.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Sage.

Richards, B. J., & Malvern, D. D. (1998). *A new research tool: Mathematical modelling in the measurement of vocabulary diversity*. Economic and Social Research Council.

Robins, S., & Treiman, R. (2009). Talking about writing: What we can learn from conversation between parents and their young children. *Applied Psycholinguistics, 30*(3), 463–484.

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development, 83*(5), 1762-1774.

Rowe, M. L., & Goldin-Meadow, S. (2009). Differences in early gesture explain SES disparities in child vocabulary size at school entry. *Science, 323*(5916), 951-953.

Rowe, M. L., Coker, D., & Pan, B. A. (2004). A Comparison of Fathers' and Mothers' Talk to Toddlers in Low-income Families. *Social Development,13*(2), 278-291.

Rowe, M.L., Levine, S.C., Fisher, J.A., & Goldin-Meadow, S. (2009). Does linguistic input play the same role in language learning for children with and without early brain injury? *Developmental Psychology, 45*(1), 90-102.

Rowe, M. L., Raudenbush, S. W., & Goldin-Meadow, S. (2012). The pace of vocabulary growth helps predict later vocabulary skill. *Child Development, 83*(2), 508-525.

Scarborough, H.S., & Dobrich, W. (1994). On the efficacy of reading to preschoolers. *Developmental Review, 14*(3), 245-302.

Sénéchal, M., & Lefevre, J. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Developmental Psychology, 73*(2), 445-460.

Sénéchal, M., Lefevre, J., Thomas, E.M., & Daley, K.E., (1998). Differential effects of home literacy experiences on the development of oral and written language. *Reading Research Quarterly*, *33*(1), 96-116.

Toub, T. S., Hassinger-Das, B., Nesbitt, K. T., Ilgaz, H., Weisberg, D. S., Hirsh-Pasek, K., Golinkoff, R. M. Nicolopoulou, A. & Dickinson, D. K. (2018). The language of play: Developing preschool vocabulary through play following shared book-reading. *Early Childhood Research Quarterly*, *45*, 1-17.

Vigil, D. C., Hodges, J., & Klee, T. (2005). Quantity and quality of parental language input to late-talking toddlers during play. *Child Language Teaching and Therapy*, *21*(2), 107-122.

Wade, M., Jenkins, J. M., Venkadasalam, V. P., Binnoon-Erez, N., & Ganea, P. A. (2018). The role of maternal responsiveness and linguistic input in pre-academic skill development: A longitudinal analysis of pathways. *Cognitive Development*, *45*, 125-140.

Wasik, B. A., Hindman, A. H., & Snell, E. K. (2016). Book reading and vocabulary development: A systematic review. *Early Childhood Research Quarterly*, *37*, 39-57.

Weizman, Z.O., & Snow, C.E. (2001). Lexical output as related to children's vocabulary acquisition:

Effects of sophisticated exposure and support for meaning. *Developmental Psychology*, *37*(2), 265.

Westby, C. E. (1991). Learning to talk, talking to learn: Oral-literate language differences. *Communication Skills and Classroom Success*, 334 –357.

Whitehurst, G.J., Arnold, D.S., Epstein, J.N., Angell, A.L., Smith, M., & Fischel, J.E. (1994). A picture book reading intervention in day care and home for children from low-income families. *Developmental Psychology, 30*(5), 679-689.

Whitehurst, G. J., & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development, 69*(3), 848-872.

Wigfield, A., & Guthrie, J.T. (1997). Relations of children's motivation for reading to the amount and breadth or their reading. *Journal of Educational Psychology*, *89*(3), 420-432.

Woodcock, R.W., McGrew, K.S., & Mather, N. (2001). *Woodcock-Johnson III Tests of Achievement*. Itasca: Riverside Publishing.

Appendix 1. Reading Motivation Questionnaire

Internal Motivation

Reading is one of my favorite activities

I think reading is a great way to spend time

External Motivation

I read to improve my grades

I like to get compliments for my reading

I like having the teacher say I read well

Perceived reading competence

I am a good reader

I am a fast reader

When I am reading by myself, I understand what I read

Table 1. Average number of parent book utterances at each visit.

	Child Age				
	14 m	18 m	26 m	30 m	Average
Non-book reading utterances	969.0	945.9	949.3	989.7	963.4
Book reading utterances	98.7	144.6	95.5	44.7	96.1
Reading the Text	19.2	31.0	30.0	10.5	22.7
Extending the Topic	8.5	14.4	7.7	5.7	9.1
Describing the Picture	33.4	50.0	26.1	14.4	31.1
Print	1.1	0.9	2.0	1.3	1.3
Comment	4.2	4.3	2.2	1.1	3.0
Conversation	14.9	24.3	19.1	8.6	16.8
Behavioral directives	17.3	19.6	8.2	3.1	12.1

Table 2. Correlations between number of parent and child book and non-book reading utterances (average across 4 visits).

	Parent non-book reading utterances	Child non-book reading utterances	Parent book reading utterances	Child book reading utterances
Parent SES	.26~	.13	.35*	.17
Parent non-book reading utterances		.22	.40**	.21
Child non-book reading utterances			.14	.51**
Parent book reading utterances				.64**

~ p< .10, * p < .05, ** p <.01

Table 3. Correlations between number of different types of book utterances.

	Reading the Text	Extending the Topic	Describing the Picture	Print	Behavioral directives	Comment	Conversation
Reading the Text	-	.61**	.47**	.34*	.60***	.70***	.56***
Extending the Topic	-	-	.76**	.45**	.65***	.76***	.78***
Describing the Picture	-	-	-	.47**	.75***	.72***	.90***
Print					.45**	.44**	.44**
Behavioral directives						.74***	.81***
Comments							.82***

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. Estimates of fixed effects, random effects, and goodness of fit for growth models using SES to predict intercept and change in parent and child book and non-book utterances. Coefficients are presented outside the brackets, and standard errors are presented inside the brackets.

	Parent book utterances	Parent non-book utterances	Child book utterances	Child non-book utterances
	Model 1	Model 2	Model 3	Model 4
Fixed Effects				
Intercept	136.9 (23.7)***	961.9 (44.7)***	28.1 (6.5)***	341.3 (28.7)***
Linear Change	-3.9 (1.4)**	.7 (2.9)	1.3 (.4)**	35.5 (2.2)***
Quadratic Change	-1.1 (.3)**	-	-.2 (.1)*	-.4 (.4)
SES	27.9 (29.2)	100.6 (60.4)~	4.3 (7.6)	31.7 (28.4)
SES x Age	-.8 (1.7)	-1.18 (2.9)	.7 (.4)~	4.7 (2.4)~
SES x Age^2	.02 (.04)	-	.01 (.1)	-.08(.4)
Random effects				
Level 2				
Intercept	18368. 1 (135.5)***	87109.5 (295.1)***	1416.6 (37.6)***	30491 (174.6)***
Linear Change	23.9 (4.9)~	105.3 (10.3)~	6.4 (2.5)***	180.5 (13.4)***
Quadratic Change	2.5 (1.6)	-	.2 (.5)***	2.7 (1.6)
Goodness of fit -2 log likelihood	2354.5 (7)	2679.2 (4)	1878.1 (7)	2417.3 (7)

Note. SES = socioeconomic status.
~p < .10. *p < .05. **p < .01. ***p < .001

Table 5. Partial correlations between parent and child book and non-book empirical Bayes estimated growth parameters and child language, literacy and math outcomes, controlling for parental SES.

	Decoding	Reading comprehension	Vocabulary	Calculation	Math word Problems	Internal motivation	External motivation	Perceived reading competence
Parent book utterances intercept	.34*	.26~	.40*	.19	.31~	.38*	.01	.06
Parent non-book utterances intercept	-.04	-.11	.15	.24	.18	.11	.01	-.09
Child book utterances intercept	.34*	.19	.16	.14	.20	.25	-.09	-.03
Child non-book utterances intercept	.37*	.34*	.36*	.25	.38*	.17	.08	.17

Table 6. Estimates of fixed effects, random effects, and goodness of fit for growth models using SES and book and non-book growth estimates to predict child school language, literacy and math outcomes. Coefficients are presented outside the brackets, and standard errors are presented inside the brackets.

	Model 1	Model 2
Fixed Effects		
Decoding		
Intercept	100.602***	100.594***
SES	-.515	-.506
Parent book intercept	-.003	-.006
Parent non-book intercept	-.001	-.001
Child book intercept		.025
Child non-book intercept		-.001
Comprehension		
Intercept	97.509***	97.572***
SES	3.319***	3.235***
Parent book intercept	.016*	.016*
Parent non-book intercept	-.003	-.005
Child book intercept		-.024
Child non-book intercept		.017*
Vocabulary		
Intercept	113.467***	113.486***
SES	5.576*	5.587*
Parent book intercept	.036*	.047*
Parent non-book intercept	.007	.004
Child book intercept		-.017*
Child non-book intercept		.036*
Math word problems		
Intercept	112.913***	113.414***
SES	6.708**	7.111**
Parent book intercept	.032*	.046*

Parent non-book intercept	.008	.002
Child book intercept		-.234
Child non-book intercept		.059*
Internal motivation		
Intercept	78.05***	78.08***
SES	-2.581	-2.590
Parent book intercept	.069**	.081**
Parent non-book intercept	-.003	-.005
Child book intercept		-.156
Child non-book intercept		.024
Level 2		
Decoding	1.381 (1.175)	1.345 (1.159)
Comprehension	23.203 (4.817)***	21.059 (4.589)***
Vocabulary	148.926 (12.204)***	138.584 (11.772)***
Math word problems	264.004 (16.247)***	239.536 (15.479)***
Internal motivation	407.642 (20.190)***	418.222 (20.450)***
Goodness of fit		
-2 log likelihood	1632.971 (16)	1672.368 (16)

Note. SES = socioeconomic status.
$\sim p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$