RESEARCH REPORT

Children with Late Language Emergence: Effects of Maternal Education and Language Use

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Abstract: This study investigated the effects of maternal education and language use on vocabulary and mean-length-of-utterance (MLU) in 20 children with late language emergence (LLE). Multiple home visits were conducted over an 8-month period to measure child vocabulary growth using a standardized checklist and to collect spontaneous mother-child language samples. Standardized receptive and expressive test scores for the 20 children were obtained at the end of the 8 months. Results indicated that maternal education was positively associated with child MLU. Furthermore, the number of different words (NDW) used by mothers was positively associated with child receptive vocabulary scores but curiously not with expressive vocabulary scores. Hierarchical Linear Modeling (HLM) indicated that children with LLE differed in their vocabulary sizes and rates of growth, but that these differences were not accounted for by maternal education. Children with LLE appeared to benefit from hearing a wide variety of words, even though they may not immediately produce them. The primary mechanism driving vocabulary growth in children with LLE may differ from that in typical children, where maternal education has been argued to play a significant role. In any case, SLPs have further evidence that use of a large variety of words may be helpful in treating children with LLE, and they should continue to recommend this strategy to parents.

Children with late language emergence (LLE; a term coined by Zubrick, Taylor, Rice, & Slegers, 2007) have small expressive vocabularies compared to their age peers, often defined as producing fewer than 50 words and/or no two-word combinations by 2 years of age (Rescorla, 1989). Other researchers (e.g., Moyle, Weismer, Evans & Lindstrom, 2007) have used a vocabulary score below the 10th percentile on the MacArthur Communicative Development Inventories (CDI; Fenson, et al., 1993) to identify these children. Hearing and nonverbal cognition are unimpaired. These children have also been labeled as demonstrating slow expressive language development (SELD, Paul & Elwood, 1991; Paul, Hernandez, Taylor & Johnson, 1996) and/or as late talkers (Rescorla, 1989, 2002; Vigil, Hodges, & Klee, 2005). Zubrick et al. (2007) reported a 13.9% prevalence rate for LLE in the general population.

Studies of language development in typical children have suggested several candidates for predictors of later vocabulary growth. Huttenlocher, Haight, Bryk, Selter, and Lyons (1991) investigated the extent to which maternal input altered vocabulary size in 22 typical children who were between 14 and 26 months of age. Maternal speech

Table 1

Characteristics for 20 Participants including Age at Enrollment, Gender, Nonverbal IQ, and Vocabulary Size

Participant Number	Age at Enrollment (Years; months)	Gender	Nonverbal IQ	Vocabulary Size in words at enrollment
1	2;2	M	97	37
2	2;3	M	103	96
3	2;4	M	100	171
4	3;3	M	113	140
5	2;5	F	105	97
6	2;8	M	85	77
7	2;5	F	102	77
8	2;8	M	98	25
9	2;0	F	102	37
10	3;0	M	91	59
11	2;2 (Twin A)	M	117	66
12	2;2 (Twin B)	M	113	63
13	2;5	M	105	8
14	2;1	M	111	12
15	2;0	M	113	43
16	2;6	M	105	188
17	2;11	M	113	12
18	2;4	M	105	128
19	2;5	M	109	12
20	2;7	M	85	58
Mean (SD)	2;5 4 months		103.6 9.09	70.3 52.8

was measured as the total number of words mothers directed toward their children in a 3-hour session audiotaped when the children were 16 months old. Child vocabulary size was measured by the number of words produced by each child during three to five samples collected over a 22-month period. Huttenlocher et al. (1991) reported that the relationship between quantity of maternal speech and acceleration of child vocabulary growth was positive and statistically significant.

Hart and Risley (1995) studied 42 families who varied markedly in socioeconomic status (SES) and reported that parents of high SES directed significantly more utterances to their children than did parents of low SES, and used more multi-clause sentences, a greater variety of word types, and more affirmative feedback. Additionally, Hart and Risley (1995) reported that the number of different words that parents spoke to their children was strongly related to the children's own vocabulary use.

Dollaghan et al. (1999) examined the effect of maternal educational level on vocabulary and MLU in 240 typically-developing children. Participants' mothers were divided into three educational levels: less than high school graduate; high school graduate; and college graduate. Results indicated statistically significant linear trends across maternal educational levels for MLU and the number of different words (NDW) produced. Children whose mothers had higher education levels also received significantly better scores on a standardized measure of receptive vocabulary, the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981).

Pan, Rowe, Singer, and Snow (2005) studied 108 families of low SES and collected data on maternal and child vocabulary use in spontaneous samples with children between 1 and 3 years of age. Their results indicated that the mothers' consistent use of more varied vocabulary was actually predictive of children's vocabulary growth rather than the total number of words verbalized by mothers.

Table2

Maternal Education in Years and MLU over Time for 20 Participating Children

Participant	Maternal Education in Years	MLU 1	MLU 2	MLU 3	MLU 4	MLU 5	MLU 6	MLU 7
1	18	1.85	1.67	1.68	1.55	1.86	2.18	
2	12	1.23	1.31	1.2	1.32	1.79	2.03	2.69
3	13	1.61	1.58	1.7	2.21	1.91	2.18	2.73
4	12	1.47	1.39	1.31	1.73	1.32	1.79	2.18
5	16	1.34	1.41	1.35	1.38	1.56	2.02	
6	13	1.42	1.4	1.6	1.25	1.52	1.76	
7	16	1.21	1.36	1.11	1.31	1.33	1.52	
8	12	1.17	1.37	1	1.58	1.29	1.9	
9	16	1.05	1.03	1.01	1.08	1	1.13	1.04
10	12	1.36	1.31	1.31	1.21	1.52	1.91	
11	12	1.2	1.16	1.7	1.84	2.21		
12	12	1.02	1.19	1.52	1.65	1.89		
13	13	1	1.05	1.15	1.1	1.45		
14	14	0	0	0	1	1.85		
15	16	1	1	1.31	1.73	1.67		
16	14	1.26	1.74	1.51	1.69	1.9		
17	12	1.19	1.18	1.27	1.23	1.48		
18	16	1.86	2.77	2.81	1.9	2.24		
19	18	1	1	1	1	1		
20	19	2.29	2.46	2.53	3.07	3.33		

Given the past results that both the amount and quality of maternal language input influences growth in typically-developing children, researchers have questioned whether children with LLE may have received less language input, poorer quality input, or both. Paul and Elwood (1991) compared maternal speech styles toward children with LLE and typical children. They reported no differences for use of varied sentence types (e.g., declaratives, negatives, or questions), use of varied pragmatic functions, or use of different topic management strategies. However, mothers of children with LLE did use fewer expansions and extensions. The authors concluded that mothers of typical and LLE children provided similar types and amounts of feedback, but children with LLE "do not give their mothers as much speech to work with" (Paul & Elwood, 1991, p. 982).

Vigil, Hodges, and Klee (2005) compared maternal language samples collected from 10 children with LLE and 19 typical children and found no differences between the parent groups for MLU in words, number of utterances, or total number of words (TNW). They concluded that both groups of children received similar quantities of language input. Their findings were similar to Paul and Elwood's (1991) results, though they noted that parents of children with LLE used significantly fewer expansions.

In summary, it appears that in typical children, maternal SES and language use are predictive of children's language outcomes. It does not appear that children with LLE are receiving significantly less language input overall, though their mothers may be less likely to expand their utterances. However, some authors contend that LLE in toddlers is unrelated to maternal input and is instead driven by genetic factors (cf. Dale et al., 1998). Dale et al. (1998) examined vocabulary growth in over 3,000 twin pairs, and reported that group-differences heritability was significantly greater for children in the bottom 5th percentile for vocabulary size than for children in the normal range. The shared language environment appeared to be a less important predictor of vocabulary growth in toddlers with LLE than in typical toddlers.

Zubrick et al. (2007) studied 1,766 children to examine the predictive status of maternal and child variables for LLE in 24-month-old children. They concluded that risk for LLE could not reliably be predicted from maternal educational level or family SES and concluded, like Dale et al. (1998), that early language impairment likely involves neurobiological and genetic mechanisms.

Thus, the relationship between maternal characteristics and LLE in children is open to debate. Several qualitative and correlational studies have suggested a link between maternal language input and child language growth. On the other hand, two large-scale correlational studies suggested the link is much weaker or even nonexistent. It should be noted that these large-scale studies failing to detect a link between maternal characteristics and LLE appear to have sufficient statistical power to detect even small associations. The purpose of the present study was to examine in detail the potential association between maternal education and language use on vocabulary size and rates of growth in 20 children with LLE as well as on their MLU and receptive language test scores. Specific research questions were:

1. Was maternal education positively associated with child MLU, NDW, or TNW?

2. Was maternal NDW positively associated with child receptive or expressive vocabulary scores?

3. a. Did children with LLE differ in their initial vocabulary sizes and rates of growth?

   b. If children with LLE differed in initial vocabulary size or rates of growth, were these differences accounted for by maternal education?

Methods

Participants

Participants were 20 two-year-old children with LLE (mean age at intake = 29.9 months, SD = 4.1). Children in the Central Texas area were recruited through newspaper advertising, fliers distributed at daycare centers, and by word-of-mouth from families already enrolled in the study. Criteria for enrollment included: (a) normal nonverbal intelligence as indicated by an intelligence quotient (IQ) above the 16th percentile (> 85) on the *Brief IQ of the Leiter International Performance Scale-Revised* (Roid & Miller, 2001); (b) a small vocabulary size as indicated by a score below the 10th percentile on the CDI; (c) English as the only language spoken in the home; (d) no reported or medical indication of hearing loss; and (e) no reported neurological disorder, including autism.

A total of 35 children (30 boys and 5 girls, mean age = 31.6 months, SD = 6.7) were initially tested. Of the 35 children tested, 2 were excluded for neurological diagnoses, 3 children had vocabulary sizes above the 10th percentile on the CDI, 5 scored below the 16th percentile on the Leiter, 1 was from a bilingual family, and 3 refused to complete testing. The remaining 21 children began participation in the study, but one family subsequently withdrew due to maternal illness, leaving a total of 20 children with LLE.

These 20 children ranged in age from 2;0 to 3;3 at enrollment. Seventeen participants were male (two of whom were identical twins), and three were female. Most participants (17 of 20) were Caucasian. Of the remaining three participants, two were African American and one was of Asian-American ethnicity.

At the time of enrollment, mothers completed a written questionnaire regarding the child's medical and the family's social history. Mothers self-reported their levels of education on this form, and each level of education was converted to the number of years it required to complete such that high school graduation = 12 years and so on. The 19 mothers in the study had a mean of 14.3 years of education (range = 12-19, SD = 2.36). Seven mothers reported holding a high school diploma; three mothers reported some college which was assigned a value of 13 years; one mother held an associate's degree; five mothers reported having undergraduate degrees; two mothers held master's degrees (one was a speech-language pathologist), and one mother held a juris doctor degree. Twenty children participated, but only 19 mothers participated because two of the children were twins.

Table 3

Mothers' Number of Different Words (NDW) at Time of Enrollment and PPVT-III Scores 8 Months after Enrollment for 20 Participants

Participant	Maternal NDW	PPVT-III Score
1	232	95
2	140	82
3	100	85
4	143	95
5	191	106
6	187	63
7	210	87
8	89	78
9	195	101
10	149	79
11	177	99
12	190	92
13	155	84
14	183	76
15	225	101
16	191	104
17	181	82
18	183	88
19	126	63
20	114	98
Mean	168.05	87.90
SD	39.69	12.41

Procedures

The initial testing session included completion of the written questionnaire and the CDI by the mother, as well as completion of the *Leiter Brief IQ Screener* by the child. A 15-minute spontaneous language sample was video-recorded. The first author asked mothers to "Play with (child's name) as you normally would" and provided one of three age-appropriate toy sets: a farm with animals and a tractor; a street scene with a fire station, post office, and vehicles; or a home with people and furniture. Each sample was later transcribed and analyzed using the *Systematic Analysis of Language Transcripts* (SALT 6.1) computer program (Miller & Chapman, 1986). SALT provided data on MLU, NDW, and total number of words (TNW) for both mother and child speakers.

Children with LLE were then followed for 8 months after enrollment. Each family received between five and seven home visits (mean = 5.7, SD = .8), spaced approximately equally over the 8-month period. During these visits, the mother reviewed a copy of the previous CDI and noted new words that the child had acquired, similar to procedures in Hick, Joseph, Conti-Ramsden, Serratrice, & Faragher (2002). Again, 15-minute language samples during mother-child conversational interaction were collected using the previously described toys. Toys were exchanged so that no child played with the same toy set two visits in a row. At the final home visit, 8 months after enrollment (mean age = 38.1 months; SD = 4.1 months), receptive vocabulary was assessed with the *Peabody Picture Vocabulary Test-PPVT-III* (Dunn & Dunn, 1997), and expressive vocabulary was assessed with the *Expressive One Word Picture Vocabulary Test-Revised* (Gardner, 1981).

Data concerning the first two research questions were analyzed using Pearson product-moment correlations. All correlations were two-tailed, as the direction of the effect was not predicted a priori. In order to correct for the use of multiple correlations and reduce the likelihood of reporting a significant effect by chance, a modified Bonferroni procedure was employed (Jaccard & Wan, 1996). This procedure retains an overall type-I error rate of 5% by rank ordering significance values and dividing each significant result by the number of tests performed.

Data on children's initial differences in vocabulary size and in their rates of growth were analyzed using Hierarchical Linear Modeling (Raudenbush & Bryk, 2002). HLM consists of two models: (a) an individual growth model (level-1) that represents change in each child's vocabulary size over time and (2) a between-child model (level-2) that tests for correlates of individual differences among children in their growth trajectories for vocabulary size. The individual growth parameters from the first model become the outcome variables in the second-level model, where they may (or may not) relate to the selected predictor. The multiple vocabulary size measures collected from each child are viewed as nested within the individual, and this treatment of multiple observations as nested "allows the investigator to proceed without difficulty when the number and spacing of time points vary across cases" (Raudenbush & Bryk, 2002, p. 161).

Each child's growth in vocabulary size is thus estimated at level-1 by a linear model containing an intercept (vocabulary size at enrollment) and a slope (change over time or growth rate). At level-2, then, the parameters of the level-1 model become outcome variables in linear models that contain a suspected predictor (in this case, maternal education). Equations employed are provided in the Appendix.

Reliability

To determine inter-judge measurement reliability, 16 of the 114 language samples (14.03%) were selected at random, re-transcribed, and re-analyzed with SALT 6.1 by two undergraduate student assistants. Pearson product-moment correlations were calculated by comparing the first author's measurements to those of the student assistants, and all were above 0.85 for the children's MLU, TNW, and NDW as well as for maternal NDW.

Results

Research Question 1: Was maternal education positively associated with child MLU, NDW, or TNW?

Mean child MLU across all children and samples was 1.55 morphemes (SD = 0.48), with a range from 1.0 to 3.33, and was significantly correlated with maternal education, ($r = .445$, $p < .05$). However, child NDW (mean = 57.68 words per 15-minute sample, SD = 28.5, range = 2 to 122) was not correlated with maternal education ($r = .000$, $p > .05$). Mean child TNW across all children and samples was 197.56 words per 15-min. sample (SD = 106.1) with a range from 2 to 481 words and was not correlated with maternal education ($r = -.057$, $p > .05$). The findings of a positive relationship between maternal education and child MLU are consistent with those reported by Dollaghan et al. (1999) for typically-developing children.

Research Question 2: Was maternal NDW positively associated with child receptive or expressive vocabulary scores?

Maternal NDW was significantly correlated with children's receptive language standard scores ($r = .55$, $p < .05$) but not with expressive language standard scores ($r = .219$, $p > .05$). It appeared that the children were paying attention to, and benefitted from, hearing a wide variety of words, even though they did not immediately produce them. These results do not directly replicate but are consistent with Pan, Rowe, Singer, and Snow's (2005) results. They reported that diversity of maternal vocabulary predicted child vocabulary growth.

Research Question 3a: Did children with LLE differ in their initial vocabulary sizes and rates of growth?

Because child vocabulary sizes were not uniformly distributed (Kolmogorov-Smirnov $z = 1.657$, $p < .05$), HLM analyses were performed on logarithmic-transformed vocabulary size data. Logarithmic transformation is one method of normalizing distributions that are severely skewed (Tabachnick & Fidell, 1989).

The HLM level-1 model states that vocabulary size is a function of the child's true ability, combined with growth over time, and includes an error term. In this study, the initial value for time was each child's age at enrollment, and subsequent values were calculated as time since enrollment.

The initial model of growth was unconditional in that no predictors had yet been introduced. Application of the simplest model yielded the results seen in Table 4. The estimated mean intercept and mean growth rates for vocabulary were 4.04 and 0.21 respectively. Both the mean intercept and growth rate had large t values, indicating that they were different from zero. This implied that children in the study had vocabulary sizes different from zero. More importantly, vocabulary growth rates were large enough to be measured and analyzed.

The estimates for the variance in individual vocabulary growth parameters were 0.83 and 0.005 respectively. The simplest test of homogeneity of variance in individual vocabulary growth involved the use of a X^2 statistic. The application of X^2 resulted in a statistic of 1016.63 for the intercept term ($df = 19$, $p < .05$). Thus, the null hypothesis that there was no variability in vocabulary size at the age of enrollment was rejected. Likewise, the corresponding X^2 statistic for the hypothesis that there were no differences in vocabulary growth rates was 172.24 ($df = 19$, $p < .05$). This result led to the conclusion that there was also significant variation among the children for vocabulary growth rates.

The unconditional model allowed investigation of the psychometric characteristics of the estimated individual

Table 4

Unconditional Linear Model of Vocabulary Growth in Children with Late Language Emergence (LLE)

Fixed Effect	Coefficient	Standard error	*t* Ratio	
Mean initial status, B_{00}	4.04	0.21	19.57	
Mean growth rate, B_{10}	0.21	0.02	12.25	
Random Effect	**Variance**	***df***	**X^2**	***p* Value**
Initial status, r_{0i}	0.83	19	1016.63	0.000
Growth rate, r_{1i}	0.005	19	172.24	0.000
Reliability of OLS Regression Coefficient Estimate				
Initial status, π_{0i}	0.98			
Growth rate, π_{1i}	0.89			

growth parameters. For the vocabulary size data, the estimated reliabilities for initial status and growth rates were 0.98 and 0.89, respectively. These results indicate that the level-1 models fit the raw data well in terms of both status at enrollment and growth. Thus, modeling each parameter as a function of person-level variables (e.g., maternal education) was warranted.

Research Question 3b: If children with LLE differed in vocabulary size and growth rates, were these differences accounted for by maternal education?

The level-1 model remained the same, but the predictor of maternal education was introduced into the level-2 model. Equations are detailed in the appendix.

Table 5 presents the estimated fixed effects results for this analysis. It should be noted that this model of vocabulary growth was linear, rather than quadratic. A quadratic model was tested, but did not significantly improve fit. As such, the simpler linear model was preferred.

Maternal education was not related to initial vocabulary size (t = -0.12, df = 18, p > .05), nor to rates of vocabulary growth (t = -0.058, df = 18, p > .05). It appeared that the children with LLE differed significantly in vocabulary sizes at enrollment and in their rates of vocabulary growth, but variations in maternal education did not account for these differences. It should be noted that the t values are quite low, such that even a large increase in sample size would be unlikely to boost these small effects into the putative range of significance.

Discussion

Maternal education was positively associated with child MLU, as also reported by Hart and Risley (1995) and Dollaghan et al. (1999) for typically-developing children. However, the aspects of maternal education that actually served to lengthen children's utterances in these studies remained unclear. Hart & Risley (1995) identified the advantages conferred by more maternal education as including greater linguistic diversity, positive feedback to children, symbolic emphasis, use of a gentle guidance style, and responsiveness, and they suggested that these advantages act in concert to improve child language use. Dollaghan et al. (1999) concluded that "it is impossible to pinpoint the reasons for the effects of maternal education that were observed... and understanding these relationships among particular socio-demographic variables and particular measures of early language performance is an important area for future research" (1999, p. 144).

In the current study, maternal NDW was positively associated with children's single-word vocabulary comprehension but not with expression in children with LLE. The children in this study appeared to benefit from hearing a wide variety of vocabulary words, even though they did not immediately make use of them. As reported by Vigil, Hodges, & Klee (2005), parents may adjust their conversational style to the communicative abilities of their children and should be reminded to continue use of a variety of words even when the children themselves use only a very few.

Regarding vocabulary sizes and rates of growth, children in this study demonstrated significant differences from one another, but these differences were not accounted for by variations in maternal education. These results are consistent with those of Zubrick et al. (2007), which reported that risk for LLE at 24 months was not associated with parental educational levels. While typical children have demonstrated growth in vocabulary size as an apparent function of maternal education and vocabulary use (Hart & Risley, 1995; Huttenlocher et al., 1991), children with LLE may not share this ability. It is possible that children with LLE required significantly more exposures than typically-developing children to learn specific words, or that environmental input is simply less predictive of performance in children with LLE.

Table 5

Linear Model of Growth in Vocabulary Size: Effect of Maternal Education

Fixed Effect	Coefficient	Standard Error	t Ratio
Model for initial status, π_{0i}			
Base, β_{00}	4.17	1.17	3.58
Maternal education, β_{01}	-0.009	0.08	-0.12
Model for growth rate, π_{1i}			
Base, β_{10}	0.22	0.09	2.55
Maternal education, β_{11}	-0.0003	0.005	-0.058

Conclusion

The mixed nature of these results (e.g., evidence for an environmental influence on child MLU and receptive vocabulary scores but lack of an apparent effect of maternal education on vocabulary size or growth rate) suggest that early language acquisition is a complex process that is not entirely mediated by either genetic or environmental factors. There is also the possibility that the mechanisms driving vocabulary growth in typical children (amount of maternal input, diversity of maternal vocabulary or possibly both) are not the same as those for children with

LLE. In any case, it appears that SLPs should continue to demonstrate varied vocabulary use when treating children with LLE and to recommend this strategy to parents.

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References

Dale, P., Simonoff, E., Bishop, D., Eley, T., Oliver, B., et al. (1998). Genetic influence on language delay in 2-year-old children. *Nature Neuroscience, 1,* 324-328.

Dollaghan, C. A., Campbell, T. F., Paradise, J. L., Feldman, H. M., Janosky, J. E., Pitcairn, D. N., et al. (1999). Maternal education and measures of early speech and language. *Journal of Speech, Language, and Hearing Research, 42,* 1432-1443.

Dunn, L. & Dunn, L. (1981). *Peabody picture vocabulary test (PPVT-R).* Circle Pines, MN: American Guidance Service.

Dunn, L. & Dunn, L. (1997). *Peabody picture vocabulary test (PPVT-III, 3rd ed.).* Circle Pines, MN: American Guidance Service.

Fenson, L., Dale, P., Reznick, S., Thal, D., Bates, E., Hartung, J., et al. (1993). *MacArthur communicative development inventories.* San Diego, CA: Singular Publishing Group, Inc.

Gardner, N. F. (1981). *Expressive one-word picture vocabulary test.* Novato, CA: Academic Therapy Publications.

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

Hick, R. F., Joseph, K. L, Conti-Ramsden, G., Serratrice, L., & Faragher, B. (2002). Vocabulary profiles of children with specific language impairment. *Child Language Teaching and Therapy, 21,* 165-180.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27,* 236-248.

Jaccard, J. & Wan, C.K. (1996). *LISREL approaches to interaction effects in multiple regression.* Thousand Oaks, CA: Sage Publications.

Moyle, M., Weismer, S. E., Evans, J., & Lindstrom, M. (2007). Longitudinal relationships between lexical and grammatical development in typical and late-talking children. *Journal of Speech, Language, and Hearing Research, 50,* 508-528.

Miller, J. F., & Chapman, R. S. (1986). *Systematic analysis of language transcripts.* Madison, WI: University of Wisconsin-Madison.

Pan, B., Rowe, M., Singer, J., & Snow, C. (2005). Maternal correlates of growth in toddler vocabulary production in low-income families. *Child Development, 76,* 763-782.

Paul, R. & Elwood, J. (1991). Maternal linguistic input to toddlers with slow expressive language development. *Journal of Speech and Hearing Research, 34,* 982-988.

Paul, R., Hernandez, R, Taylor, L., & Johnson, K. (1996). Narrative development in late talkers: early school age. *Journal of Speech and Hearing Research, 39,* 1295-1303.

Raudenbush, S. & Bryk, A. (2002). *Hierarchical linear models: Applications and data analysis methods.* Thousand Oaks, CA: Sage Publications, Inc.

Rescorla, L. (1989). The Language Development Survey: A screening tool for delayed language in toddlers. *Journal of Speech and Hearing Disorders, 54,* 587-599.

Rescorla, L. (2002). Language and reading outcomes to age 9 in late-talking toddlers. *Journal of Speech, Language, and Hearing Research, 45,* 360-371.

Roid, G., & Miller, L. (2001). *Leiter international performance scale-revised.* Los Angeles: Western Psychological Services.

Tabachnick, B. & Fidell, L. (1989). *Using multivariate statistics* (2nd ed.). New York: Harper Collins.

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,* 107-122.

Zubrick, S. R., Taylor, C. L., Rice, M. L., & Slegers, D. W. (2007). Late language emergence at 24 months: An epidemiological study of prevalence, predictors, and covariates. *Journal of Speech, Language, and Hearing Research, 50,* 1562-1592.

Appendix

HLM Equations

The level-1 model equation was as follows:

$$Y_{ti} = \pi_{0i} + \pi_{1i}a_{ti} + e_{ti,}$$

where *Yti* is the child's reported vocabulary size at time *t* for *i* = 1, …, *n* participants, π_{0i} (individual child's intercept parameter) is equal to the true ability of the child, π_{1i} (individual child's slope parameter) is equal to the vocabulary size growth rate for the child *i,* a_{ti} is the age variable, and e_{ti} is the error term.

The simplest level-2 model equation was as follows:

$$\pi_{0i} = \beta_{00} + r_{0i,}$$
$$\pi_{1i} = \beta_{10} + r_{1i,}$$

where π_{0i} is the intercept term from the level-1 equation, β_{00} is the level-2 intercept, and r_{0i} is the error term for the level-2 intercept. Likewise, π_{1i} is the slope term from the level-1 equation, β_{10} is the level-2 slope, and r_{1i} is the error term for the level-2 slope. Thus, in the simplest level-2 equation of the model for a particular child, the child's values for the growth parameters of the level-1 model have become that child's outcome scores.

The level-2 models using intercepts- and slopes-as-outcomes were constructed as follows:

$$\pi_{0i} = \beta_{00} + \beta_{01} \text{ (Maternal Education)}_i + r_{0i,}$$
$$\pi_{1i} = \beta_{10} + \beta_{11} \text{ (Maternal Education)} + r_{1i}$$