Published in final edited form as:
J Speech Lang Hear Res. 2010 February ; 53(1): 209–223. doi:10.1044/1092-4388(2009/08-0060).

Conversational Language Use as a Predictor of Early Reading Development: Language History as a Moderating Variable

Laura Segebart DeThorne,
University of Illinois, Champaign

Stephen A. Petrill,
The Ohio State University, Columbus

Chris Schatschneider, and
Florida State University, Tallahassee

Laurie Cutting
Kennedy Krieger Institute, Baltimore, MD

Abstract

Purpose—The present study examined the nature of concurrent and predictive associations between conversational language use and reading development during early school-age years.

Method—Language and reading data from 380 twins in the Western Reserve Reading Project were examined via phenotypic correlations and multilevel modeling on exploratory latent factors.

Results—In the concurrent prediction of children's early reading abilities, a significant interaction emerged between children's conversational language abilities and their history of reported language difficulties. Specifically, conversational language concurrently predicted reading development above and beyond variance accounted for by formal vocabulary scores, but only in children with a history of reported language difficulties. A similar trend was noted in predicting reading skills 1 year later, but the interaction was not statistically significant.

Conclusions—Findings suggest a more nuanced view of the association between spoken language and early reading than is commonly proposed. One possibility is that children with and without a history of reported language difficulties rely on different skills, or the same skills to differing degrees, when completing early reading-related tasks. Future studies should examine the causal link between conversational language and early reading specifically in children with a history of reported language difficulties.

Keywords

expressive language disorders; elementary school students; reading development

The purpose of this article is to examine the relationship between children's conversational language use and indices of early reading development. Given the longitudinal nature of our project, we view reading as a multifaceted developmental construct that encompasses a variety of skills, such as word identification and decoding, which ultimately contribute to the comprehension of written text. Numerous studies have documented that children with language disability tend toward lower reading-related skills than peers with typical language development (Catts, Adlof, Hogan, & Weismer, 2005; DeThorne et al., 2006; Nathan,

Contact author: Laura S. DeThorne, University of Illinois, 901 South Sixth Street, Champaign, IL 61820. lauras@illinois.edu.

Stackhouse, Goulandris, & Snowling, 2004). Similarly, children with reading difficulties have been found to score more poorly on semantic and morphosyntactic measures when compared to age-matched controls (e.g., Nation, Clarke, Marshall, & Durand, 2004; Nation & Snowling, 1998; Scarborough, 1990). In addition to phenotypic findings, significant behavioral genetic results have emerged to support the association between oral language and reading abilities. For example, Bishop (2001) revealed a significant genetic correlation between word reading and oral language difficulties in a twin study of 86 families. Estimates of group heritability ranged from .43 to .87 depending on whether or not literacy scores were adjusted for IQ. In regard to the population at large, a cross-sectional twin study of individual differences in literacy and language at ages 5 and 7 years (N = 126 pairs) revealed substantial genetic overlap between nonverbal cognitive skills, expressive language, phonological awareness, and literacy (Hohnen & Stevenson, 1999; see also Hayiou-Thomas, Harlaar, Dale, & Plomin, 2006).

Despite the possibility of phonological awareness as a common denominator between spoken language and reading development, recent models have emphasized the role of additional skills such as working memory, executive functioning, and fluency (see Cutting, Eason, Young, & Alberstadt, 2009, for a review). In regard to language abilities, investigators have found support for the distinct contribution of semantic and morphosyntax skills to reading development (e.g., Bishop & Snowling, 2004; Harm & Seidenberg, 2004). Conceptually, oral language abilities are thought to provide top-down support to supplement phonological decoding. For example, in reading an irregular word such as *knight*, a child with strong vocabulary is more likely to know that a word pronounced /naIt/ exists in reference to a man in armor who rides a horse. Similarly, that same child is more likely to know that a word pronounced /kənaIgt/ does not exist. In addition, morphosyntactic cues may help prime relevant word properties. For example, in the phrase “My knight in shining armor,” a child’s morphosyntactic knowledge helps narrow the word search to nouns and adjectives as more likely possibilities than verbs and prepositions.

In regard to the association between oral language skills and reading, Ricketts, Nation, and Bishop (2007) studied the association between expressive vocabulary and a variety of reading measures in 81 typically developing children (aged 8–10 years). Findings indicated that vocabulary, as measured via formal assessment tools, accounted for concurrent variance in reading irregular words and reading comprehension but not decoding. Conversely, they found that children with poor reading comprehension exhibited weaker oral vocabulary skills. In addition, Nation and Snowling (2004) found that formal assessments of oral language concurrently predicted reading comprehension above and beyond phonological awareness skills in a sample of 72 typically developing children aged 8½ years (see also Bowey & Patel, 1988).

It is possible that subgroups of children rely on different processes in learning to read, or on the same processes but to differing degrees. As an example, children at earlier stages of reading development are likely to be more dependent on phonological processing skills that aid in the decoding process, but as skills and expectations shift to reading comprehension, oral language skills may play a more significant role (Chall, 1983; Dale & Crain-Thoreson, 1999; Ehri, 1995; Harm & Seidenberg, 2004; Storch & Whitehurst, 2002). Support for this idea comes from a longitudinal study by Storch and Whitehurst (2002) of code-related skills (including phonological awareness), oral language, and reading in 626 children from Head Start. The authors found a nonlinear relationship between oral language and reading over time, with oral language demonstrating significant concurrent associations with preschool code-related abilities as well as third- and fourth-grade reading comprehension. Of interest, concurrent associations between oral language and reading were not significant during first and second grades (see also Dale & Crain-Thoreson, 1999).

In addition to developmental shifts, it is possible that subgroups of children with different cognitive profiles rely to differing degrees on various processes and strategies in learning to read. Although potential subgroup differences are not routinely studied, Wolf (1984) found that impaired readers demonstrated different associations between reading and automatic naming than did children without reading difficulties. The present study examined the extent to which the relationship between language and reading may be different based on children's reported history of language difficulties.

Regardless of the subgroup studied, literature associating oral language skills with early reading development has relied primarily on formal assessments of language, such as standardized test results. The extent to which such findings generalize to children's language use in functional contexts is unclear. Theories of situated learning (e.g., Brown, Collins, & Duguid, 1989; Ukrainetz, 1998) suggest that the learning context influences mental representations and the actual deployment of acquired skills. As an example, one might imagine that vocabulary words acquired within the context of conversational interactions are not as easily recalled within the very different context of a standardized test. The contexts are likely to offer different cues (i.e., semantic, syntactic, visual), to inspire distinct motives (e.g., communication vs. performance), and to draw upon separate skill sets (e.g., attention, frustration tolerance, extraversion). In support of this view, previous studies have found that formal language assessments versus conversational language measures tend to load on different factors (e.g., DeThorne et al., 2008; Mather & Black, 1984). Given the potential influence of assessment context, previously demonstrated associations between standardized assessments of spoken language and reading may reflect shared cognitive mechanisms of interest (e.g., phonological processing) or be influenced by extraneous factors specific to the formal assessment context (e.g., attention, motivation, frustration tolerance). One way to examine the extent to which assessment method affects the association between oral language and reading is to include language measures from a more naturalistic context.

Evidence suggests that naturalistic language abilities may play a unique and important role in reading development, at least in children with learning disabilities. A study by Scarborough (1990) found that children with dyslexia (n = 20) had poorer syntactic skills at 30 months than controls (n = 20), as measured via naturalistic language sample measures. The findings in regard to early vocabulary skills were less clear. Bishop and Adams (1990) followed the language and literacy development of 83 children whose language development had been delayed at age 4. Children whose spoken language difficulties had not resolved by 5½ years of age (n = 37) were at increased risk for difficulties in reading comprehension at age 8½ years compared to children without spoken language difficulties at age 5½ years (n = 29). Of particular interest, when groups were combined and preschool-age measures of expressive and receptive language were regressed on reading outcomes at age 8 years, mean length of utterance (MLU) served as the strongest and most consistent predictor of later reading abilities. Specifically, after controlling for performance IQ, preschool MLU accounted for an additional 9% of variance in reading accuracy and 10% in nonword reading at 8 years of age. In such cases, MLU served as a stronger predictor than standardized measures of both expressive and receptive language use.

Although there are fewer studies of naturalistic language and reading in typically developing children, Miller, Heilmann, and Nockerts (2006) focused on the association between oral language proficiency and reading proficiency in a sample of 1,531 bilingual children attending kindergarten through third grade. The children were described as Spanish-dominant and English language learners. Spoken language skills were assessed through story retell procedures, both in Spanish and in English. The resulting language samples, which averaged 40 utterances in length, were utilized to derive MLU, number of different words, words per minute, and an index of narrative coherence. When grade differences were controlled, these combined oral language measures predicted 10% of reading comprehension when both were evaluated in Spanish and 22% when both were evaluated in English. Similarly, same-language predictions of word-level reading by oral language measures accounted for 7% of unique variance in Spanish and 8% in English.

In sum, there is theoretical and empirical support for the relationship between spoken language and reading development. The present study extends prior findings by allowing us to focus on the association between conversational language and reading in a longitudinal population-based sample that includes children with and without a reported history of language difficulties. We focused on conversational rather than narrative language due to the inherent social validity of the conversational context and the increased ability to control sample length. Our specific research questions were as follows:

1. To what extent do children's word- and sentence level conversational abilities account for individual differences in early reading abilities?
2. Does the association between conversational language and early reading differ for children with a history of reported language difficulties compared to those without such a history?
3. If associations are observed, is conversational language able to predict early reading skills above and beyond formalized measures of vocabulary?

Method

Participants

Participants for the present study involved 380 children (42%male) from the Western Reserve Reading Project (WRRP), a longitudinal twin study of reading and related cognitive abilities (Petrill, Deater-Deckard, Thompson, DeThorne, & Schatschneider, 2006). Twins were recruited from the large metropolitan areas of Cleveland, Columbus, and Cincinnati, Ohio, primarily through school nominations and media advertisements. The project involved four direct assessment periods during the initial 3 years. The first home visit was conducted after children entered kindergarten but before they completed first grade. Assessments consisted of direct assessment during home visits and parent/teacher questionnaires. Note that behavioral genetic results for the early reading and language measures are reported in Petrill et al. (2006) and DeThorne et al. (2008), respectively. Consistent with DeThorne et al. (2008), children were selected for the current study based on the following criteria: (a) complete data on zygosity, age, and sex; (b) a reported history of typical hearing; and (c) a conversational language sample of at least 50 child utterances from the second-year home visit.

The selected sample included 156 monozygotic twins (MZ; 39% male) and 224 dizygotic twins (DZ; 44% male) with the mean age of the sample being 7.13 years (*SD* = .65) at the time of the second home visit. Based on caregiver self-report of race/ethnicity, the vast majority of the sample was white (93%), with at least 94% of the primary caregivers having attained a high school diploma. See DeThorne et al. (2008) for additional sample detail.

Procedures

After returning initial paperwork, including a speech-language survey, families were contacted to schedule initial home visits (HV1), which focused largely on the assessment of early reading and did not include a measure of conversational language. The second home visit (HV2) assessed children's conversational language use in addition to reading and was scheduled approximately 1 year after the initial home visit, with the third home visit (HV3), which mirrored the second visit in terms of content, scheduled approximately 1 year after that. At each home visit, twins were assessed simultaneously in separate rooms by different examiners.

Information on the examiners was available for 85% (322/380) of the study participants. Of the 13 different examiners who collected these data, all held bachelor's degrees. Many of the examiners were enrolled in graduate study of related disciplines, such as psychology, but none were certified speech-language pathologists (see DeThorne & Hart, 2009, for additional information). In terms of training, each examiner reviewed the full assessment protocol and observed at least two home visits conducted by a seasoned examiner. Twin zygosity was determined through DNA testing on buccal swabs, with a few families choosing instead to complete a measure of twin physical similarity reported to be 95% accurate when compared to DNA analyses (Goldsmith, 1991; Price, Eley, Dale, Stevenson, Saudino, & Plomin, 2000).

Measures

Speech-language survey: Developed explicitly for WRRP, the Speech-Language Survey included a series of 12 questions related to children's speech-language development, including history of hearing difficulties. A history of difficulty in any area was identified separately for each twin. Most relevant to the present study is the question regarding the children's expressive language development: "Has either of your twins ever had difficulty learning words (vocabulary) and/or forming sentences (using correct grammar)?" If the response was yes, the caregiver was asked to specify which twin(s) and whether or not the difficulty had abated. For the purpose of this study, responses to this question were used to group children according to their reported history of language difficulties. Although a single questionnaire item represents a limited form of assessment, we utilized it here due to its intrinsic social validity and the fact that direct assessments prior to kindergarten were not available. DeThorne et al. (2006) demonstrated that parents' report on this questionnaire item led to significant estimates of heritability and revealed predictable group differences in language functioning.

Conversational language sample: The collection of the language sample encompassed a 15-min conversational exchange between examiner and child while the two were engaged with modeling clay. Examiners were free to follow the child's interest, but potential topics were provided, such as school, holidays, movies, and sports. In addition, examiners were trained to follow guidelines provided by Leadholm and Miller (1992) such as (a) ask open-ended questions, (b) offer comments and information of interest to the child, and (c) be patient. Samples were recorded using a Marantz analogue tape recorder (PMD201) and Sony stereo digital omnidirectional microphone (ECM-717).

Audio samples were sent to the first author's laboratory for transcription into Systematic Analysis of Language Transcripts, Version 8.0 (SALT; Miller, 2004) by trained research assistants. Research assistants included both undergraduate and graduate students in speech and hearing science. Transcription training included a review of related guidelines (e.g., SALT tutorial and lab manual), consultation with experienced transcribers, and practice transcription. Students did not begin to transcribe independently until at least one practice transcript resulted in a minimum agreement of 85% with the transcription of a seasoned transcriber in regard to utterance boundaries and individual morphemes. Transcription conventions included segmenting utterances into communication units (C-units), as outlined in Nippold (1998). Specifically, independent clauses joined by coordinating conjunctions (i.e., *and*, *or*, *but*) were segmented. Each transcribed sample was reviewed independently by a second transcriber who corrected obvious errors. Ambiguous situations were resolved through discussion with the first author at weekly meetings. Transcription agreement on 43 randomly selected transcripts averaged 90% (range = 70%–100%) for C-unit boundaries and 91% (range = 80%–98%) for individual morphemes.

The following measures were derived from each language sample using SALT: mean length of C-unit in morphemes (MLU-C), number of total words (NTW), number of different words

(NDW), total number of conjunctions (TNC), and Developmental Sentence Score (DSS; Lee, 1974). All measures were calculated from the first 100 complete and intelligible child utterances from each transcript, with the following two exceptions. Given that MLU-C is an average metric that increases in reliability with increased sample size (Gavin & Giles, 1996), it was derived from the total number of complete and intelligible utterances, which varied across samples. In addition, DSS was calculated on all utterances that contained both a subject and a predicate. Utterances that were eligible for DSS were submitted to automated analyses using a program referred to as gcSalt (Channell, 2006), and then automated scores were subjected to manual correction. Scoring conventions were consistent with Lee (1974) and Lively (1984) with two exceptions: (a) the scoring of *like* abided by suggestions made by Hughes, Fey, and Long (1992), and (b) all initial conjunctions other than *and* were assigned credit due to the subsentential nature of C-units. Although reference data for children of early school age are scarce, findings from Lee (1974) combined with Dallmann (1973) suggest a relatively steady increase in DSS from age 2 to 9 years. Samples that did not include at least 35 eligible utterances were excluded from DSS analysis due to concerns with reliability (Johnson & Tomblin, 1975). Likewise, samples with fewer than 100 total complete and intelligible utterances were not included in analyses of NDW, NTW, and TNC (Gavin & Giles, 1996). Additional information regarding the rationale for selecting the language sample measures and the details involved in calculating them is available in DeThorne et al. (2008).

Reading-related measures: Measures of reading were selected to reflect multiple components of development, including both phonological and print-based skills, and to be consistent with prior literature. Specifically, phonological awareness skills were tapped using tasks from the Phonological Awareness test (PA; Robertson & Salter, 1997): rhyming, initial phoneme isolation, whole-word phonemic segmentation, and phonemic deletion. Based on factor analyses (DeThorne et al., 2008) and general support for phonological awareness as a unitary construct (Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999), the raw scores from these tasks were summed to derive a measure of phonological awareness. Three subtests from the Woodcock Reading Mastery test (Woodcock, 1987) were also employed: Word Attack (WA), which requires children to read nonsense words or English words of very low frequency; Word Identification (WID), which asks children to identify relatively common English words from print; and Passage Comprehension (PC), which utilizes a modified cloze procedure. More specifically, PC involves presenting children with written material of one to three sentences in length with a key word missing from the text. Easier items include a line drawing in conjunction with the text.

Due to our theoretical framework of reading development, analyses focused on reading measures fromHV2 and HV3, rather than from HV1. Because spoken language development generally precedes reading, we would expect spoken language skills to predict current and future reading skills rather than the other way around. As reading skills progress and the focus shifts to reading as a means to acquire information, we would expect reading skills to exert a greater influence on spoken language development (Chall, 1983; Dale & Crain-Thoreson, 1999; Ehri, 1995; Harm & Seidenberg, 2004; Storch & Whitehurst, 2002).

Formal vocabulary measures: Given associations between expressive vocabulary and reading development (e.g., Lyytinen & Lyytinen, 2004; Ricketts et al., 2007), we included two formal measures to reflect skills in both confrontational naming and generation tasks (cf. Wolf, 1984). Confrontational naming was assessed via the Boston Naming Test (BNT; Goodglass & Kaplan, 2001), which elicits names of pictured items. The Vocabulary subtest from the Stanford-Binet Intelligence Test (SB-Vocab; Thorndike, Hagen, & Sattler, 1986) was administered as a generation task, which elicits word definitions.

Due to the sizeable sample, corrections for age and sex on all measures were accomplished through regression procedures on raw scores rather than through use of normative data from test manuals. In addition to descriptive and correlation analyses, study questions were addressed via multilevel modeling using factors for formal vocabulary, conversational language, and reading.

Results

Descriptive statistics for language and reading raw scores are summarized in Table 1. Conversational samples ranged in length from 50 to 272 complete and intelligible utterances, with a mean of 144 utterances and a standard deviation of 42. DSS data were restricted to the 342 children whose samples contained a minimum of 35 eligible utterances (i.e., contained a subject and predicate); on average, these samples contained 99 eligible utterances (*SD* = 34). Similarly, NTW, NDW, and TNC measures were restricted to the 326 samples that contained a minimum of 100 complete and intelligible utterances. Note that our sample means for conversational measures are comparable to reference values provided via SALT. Specifically, a comparison sample of 49 children between the ages of 6;8 and 7;6 (years; months) yielded mean values of 5.38 for MLU, 181 for NDW, 491 for NTW, and 48 for TNC. Since reference values were derived using 100 complete and intelligible C-units, a comparison of the total number of complete and intelligible C-units (TCICU) is not appropriate. In short, results suggest that our language sample measures are comparable to typical variation in singleton samples and support the view that findings from twins can be generalized to the singleton population (see DeThorne & Hart, 2009;DeThorne et al., 2008;Evans & Martin, 2000, for additional discussion).

Consistent with prior WRRP studies, raw scores for all variables were corrected for both linear and nonlinear effects of age and sex so that associations between measures would not be inflated by these factors. Prior to correction, correlations with child age ranged from small to moderate in effect size. Mean differences based on sex were relatively small and emerged for two variables, favoring girls in the case of TNC and boys in the case of BNT. Distributions of the corrected variables were relatively normal, with skewness values ranging from −0.53 for BNT at HV3 to 0.93 for TNC at HV2. Kurtosis values ranged from −.76 for WA at HV2 to 1.54 for TNC at HV2.

Of the 378 children with data from the Speech- Language Survey, 73 (19%) were reported by caregivers to have had difficulties in expressive language development at some point prior to initiation of WRRP. The percentage was relatively similar across zygosity types, with 18% and 21% of DZ and MZ twins, respectively. Many of these difficulties were reported to have subsided, however, with a lesser number, 12%, of the twins, reported to behaving expressive language difficulties at the time they were enrolled in the study (8% and 18% for DZ and MZ twins, respectively). Given that group analyses focused on reported history of language difficulties, not the reported recovery of these difficulties, MZ twins were represented in relatively equal proportion in both groups being compared in the present study. Specifically, 45% (33/73) of the children with a history of reported difficulties were MZ versus 40% of the 121 children without reported difficulties. Finally, only 7% of the twins were reportedly being seen by a speech-language pathologist at the initiation of the WRRP, with the percentage being similar for DZ and MZ twins at 8% and 7%, respectively.

Twins with a reported history of language difficulties, either persistent or resolved, were grouped and compared to children without any reported history of language difficulties. For the comparison, children's age- and sex corrected scores were converted to *z* scores so that mean differences would represent standard deviation units related to the sample as a whole. Mean differences in favor of children without a history of difficulties were observed for all conversational language measures ($p < .01$), except TNC, and for all reading measures at HV2 and HV3 (see Table 2). Mean differences ranged from 0.23 to 0.46 of a standard deviation for the conversational measures, from 0.37 to 0.69 of a standard deviation for the formal vocabulary and reading measures from HV2, and from 0.53 to 0.98 of a standard deviation for formal measures from HV3. Not only did group differences persist at HV3, but they appeared to increase across the board, particularly for the reading-related measures. The present study is not set up to explain this trend toward larger group differences at the later HV; however, we speculate that it may be an artifact of test construction or a real indication that children at risk for reading difficulties tend to fall further behind as expectations increase.

Based on this descriptive information, our subgroup of children with a reported history of language difficulties is not easily translated into other groups previously reported in the literature. However, the subgroup likely overlaps in part with children referred to as “late talkers” or “late bloomers” because of the high percentage of the children in this study whose difficulties reportedly resolved before the initiation of the study (see Paul, 1996). Although receptive language difficulties were not ruled out in the present sample, additional information from parent report suggest that the majority of these children did not have concomitant receptive language difficulties (DeThorne et al., 2006). In addition, the language and reading data from both HV2 and HV3 suggest that this subgroup also includes children identified with language and/or reading disability in their early school-age years, thereby overlapping in part with participant pools with specific language impairment and dyslexia. Specifically 16 of the 73 children (22%)with a history of reported language difficulties were receiving speech-language services as they entered WRRP around kindergarten/first grade.

Correlation matrices were all derived from age- and sex-corrected raw scores to examine associations between reading and language measures. Table 3 provides the coefficients for HV2 child language and HV2 reading measures on the entire sample. Given the large number of correlations, alpha was set at .01 to minimize false positives. Three findings worth highlighting include (a) the significant correlations across all conversational language measures and across all reading measures, with effect sizes ranging from medium to large (Cohen, 1988); (b) a significant correlation between the two formal vocabulary measures of medium effect size; and (c) the inconsistent and relatively small correlations between conversational language and reading measures. In regard to the last point, NDW correlated significantly with all reading measures, but the effect size was small. Similarly, DSS, TNC, and NTW all correlated with PA while DSS and NTW correlated with WA as well, but the effect size was small in each case.

To examine the extent to which relationships between conversational language and reading might be different for children with language difficulties, correlations were derived for the 73 children with a reported history of language difficulties (see Table 4). Given an alpha of .01, significant correlations emerged between WA and all conversational language measures and between PC and all conversational language measures except DSS and NTW. In addition, PA correlated with both DSS and NDW, while WID correlated with NDW. All statistically significant correlations reached medium effect sizes, with coefficients ranging from .32 to .50. Figure 1 illustrates the association between two representative variables, MLU-C and WA, in children with and without a history of reported language difficulties. As depicted in Figure 1, correlation findings suggested that history of reported language difficulties served as a moderator variable by impacting the strength of the association between conversational language and early reading development (see Baron & Kenny, 1986, for a general description of moderator variables).

The stability of the correlation findings was examined by deriving correlations between HV2 child language measures and the reading measures collected 1 year later at HV3 (see Tables 5 and 6). Results largely mirrored findings of the concurrent relationships. Specifically, findings from the entire sample revealed significant correlations between NDW and all reading measures, but with primarily small effect sizes. In addition, MLU-C and NTW both correlated significantly with WA and PC but with coefficients of small effect size. Within a selected sample of 73 children with a history of reported language difficulties, WA and PC yielded the most consistent relationships with conversational measures reflected by correlation coefficients of medium effect sizes.

Exploratory Factor Analyses

Consistent with DeThorne et al. (2008), we formed factor scores for reading and language using unrotated principal component factor analyses. Factor 1 (hereby referred to as the formal vocabulary factor) consisted of the two formal vocabulary assessments, SB-Vocab and BNT, with loadings of .86 for both variables. Factor 2 (hereby referred to as the conversational factor) included MLU, NTW, NDW, TNC, and DSS, with loadings ranging from .73 to .96. Finally, the third factor (hereby referred to as the reading factor) contained all reading measures, with loadings ranging from .68 to .94 for HV2 and from .66 to .92 for HV3.

Multilevel Modeling

Multilevel modeling was employed to provide statistical analyses of reported language history as a moderator in the relationship between conversational language and early reading. Multilevel modeling was chosen over regression analyses due to the nested issues inherent in twin designs. In any phenotypic analyses of twin data, the primary statistical issue is lack of independence across observations that is a common assumption for key distributions (such as the *t* and *F* distributions) and standard statistical techniques (such as regression). Without some means to model this lack of independence, Type 1 error rates could be inflated. In order to control for this lack of independence, we employed multilevel modeling, which is designed more generally to handle dependent observations. This is done by treating each twin as “nested” within the twin pair. In the language of multilevel modeling, each twin is considered at level 1 and the pair is considered level 2. By portioning the variability into between-pair variance and within-pair variance, we are able to get the correct standard errors for our fixed effects (such as language status and other predictors).

In the present analyses, the reading factor from both HV2and HV3was each predicted separately from (a) the formal vocabulary factor, (b) children’s history of reported language problems, (c) the conversational factor, and (d) relevant two-way interaction terms. Formal vocabulary was entered first in order to determine whether conversational language predicted unique variance in early reading above and beyond formalized vocabulary assessments. Consistent with the correlation analyses, the best fitting model in predicting reading at HV2 included the interaction term between conversational language and history of reported language difficulties (see Table 7). In contrast, the best fitting model in predicting HV3 reading relied only on the formal vocabulary factor and history of reported language difficulties. Estimates from the best-fitting models are provided in Table 8. In sum, formal vocabulary and history of reported language difficulties contributed significantly to reading outcomes at both home visits. Conversational language offered concurrent associations with early reading development above and beyond the variance attributed to formal vocabulary scores, but only in children with a reported history of language difficulties atHV2. Specifically, 4%(0.21^2) of the variance in HV2 reading was uniquely predicted by theHV2 conversational language factor for children with a reported history of language difficulties. Conversational language did not provide unique variance to early reading in children without a reported history of language difficulties. Although the best-fitting model in predictingHV3 reading did not include conversational language, it is worth noting that the interaction between conversational language and reported history of language difficulties approached significance in the fixed effects model, with an estimate of 0.23 ($p = .07$).

Discussion

In sum, this study found that reported history of language difficulties moderated the concurrent relationship between conversational language and early reading at the second home visit. Specifically, conversational language skills predicted a relatively small but significant amount of unique variance in children's early reading development, above and beyond formalized vocabulary measures, but only for children with a reported history of language difficulties. The ensuing discussion will review evidence for the moderation effect and focus on three possible explanations for it. In addition, the potential role of assessment methods in interpreting differences across studies will be included, followed by an overview of implications and future directions.

Language History as a Moderator

Support for language history as a moderator of the association between conversational language and reading came from two primary sources. First, correlations between language and reading were relatively small and most often nonsignificant for the population as a whole, but when the sample focused on children with a reported history of language difficulties, correlations were more apt to reach significance (despite decreased sample size), and effect sizes increased (see Tables 3, 4, 5, and 6). Second, results from the multilevel modeling revealed a statistically significant interaction between conversational language and children's reported history of language difficulties in the prediction of concurrent reading abilities at HV2. Although the same interaction was not significant in the prediction of reading at HV3, the trend was in a similar direction. It is prudent to note that the effect size of the significant interaction for HV2 is relatively small, with only 4% of the variance in reading at HV2 being uniquely accounted for by conversational language at the same time point. However, the unique variance being accounted for is above and beyond associations between reading and formalized vocabulary, which were significant and mostly moderate in effect size (see Table 3). In the correlation matrices, where variance attributed to the formal vocabulary factor was not regressed out of reading, individual conversational language measures accounted for up to 25% of the variance in WA at HV2 and up to 44% at HV3 specifically in children with a reported history of language difficulties.

Given support for language history as a moderator of the association between conversational language and reading, we have considered three possible models to account for the significant group interaction, none of which is mutually exclusive of the others (see Figure 2). First, we considered a *threshold model,* in which children's conversational language skills would only be associated with early reading development until a certain level of language competence is achieved. After this point or "threshold," additional gains in conversational language skill would not transfer as directly to gains in reading (see Figure 2a.). Although the specifications of *threshold effects* vary across the literature (e.g., Lee & Schallert, 1997), we refer here to an interaction effect in which the association between language and reading development would vary based on children's level of language ability. As an example, one might imagine that early differences in children's expressive vocabulary might help children decode phonologically ambiguous words, such as *car,* in which the initial letter could represent either /s/ or /k/. However because early reading material focuses on relatively simple vocabulary, variations in more advanced word knowledge (e.g., *convertible, SUV*) may not contribute directly to differences in reading at this stage. Another contributing factor to a threshold effect would be if conversational language measures were not adequately sensitive to individual language differences in the population as a whole and therefore not able to differentiate children in the group without a history of language difficulties. Either way, results were generally not supportive of a threshold effect interpretation. Specifically, there was no clear indication that the subgroup of children with a reported history of language difficulties was substantially different in their current conversational abilities. Although mean differences in conversational language measures did favor children without a reported history of difficulties by approximately a third of a standard deviation, the range in conversational language skills was largely overlapping between the two groups (see Figure 1).

The second explanatory model suggests that the association between conversational language and reading is dependent upon children's stage of reading development (see Figure 2b). Various authors have suggested that children at earlier stages of reading development are more likely to be dependent on phonological awareness skills as they focus on the process of decoding. As children's reading develops, they become increasingly dependent on oral language skills as the focus shifts to the comprehension of written material (Chall, 1983; Cutting et al., 2009; Dale & Crain-Thoreson, 1999; Ehri, 1995; Harm & Seidenberg, 2004; Rack, Snowling, & Olson, 1992). The shift from phonological awareness skills to increased reliance on top-down processes is reported to begin around fourth grade (Dale & Crain-Thoreson, 1999), a grade or two later than that of the current study participants. Consequently, it is possible that conversational language was not significantly associated with reading in the children without a reported history of language difficulties due to their current age and stage of reading development, which may focus largely on decoding. This finding is consistent with Storch and Whitehurst's (2002) finding that oral language is not significantly associated with reading in first and second grades.

Although a reading stage model may account for the limited associations between conversational language and reading in the sample as a whole, it does not account readily for why that same relationship was significant in the selected group of children with a reported history of language difficulties. If anything, a two-stage reading model, as it has been presented here, would predict a weaker association in this subgroup because as a whole, these children are at an earlier stage of reading development. Note that mean differences across reading measures consistently favored the group without a history of language difficulties by a third to nearly a full standard deviation (see Table 2), thereby supporting the position that they are at a substantially lower reading level than their peers. With the finding of substantially depressed reading scores, it is possible our findings in the selected group are comparable to positive correlations reported between oral language and emergent literacy skills in studies of preschool-age children. For example, the longitudinal study by Storch and Whitehurst (2002) found that oral language skills accounted for 48% of the variance in code-related skills (e.g., phonological awareness, letter identification) within preschool-age children. This relationship decreased in kindergarten and then re-emerged in later years (third and fourth grades) but with different reading measures. However, our findings do not seem entirely comparable to the associations between code-related skills and oral language found in preschool children, because the significant correlations in our group extended to reading skills outside of phonological awareness, such as passage comprehension. That said, if our selected group is comparable to preschool-age children in regard to their stage of reading development, it's possible that a three-stage model with a cubic trend between oral language and reading skills could account for our findings.

A third potential explanation for the significant interaction, and the one we currently favor, is that children's reported history of language difficulties segments the sample into two somewhat distinct subpopulations. Note that the subpopulation argument is not a new idea; Wolf (1984) identified "a whole different set of relationships between naming and reading" in children with impaired reading skills versus those without such challenges (p. 109). It is possible that the groups may be qualitatively or quantitatively different in regard to the type of cognitive processes utilized in spoken language and reading development. As an example, a reported history of language difficulties may reflect difficulties in phonologic processing that would make children more dependent on top-down processes in reading acquisition, and consequently more apt to struggle in early stages of reading development that rely strongly on phonological decoding. Consequently, the positive association between conversational language and reading in this group may reflect an increased reliance on top-down processes, such as semantic and morphosyntactic skills, during early reading development. In other words, individual differences in semantic and morphosyntactic skills have a larger impact on reading development in the group with a reported history of language difficulties because their reading development is more dependent upon such skills due to deficits in other areas. Although the children with a reported history of language difficulties did score lower overall on measures of conversational language, their scores were highly variable and the group differences were not as pronounced as for the reading-related measures. Some children without a reported history of language difficulties may struggle with early reading too but perhaps to a lesser degree or for different reasons.

Two forms of evidence support the different subpopulations interpretation. First, mean differences in reading measures consistently favored the group without a reported history of language difficulties, with differences up to 1 *SD* between the two groups on measures such as WA and WID. The group differences in reading not only persisted in HV3 but appeared to increase in effect size, thereby implying more than a transient difficulty. Given that groups were formed based on past language abilities, it was surprising to see that group differences were more striking for reading than for current conversational language skills. Consequently, it is feasible that the children with a history of reported language difficulties may approach early reading in a somewhat distinct way from their peers for reasons that overlap in part with their early difficulties with language development.

A second form of support for the position that children with a reported history of language difficulties may be relying more on top-down processes is the pattern of observed correlations between conversational language measures and reading-related skills. Although we cannot assume that individual coefficients are significantly different from each other, a couple of general trends are notable. First, WA and PC demonstrated the most consistent positive correlations across conversational language measures in the selected group for both HV2 and HV3. In fact, correlations for the selected group appeared stronger during HV3 than HV2, but the same could be said for these correlations in the sample as a whole, which is perhaps why the interaction term was shy of significance for HV3. Both WA and PC could be considered more susceptible to top-down semantic and morphosyntactic processing than measures of WID and phonological awareness. Reading comprehension in general is considered more susceptible to differences in children's oral language abilities (cf. Nation & Snowling, 2004), and although WA is considered a measure of phonological decoding due to its reliance on unfamiliar words (cf. Storch & Whitehurst, 2002), even unfamiliar words could be decoded more easily with increased vocabulary knowledge. For example, the pronunciation of the nonwords *plip* and *vauge* could be aided through prior knowledge of phonologically similar words, such as *slip* and *gauge*. Given the age of our participants and resulting focus on word level processes rather than in-depth reading comprehension, the present results may actually provide a conservative estimate of the associations between language and reading comprehension. The more in-depth measures of reading comprehension that accompany later stages of reading assessment may reveal stronger associations with conversational language measures in the sample at large (see Cutting et al., 2009).

Altogether, results provide modest, but by no means definitive, support for the subpopulations model (see Figure 2c), thereby suggesting that children with a reported history of language difficulties may be approaching early reading tasks in a somewhat distinct way, either relying on different cognitive processes or on the same process to differing degrees, than children without a reported history of language difficulties. That being said, we will be the first to note that this is not the outcome we predicted. Consistent with scientific parsimony, current views of language difficulties, especially difficulties without an identified organic origin, favor quantitative rather than qualitative differences (e.g., Plomin & Kovas, 2005). In other words, children with language difficulties of unknown origin are often viewed as the lower end of a common continuum that includes children without language disabilities as well (cf. Plomin, Colledge, & Dale, 2002). Speaking to this view, the distribution of current conversational language skills in our subgroup largely overlapped with the distribution from children without a reported history of language difficulties (see Figure 1). As we already discussed, group differences in reading-related skills were more notable than differences in conversational language abilities. Consequently, replicating these findings using different samples, particularly samples in which the nature of children's past language difficulties is better understood, is needed.

Assessment Method as Influential Factor

In addition to solidifying the association between early spoken language difficulties and early reading challenges, the current study highlights the potential impact of assessment method on the relationship between language and reading skills in children without language disability. Note that formalized vocabulary assessments, specifically the BNT and SB-Vocab, correlated significantly with reading-related measures for the entire sample (see Table 3) and served as a significant predictor of reading outcomes during both home visits (see Table 8). In this regard, findings are consistent with previous studies that have demonstrated associations between formalized expressive vocabulary measures and reading skills in typically developing children (e.g., Nation & Snowling, 2004;Ricketts et al., 2007). However, our finding that conversational language measures do not predict early reading in children without a reported history of language difficulties suggests that associations may be tempered by the form of assessment utilized. For example, associations between decontextualized assessments may be influenced by common factors other than the domains being tested—factors such as motivation, frustration tolerance, task persistence, etc. Most simply put, measures of reading and language may covary in part because certain children are better at "taking tests" regardless of what the test content might be. Measures of conversational language are likely to be influenced by extraneous factors as well, but not the same extraneous factors that influence formal assessments of early reading (see DeThorne & Watkins, 2006). Consequently, associations between formalized assessments of both reading and language may provide inflated estimates of shared underlying processes between the two domains.

On the topic of assessment context, it is important to consider that results may have differed had we focused on narrative rather than conversational language samples (see Scott & Stokes, 1995). Specifically, results from Miller et al. (2006) found that narrative language measures, as a whole, predicted relatively small but unique variance in children's word identification and reading comprehension. However, two differences between studies, other than narrative versus conversational samples, are particularly worth noting. First, the sample in Miller et al. (2006) was bilingual in their language and reading development, which may or may not influence the nature of such relationships. Second, the language measures were combined with an index of narrative coherence, so it is not clear to what extent the structural measures of MLU, NDW, and words per minute would have independently predicted variance in reading development. Regardless of the effect of such differences, one might expect greater relation between narrative language skill and reading outcomes, especially in regard to reading comprehension, due to overlapping features such as plot development and structural organization. In fact, children are sometimes taught a formula for narrative structure in school that may influence both reading comprehension and narrative language skill.

One final consideration in regard to the reported relationship between language and reading is the important distinction between expressive and receptive language abilities. By design, language samples have focused on expressive skills, largely because receptive abilities are harder to measure reliably in a naturalistic context. However, given that reading comprehension is largely a receptive skill, one might anticipate more direct associations with receptive language than with expressive tasks. Whereas both receptive and expressive language skills tap into language knowledge, expressive language places additional demands on motoric and social development, for example, in comparison to strictly receptive tasks. Consequently the present study is not able to speak directly to the association between receptive language skill and reading development.

Implications and Future Directions

In regard to clinical implications, strong semantic and morphosyntactic skills within a conversational context are likely to lessen the risk of early reading difficulties in children with a reported history of language difficulties. On a related note, strategies to compensate for difficulties in early reading should be considered, such as the use of semantic knowledge and the surrounding linguistic context. For example, a child stuck on the pronunciation of *cantaloupe* in the sentence “She cut up a cantaloupe for the fruit salad” could be prompted with cues such as the following: “Given the rest of the sentence, what word would make sense?” or “What kind of fruit starts with the letter *c*?” A review by Rack, Snowling, and Olson (1992) supports phonological deficit as a key factor in reading disability but also highlights the potential role of other factors, such as oral language skills, in supplementing or compensating for weakness in the phonological domain. For example, speech-language pathologists could work on facilitating the understanding of vocabulary and morphosyntactic structures embedded within the children’s reading material at home or in school (see van Kleeck, 2007).

In addition to studying the effectiveness of such treatment strategies, future studies should consider searching for neurological and allelic differences in children with a reported history of language difficulties. Within a behavioral genetic design, oversampling of children at risk for language and reading difficulties could provide enough power to test for shared genetic and environmental influences between language and reading, an analysis that was not possible in the present study due to the limited number of children with speech-language disability in our population-based sample. In addition, studies of neurological differences in children with language disability would benefit from including participants with and without accompanying reading difficulties in order to identify what neuro-correlates underlie observed behavioral differences in these two subpopulations. Finally, studies of child language need to consider including measures of naturalistic language use, such as conversational or narrative samples, in order to tease apart the contextual effects on the construct of interest. If we are to make the most difference in children’s everyday lives, the ultimate goal must be to understand causal influences on meaningful discourse.

Acknowledgments

The Western Reserve Reading Project is supported by National Institute on Child Health and Human Development (NICHD) Grants HD38075 and HD46167. In addition, transcription and analyses have been supported by the American Speech-Language-Hearing Foundation New Investigator Award, the UIUC Campus Research Board, and the Children Youth and Families Consortium at the Pennsylvania State University. Interdisciplinary collaborations have been enhanced by the American Speech-Language-Hearing Association Advancing Academic–Research Careers (AARC) Award. In addition, we sincerely appreciate the time and effort of all participating families and affiliated research staff. Special thanks to Ron Channell for deriving DSS.

References

Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology 1986;51:1173–1182. [PubMed: 3806354]

Bishop DVM. Genetic influences on language impairment and literacy problems in children: Same or different? Journal of Child Psychology and Psychiatry and Allied Disciplines 2001;42:189–198.

Bishop DVM, Adams C. A prospective study of the relationship between specific language impairment, phonological disorders and reading retardation. Journal of Child Psychology and Psychiatry and Allied Disciplines 1990;31:1027–1050.

Bishop DVM, Snowling MJ. Developmental dyslexia and specific language impairment: Same or different? Psychological Bulletin 2004;130:858–886. [PubMed: 15535741]

Bowey JA, Patel RK. Metalinguistic ability and early reading achievement. Applied Psycholinguistics 1988;9:367–383.

Brown JS, Collins A, Duguid P. Situated cognition and the culture of learning. Educational Researcher 1989;17:32–41.

Catts HW, Adlof SM, Hogan TP, Weismer SE. Are specific language impairment and dyslexia distinct disorders? Journal of Speech, Language, and Hearing Research 2005;48:1378–1396.

Chall, JS. Stages of reading development. New York: McGraw-Hill; 1983.

Channell, RW. gcSalt (Version 1.02) [Computer software]. Provo, UT: Brigham Young University; 2006.

Cohen, J. Statistical power analysis for the behavioral sciences. 2. Hillsdale, NJ: Erlbaum; 1988.

Cutting, LE.; Eason, SH.; Young, K.; Alberstadt, AL. Reading comprehension: Cognition and neuroimaging. In: Pugh, K.; McCardle, P., editors. How children learn to read: Current issues and new directions in the integration of cognition, neurobiology, and genetics of reading and dyslexia research and practice. Philadelphia: Erlbaum; 2009. p. 195-213.

Dale PS, Crain-Thoreson C. Language and literacy in a developmental perspective. Journal of Behavioral Education 1999;9:23–33.

Dallmann WC. Linguistic performance in children six through nine. Dissertation Abstracts International (UMI No. 7404952) 1973;34(09):4733B.

DeThorne LS, Hart SA. Use of twin design to examine evocative gene-environment effects within a conversational context. European Journal of Developmental Science 2009;3:175–194.

DeThorne LS, Hart SA, Petrill SA, Deater-Deckard K, Thompson LA, Schatschneider C, Davison MD. Children's history of speech-language difficulties: Genetic influences and associations with reading-related measures. Journal of Speech, Language, and Hearing Research 2006;49:1280–1293.

DeThorne LS, Petrill SA, Channell RW, Hart SA, Campbell RJ, Deater-Deckard K, et al. Genetic effects on children's conversational language use. Journal of Speech, Language, and Hearing Research 2008;51:423–435.

DeThorne LS, Watkins RV. Language abilities and nonverbal IQ in children with language impairment: Inconsistency across measures. Clinical Linguistics and Phonetics 2006;20:641–658. [PubMed: 17342874]

Ehri LC. Phases of development in learning to read words by sight. Journal of Research in Reading 1995;18:116–125.

Evans DM, Martin NG. The validity of twin studies. GeneScreen 2000;1:77–79.

Gavin WJ, Giles L. Sample size effects on temporal reliability of language sample measures of preschool children. Journal of Speech and Hearing Research 1996;39:1258–1262. [PubMed: 8959610]

Goldsmith HH. A zygosity questionnaire for young twins: A research note. Behavior Genetics 1991;21:257–269. [PubMed: 1863259]

Goodglass, H.; Kaplan, E. The Boston Naming Test. 2. New York: Lippincott Williams & Wilkins; 2001.

Harm MW, Seidenberg MS. Computing the meanings of words in reading: Cooperative division of labor between visual and phonological processes. Psychological Review 2004;111:662–720. [PubMed: 15250780]

Hayiou-Thomas ME, Harlaar N, Dale PS, Plomin R. Genetic and environmental mediation of the prediction from preschool language and nonverbal ability to 7-year reading. Journal of Research in Reading 2006;29:50–74.

Hohnen B, Stevenson J. The structure of genetic influences on general cognitive, language, phonological, and reading abilities. Developmental Psychology 1999;35:590–603. [PubMed: 10082029]

Hughes DL, Fey ME, Long SH. Developmental sentence scoring: Still useful after all these years. Topics in Language Disorders 1992;12:1–12.

Johnson MR, Tomblin JB. The reliability of developmental sentence scoring as a function of sample size. Journal of Speech and Hearing Research 1975;18:372–380.

Leadholm, BJ.; Miller, JF. Language sample analysis: The Wisconsin guide. Madison: Wisconsin Department of Public Instruction; 1992. Analysis; p. 36-51.

Lee, L. Developmental sentence analysis. Evanston, IL: Northwestern University Press; 1974.

Lee J, Schallert DL. The relative contribution of L2 language proficiency and L1 reading ability to L2 reading performance: A test of the threshold hypothesis in an EFL context. TESOL Quarterly 1997;31:713–739.

Lively M. Developmental sentence scoring: Common scoring errors. Language, Speech, and Hearing Services in Schools 1984;15:154–168.

Lyytinen P, Lyytinen H. Growth and predictive relations of vocabulary and inflectional morphology in children with and without familial risk for dyslexia. Applied Psycholinguistics 2004;25:397–411.

Mather PL, Black KN. Hereditary and environmental influences on preschool twins' language skills. Developmental Psychology 1984;20:303–308.

Miller, J. Systematic Analysis of Language Transcripts (Research Version 8.0) [Computer software]. Madison: University of Wisconsin; 2004.

Miller JF, Heilmann J, Nockerts A. Oral language and reading in bilingual children. Learning Disabilities for Research & Practice 2006;21:30–43.

Nathan L, Stackhouse J, Goulandris N, Snowling MJ. The development of early literacy skills among children with speech difficulties: A test of the "critical age hypothesis". Journal of Speech, Language, and Hearing Research 2004;47:377–391.

Nation K, Clarke P, Marshall CM, Durand M. Hidden language impairments in children: Parallels between poor reading comprehension and specific language impairment? Journal of Speech, Language, and Hearing Research 2004;47:199–211.

Nation K, Snowling MJ. Semantic processing and the development of word-recognition skills: Evidence from children with reading comprehension difficulties. Journal of Memory and Language 1998;39:85–101.

Nation K, Snowling MJ. Beyond phonological skills: Broader language skills contribute to the development of reading. Journal of Research in Reading 2004;27:342–356.

Nippold, MA. Later language development: The school-age and adolescent Years. 2. Austin, TX: Pro-Ed; 1998.

Paul R. Clinical implication of the natural history of slow expressive language development. American Journal of Speech-Language Pathology 1996;5:5–21.

Petrill SA, Deater-Deckard K, Thompson LA, DeThorne LS, Schatschneider C. Reading skills in early readers: Genetic and shared environmental influences. Journal of Learning Disabilities 2006;39:48–55. [PubMed: 16512082]

Plomin R, Colledge E, Dale PS. Genetics and the development of language disabilities and abilities. Current Paediatrics 2002;12:419–424.

Plomin R, Kovas Y. Generalist genes and learning disabilities. Psychological Bulletin 2005;131:592–617. [PubMed: 16060804]

Price TS, Eley TC, Dale PS, Stevenson J, Saudino K, Plomin R. Genetic and environmental covariation between verbal and nonverbal cognitive development in infancy. Child Development 2000;71:948–959. [PubMed: 11016558]

Rack JP, Snowling MJ, Olson RK. The nonword reading deficit in developmental dyslexia: A review. Reading Research Quarterly 1992;27:28–53.

Ricketts J, Nation K, Bishop DVM. Vocabulary is important for some, but not all reading skills. Scientific Studies of Reading 2007;11:235–257.

Robertson, C.; Salter, W. The Phonological Awareness Test. East Moline, IL: LinguiSystems; 1997.

Scarborough HS. Very early language deficits in dyslexic children. Child Development 1990;61:1728–1743. [PubMed: 2083495]

Schatschneider C, Francis DJ, Foorman BF, Fletcher JM, Mehta P. The dimensionality of phonological awareness: An application of item response theory. Journal of Educational Psychology 1999;91:467–478.

Scott CM, Stokes SL. Measures of syntax in school-age children and adolescents. Language, Speech, and Hearing Services in Schools 1995;26:309–319.

Storch SA, Whitehurst GJ. Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. Developmental Psychology 2002;38:934–947. [PubMed: 12428705]

Thorndike, RL.; Hagen, EP.; Sattler, JM. The Stanford-Binet Intelligence Scale IV: Guide for administering and scoring. Itasca, IL: Riverside; 1986.

Ukrainetz TA. Beyond Vygotsky: What Soviet activity theory offers naturalistic language intervention. Journal of Speech-Language Pathology and Audiology 1998;22:164–175.

van Kleeck A. SLPs' foundational role in reading comprehension: A response to Alan Kamhi. The ASHA Leader 2007 August 14;12:32–33.

Wolf M. Naming, reading, and the dyslexias: A longitudinal review. Annals of Dyslexia 1984;34:87–115.

Woodcock, RW. Woodcock Reading Mastery Tests—Revised. Circle Pines, MN: AGS; 1987.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

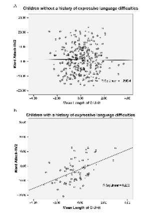

Figure 1.

Associations between mean length of C-unit and Word Attack in children without a history of reported language difficulties (see Panel A) and those with a history of reported language difficulties (see Panel B). HV2 = second home visit.

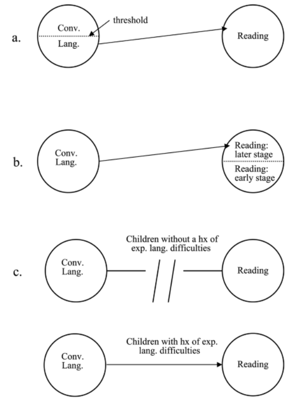

Figure 2.
Models of the association between conversational language and reading. *Threshold model* (a), in which conversational language relates to reading up to a certain point in development; *two-stage reading model* (b), in which oral language skills, such as semantics and morphosyntax, contribute to differences in reading as reading skills transition from decoding to comprehension; and *subpopulations model* (c), in which the relationship between conversational language and reading differs across groups of children with different predispositions to early language learning. Conv. lang. = conversational language; hx = history; exp. = expressive.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 1

Descriptive raw score data on language measures from the second home visit and reading measures from the second and third home visit.

Child language measure	*n*	*M (SD)*	Range
MLU-C	380	5.70 (1.13)	2.65–9.50
NTW	326	523.73 (100.91)	263–887
NDW	326	190.19 (28.22)	104–275
TNC	326	36.21 (18.29)	5–109
DSS	342	9.77 (1.54)	5.74–15.83
BNT-2	377	32.47 (6.97)	14–51
BNT-3	248	37.21 (6.38)	19–50
SB-Vocab-2	379	18.34 (2.63)	13–25
SB-Vocab-3	247	20.22 (3.09)	13–32
PA-2	379	18.82 (5.05)	0–30
PA-3	248	20.83 (3.51)	8–30
WA-2	370	15.48 (10.10)	0–40
WA-3	245	23.89 (9.44)	3–40
WID-2	372	39.84 (19.22)	0–77
WID-3	246	58.57 (13.17)	17–83
PC-2	345	21.63 (10.37)	0–44
PC-3	232	31.34 (8.13)	6–49

Note. Abbreviations followed by "−2" or "−3" represent measures taken at the second home visit or the third home visit, respectively. MLU-C = mean length of utterance in morphemes; NTW = number of total root words; NDW = number of different root words; TNC = total number of conjoining and subordinating conjunctions; DSS = Developmental Sentence Score; BNT = Boston Naming Test; SB-Vocab = Vocabulary subtest from the Stanford-Binet Intelligence Test; PA = phonological awareness composite; WA =Word Attack subtest of the Woodcock Reading Mastery Test; WID = Word Identification subtest of the Woodcock Reading Mastery Test; PC = Passage Comprehension subtest of the Woodcock Reading Mastery Test.

Table 2

Mean *z* score difference in age- and sex-corrected language and reading variables at HV2 and HV3 between children with and without a history of reported language difficulties.

Variable	*t* (*df*)	*p* (two-tailed)	Mean difference
MLU-C	3.02 (376)	.003	.388
NTW	3.39 (322)	.001	.460
NDW	3.40 (322)	.001	.463
TNC	1.69 (322)	.093	.232
DSS	2.80 (338)	.005	.384
BNT-2	5.52 (373)	.000	.692
BNT-3	4.02 (49)[a]	.000	.791
SB-Vocab-2	2.90 (375)	.004	.372
SB-Vocab-3	3.20 (245)	.002	.534
PA-2	3.11 (375)	.002	.400
PA-3	3.82 (246)	.000	.589
WA-2	3.75 (366)	.000	.489
WA-3	6.13 (243)	.000	.981
WID-2	3.37 (368)	.001	.436
WID-3	5.06 (244)	.000	.829
PC-2	3.27 (341)	.001	.442
PC-3	4.29 (230)	.000	.721

Note. HV2 = second home visit; HV3 = third home visit.

[a]Reduced degrees of freedom are due to unequal variances.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 3

Correlation matrix of child language and reading measures corrected for age and sex from HV2 on entire sample (N = 380).

Measure	1	2	3	4	5	6	7	8	9	10	11
1. MLU-C	—										
2. NTW	.921**	—									
3. NDW	.787**	.836**	—								
4. TNC	.736**	.767**	.637**	—							
5. DSS	.641**	.590**	.541**	.470**	—						
6. BNT	.172**	.201**	.296**	.081	.151*	—					
7. SB-Vocab	.251**	.256**	.305**	.215**	.184*	.461**	—				
8. PA	.129	.144*	.191**	.111	.233**	.388**	.221**	—			
9. WA	.105	.162*	.247**	.108	.157*	.379**	.283**	.563**	—		
10. WID	.061	.100	.211**	.048	.123	.389**	.316**	.517**	.836**	—	
11. PC	.054	.077	.179*	.065	.088	.391**	.362**	.469**	.766**	.892**	—

* Statistical significance at α =.01.

** Statistical significance at α = .001.

Table 4

Correlation matrix of HV2 child language and reading measures corrected for age and sex on selected sample of children with a history of reported language difficulties (*n* = 73).

Measure	MLU-C	NTW	NDW	TNC	DSS
BNT	.183	.225	.204	.157	.231
SB-Vocab	.229	.258	.205	.221	.178
PA	.273	.298	.324*	.296	.394**
WA	.482**	.503**	.449**	.491**	.395**
WID	.284	.279	.328*	.288	.241
PC	.379*	.337	.385*	.342*	.329

* Statistical significance at $\alpha = .01$.

** Statistical significance at $\alpha = .001$.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 5

Correlation matrix of HV2 child language and HV3 reading measures corrected for age and sex on entire sample (*N* = 380).

Measure	MLU-C	NTW	NDW	TNC	DSS
BNT	.242**	.272**	.329**	.151	.093
SB-Vocab	.220**	.212*	.190*	.063	.191*
PA	.134	.165	.193*	.131	.056
WA	.177*	.208*	.270**	.161	.056
WID	.117	.131	.227*	.072	.025
PC	.176*	.190*	.300**	.103	.090

* Statistical significance at α = .01.

** Statistical significance at α = .001.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 6

Correlation matrix of HV2 child language and HV3 child reading measures corrected for age and sex on selected sample of children with a history of reported language difficulties (n = 73).

Measure	MLU-C	NTW	NDW	TNC	DSS
BNT	.199	.220	.162	.188	.064
SB-Vocab	.315	.330	.277	.249	.381
PA	.032	.057	.116	.000	.171
WA	.535**	.575**	.522**	.661**	.445*
WID	.329	.354	.339	.475*	.272
PC	.434*	.463*	.436*	.482*	.386

* Statistical significance at α = .01.

** Statistical significance at α = .001.

Table 7

Multilevel modeling: Formal vocabulary, conversational language, and child language history as predictors of HV2 and HV3 reading.

Model	−2ll	χ^2
HV2 Reading		
Null	724.6	
Vocab	667.3	57.3*
Vocab, Hx	654.0	13.3*
Vocab, Hx, Con	653.2	0.8
Vocab, Hx, Con, Con × Hx	649.1	4.1*
Vocab, Hx, Con, Vocab × Con	652.2	−3.1
Vocab, Hx, Con, Vocab × Hx	650.9	1.3
HV3 Reading		
Null	490.6	
Vocab	463.1	27.5*
Vocab, Hx	442.5	20.6*
Vocab, Hx, Con	441.2	1.3
Vocab, Hx, Con, Con × Hx	437.8	3.4
Vocab, Hx, Con, Vocab × Con	440.6	−2.8
Vocab, Hx, Con, Vocab × Hx	440.6	.0

Note. Vocab = formal vocabulary; Hx = history of reported language difficulties; Con = conversational language.

*Statistical significance at $\alpha = .05$.

Table 8

Estimates from best-fitting model: Fixed effects.

Parameter	*p*	Estimate	*SE*	*df*	*t*
Independent variables: vocabulary, conversation, history of language difficulties					
Dependent variable: HV2 reading					
Intercept	.74	.02	.07	160	0.33
Vocab	<.0001	.37	.06	110	6.70
Hx	.005	−.42	.15	110	−2.86
Con	.81	−.01	.06	110	−0.24
Con × Hx	.05	.21	.10	110	2.03
Independent variables: vocabulary, conversation, history of language difficulties					
Dependent variable: HV3 reading					
Intercept	.28	.09	.08	109	1.09
Vocab	<.0001	.33	.07	76	4.83
Hx	<.0001	−.81	.17	76	−4.67