Published in final edited form as:
Dev Sci. 2018 March ; 21(2): . doi:10.1111/desc.12536.

What Explains the Correlation Between Growth in Vocabulary and Grammar? New Evidence From Latent Change Score Analyses of Simultaneous Bilingual Development

Erika Hoff[1], **Jamie M. Quinn**[2], and **David Giguere**[1]

[1]Department of Psychology, Florida Atlantic University, USA

[2]Department of Psychology, Florida State University, USA

Abstract

A close relation between children's vocabulary size and the grammatical complexity of their speech is well attested but not well understood. The present study used latent change score modeling to examine the dynamic relations between vocabulary and grammar growth within and across languages in longitudinal data from 90 simultaneous Spanish-English bilingual children who were assessed at 6-month intervals between 30 and 48 months. Slopes of vocabulary and grammar growth were strongly correlated within each language and showed moderate or nonsignificant relations across languages. There was no evidence that vocabulary level predicted subsequent grammar growth or that level of grammatical development predicted subsequent vocabulary growth. We propose that a common influence of properties of input on vocabulary and grammatical development is the source of their correlated but uncoupled growth. An unanticipated across-language finding was a negative relation between level of English skill and subsequent Spanish growth. We propose that the cultural context of Spanish-English bilingualism in the US is the reason strong English skills jeopardize Spanish language growth while Spanish skills do not affect English growth.

In the first years of language development, the size of children's productive vocabularies and the grammatical complexity of their speech are robustly related. A positive correlation between measures of vocabulary and measures of grammar has been observed in children acquiring different languages, in children passing through the early stages of lexical and grammatical development at different ages, in studies using different means of assessing vocabulary and grammar, and in studies using both cross-sectional and longitudinal designs (Bates, Bretherton, & Snyder, 1988; Caselli, Casadio, & Bates, 1999; Dale, Dionne, Eley, & Plomin, 2000; Dionne, Dale, Boivin, & Plomin, 2003; Fenson et al., 1994; Marchman, Martínez-Sussman, & Dale, 2004; Naigles, Hoff, & Vear, 2009; Snedeker, Geren, & Shafto, 2007, 2012).

This robust finding that individual differences among children in their level of grammatical development are related to individual differences in vocabulary size has been widely interpreted as evidence against an account of language acquisition in which the acquisition

Erika Hoff, Department of Psychology, Florida Atlantic University, ehoff@fau.edu.

of grammar is autonomous and governed by an innate module and for an account in which lexical development provides the foundation for grammatical development. That interpretation is consistent with theoretical approaches to grammatical development which hold that much of grammar is acquired and represented as properties of individual lexical items (Bresnan, 1982; Goldberg, 1999; Tomasello, 2003) and is also consistent with the not incompatible idea that a critical mass of vocabulary items is necessary for the learner to detect the grammatical regularities that operate over lexical items (Marchman & Bates, 1994). But despite the attractive coherence between data and theory in this interpretation, there are reasons to question the conclusion that the correlation between lexical and grammatical development arises from the dependence of grammatical development on lexical development. As is the case for any bivariate relation, it is also possible that the path of influence works in the opposite direction—that lexical development depends on grammatical development–or that both developments are the result of the common influence of a third variable.

The argument for interpreting this correlation as reflecting a direct dependency operating in the direction of grammar depending on the lexicon rests on two other sorts of evidence: evidence that the relation is language specific and evidence of temporal precedence. The evidence of language specificity comes from studies of bilingual children which have found that the relations between lexical and grammatical development are stronger within each language the children are acquiring than across languages (Marchman et al., 2004; Parra, Hoff, & Core, 2011). While there are genetic influences on language development and even evidence of a genetic component to the correlation between lexical and grammatical development (Dale, Dionne, Eley, & Plomin, 2000), evidence that the correlation between lexical and grammatical development is language specific in bilingual children argues that a common underlying ability to acquire language does not fully explain the relation. Importantly, in both studies that have found language specific relations, these findings held even when the children's relative exposure to each language was held constant. This is important because the necessary trade-off in relative exposure would push across-language correlations in a negative direction, potentially obscuring a positive relation due to a common effect of general ability. The only weakness in the previous data is that they were from concurrent associations in cross-sectional data; conclusions about relations in development are better drawn from longitudinal data. The sole longitudinal study to examine the language specificity of ties between the lexicon and grammar found mixed results. Conboy and Thal (2006) found that Spanish-English bilingual children's English vocabulary size predicted subsequent growth in measures of English grammar, while a language-general measure of vocabulary, conceptual vocabulary, did not. For Spanish grammar, however, both Spanish vocabulary and conceptual vocabulary were significant predictors.

The evidence of temporal precedence is not as strong as the evidence of language specificity. The evidence consists of findings from longitudinal studies that early measures of lexical development predict subsequent measures of grammatical development, suggesting the early developments provide the foundation for the later developments (Bates, Bretherton, & Snyder, 1988; Conboy & Thal, 2006) and of findings from cross-sectional studies that the relation between lexical development and grammatical development, in the very early stages of language development, is a curvilinear relation in which small increments in vocabulary size anticipate greater growth in grammar—which has also been interpreted as reflecting a causal influence of vocabulary on grammar (Marchman & Bates, 1994; Marchman et al., 2004). Both sorts of findings admit of other interpretations, however. Conboy and Thal (2006) found that, in English, early lexical measures predicted subsequent growth in grammar, but they did not investigate the alternate path. They did not test whether early grammatical measures predicted subsequent growth in the lexicon. In a study widely cited as support for temporal precedence, Bates, Bretherton, and Snyder (1988) found, among monolingual English-learning children, that individual differences in vocabulary size at 13 months were a better predictor of individual differences in utterance length at 28 months than individual differences in utterance length at 20 months (Bates et al., 1988). It is possible, however, that this correlation reflects the common influence of a general language learning ability on both vocabulary at 13 months and grammar at 28 months, and that a measure of utterance length at 20 months is just not a particularly sensitive measure of individual differences in this capacity. The findings from cross-sectional studies, both of monolingual and bilingual children, that the relation between vocabulary and grammar is curvilinear (Marchman & Bates, 1994; Marchman et al., 2004) also admits of another interpretation. Dixon and Marchman (2007) provided evidence that the observed curvilinear relation between vocabulary and grammar arises from measurement properties of the MacArthur-Bates inventory, which has been the assessment tool that yielded that curvilinear relation. They concluded that the true relation between vocabulary and grammar is one of synchronous growth arising from lexical and grammatical development depending on common resources.

There are also other findings in the literature that raise questions about whether the correlation between lexical and grammatical development is best interpreted as evidence that grammatical development depends on lexical development. There is evidence that lexical development depends on grammatical development, and this path of influence has not been directly tested in studies of the correlation between children's lexical and grammatical skills. Children's use of grammatical clues to word meaning was first described by Roger Brown, who observed that children assigned different meanings to the novel term *sib* paired with a picture of hands manipulating material in a container, depending on whether the picture was described as *a sib*, *some sib*, or *sibbing* (Brown, 1957). Decades of more recent research have documented this process, known as syntactic bootstrapping, in laboratory-based studies of word learning and in corpus-based studies of the syntactic properties of children's input and their relation to children's lexical growth (Naigles & Swensen, 2007; Naigles & Hoff-Ginsberg, 1998). Further support for the idea that grammatical development supports lexical development comes from a longitudinal study of twins which assessed vocabulary and grammar at 2 and 3 years and found evidence of bi-directional influences between domains over time and, also, evidence of a common genetic influence (Dionne, Dale, Boivin, & Plomin, 2003).

In sum, although the correlation between the lexicon and grammar in development is robust and well attested, evidence for the paths of influence that underlie that correlation is inconclusive. There are reasons to doubt that the correlation arises solely from a direct dependence of grammatical development on prior lexical development, as has been widely argued. Influences of grammatical development on lexical development and common influences of third variables are both real possibilities.

In the present study we bring new data and a new a data analytic technique to bear on the question of what underlies ties between the lexicon and grammar in development. The new data come from a sample of 90 Spanish-English bilingual children assessed at 6-month intervals from the age of 30 months to 48 months. The new data analytic technique is latent change score modeling, which allows simultaneously modeling growth in two domains and testing relations between those domains over time (LCS modeling; for a review, see McArdle, 2009). Using LCS modeling we tested the relations between growth in vocabulary and growth in the grammatical complexity of bilingual children's speech both within each language and across their two languages. We thus tested the language specificity of the relation between lexical and grammatical development. Using LCS modeling we also tested the hypotheses that lexical development predicts subsequent growth in grammar, that grammatical development predicts subsequent lexical growth, and that lexical and grammatical development are not directly dependent on each other but are related because of the common influence of a third factor.

Method

Participants

The participants were 90 Spanish-English bilingual children (49 females, 41 males), with a mean age of 30.6 months (SD = 0.4) at the start of the study. The children were all born in the United States and resided in South Florida. All children were full term and healthy at birth, with normal hearing. All children were screened for evidence of communicative delay at 30 months. Participants were recruited through advertisements in local magazines and at programs for parents with young children, as well as through word of mouth.

The participants were selected from a larger longitudinal study of language development in children from Spanish-speaking homes and met the following criteria: (1) at least one of the child's parents was born in a Spanish speaking country, (2) Spanish was spoken in the home, and no language other than Spanish and English was spoken in the home more than 10% of the time, and (3) the child was producing words in both English and Spanish at 30 months and there was a family member able to complete the MacArthur-Bates inventory for each language.

Fifty-three of the children came from households in which both parents described themselves as native Spanish speakers, 33 came from households in which one parent was a native speaker of English and one a native speaker of Spanish, and 4 children came from other household configurations including those in which one parent described him or herself as a native bilingual. Seventy-five of the mothers and 61 of the fathers were born in Spanish speaking countries in Latin America or the Caribbean. Mean years of maternal education was 15. 07 (SD = 2.12) and mean years of paternal education was 14.44 (SD = 2.28), where 10= less than high school, 12 = high school degree, 14 = AA degree, 16 = a college degree, and all advanced degrees treated as 18.

Procedure

Children were assessed and their primary caregivers were interviewed at 4 time points, between two weeks before and 4 weeks after the target ages of 30, 36, 42, and 48 months. Assessment and interviews occurred in the participants' homes or in a university play space, depending on the participants' preferences. Approximately 85% of participants were visited at home. Data were collected by fully bilingual research assistants, and the interview was conducted in whichever language the caregiver chose.

At each time point, an extensive interview about language and literacy practices in the home and the languages spoken in the home was conducted with the caregiver. In the course of this interview, the caregiver estimated the relative proportion of English and Spanish use in the home. The family member most familiar with the child's English and Spanish skills completed the MacArthur-Bates inventories: the *MacArthur-Bates Communicative Development Inventory: Words and Sentences* (*CDI*, Fenson et al., 2007) and its Spanish counterpart, *El Inventario del Desarrollo de Habilidades Comunicatives* (*IDHC*, Jackson-Maldonado, Thal, Fenson, Marchman, Newton & Conboy, 2003). In most cases the same bilingual caregiver completed both inventories. In addition, the child was administered the *The Expressive One Word Picture Vocabulary Test-Spanish-English Bilingual Edition* (*EOWPVT*, Brownell, 2001) in English and in Spanish, on different days in counterbalanced order.

Instruments and Measures

The measure of children's relative exposure to English and Spanish at home was an estimate provided by the primary caregiver in the context of an extensive interview about the child's home language experience. For children living in two households, a weighted average of the percentage of English and Spanish heard in each home was calculated. Previous research has found caregiver estimates obtained in this way to be strongly related to diary-based measures of the amount of time children are exposed to each language and to their skill levels in each language (Hoff, Core, Place, Rumiche, Señor, & Parra, 2012). The estimates do not, however, capture differences in the density or quality of input, which also contribute to differences in children's language growth (Marchman, Martínez, Hurtado, Grüter, & Fernald, 2016).

One of the measures of children's vocabulary in each language comes from the *EOWPVT-Spanish Bilingual Edition*, which is an examiner-administered test of productive vocabulary. It is an adaptation of the English test, created by excluding items that were determined by the test developers to be untranslatable, grossly different in difficulty between English and Spanish, or culturally biased. Standard administration procedure of the bilingual version allows the child to respond in either language and yields a conceptual score. We modified this procedure to only allow English labels during English assessment and Spanish labels during the Spanish assessment in order to obtain separate assessments of English and Spanish vocabulary knowledge, as have others (Anthony, Solari, Williams, Schoger, & Zhang, 2009). The test was administered in English and Spanish on different days with order of administration counterbalanced across subjects.

The second measure of vocabulary and both measures of grammar come from the *CDI* and *IDHC*, which are caregiver report instruments, completed by caregivers familiar with the child's production in each language. The vocabulary score is based on the number of words on the inventory the caregiver reports having heard her child produced. A grammatical complexity score is based 37 pairs of items, one more advanced than the other. The caregiver indicates for each pair which item sounds more like her child's speech; the child's score is the number of pairs on which the more advanced form is chosen. Finally, these instruments ask caregivers to report the three longest utterances the child has been heard to produce, from which we calculated the mean length in words (M3L).

The MacArthur-Bates inventories were designed to be used with monolingual children between 16 and 30 months, whereas we used them with children between 30 and 48 months. The lag in single language development that is characteristic of bilingually developing children relative to monolingual children resulted in these instruments satisfactorily capturing the variability in vocabulary and grammar in these children over this developmental period. Two statistics support this claim: (1) at 48 months, the oldest age assessed, the children's mean raw scores in English vocabulary and grammatical complexity were below the 50^{th} percentile for 30 month olds on the CDI norms, and English was, on average, the children's stronger language at 48 months, and (2) no measure at 48 months had a negative skewness statistic with an absolute value greater than 1.

Means for children's actual ages, means for the estimates of the percentage of home language use that was in Spanish and in English, and sample size at each time point are presented in Table 1. Missing data were handled using full information maximum likelihood (FIML) in Mplus 7.11 (Muthén & Muthén, 1998–2015) during model estimation.

Data Analysis: Bivariate Latent Change Score Modeling

The relation between vocabulary and grammar over time was analyzed using bivariate latent change score (LCS) modeling. LCS does the following: Latent measures of two constructs, in this case vocabulary and grammar, are created from the manifest variables, in this case the MacArthur-Bates scores and the EOWPVT scores for vocabulary and the MacArthur Bates grammatical complexity scores and M3L for grammar. Growth in each construct is modelled, yielding estimates of the intercept and slope, of the relation between intercept and slope, and estimates of proportional growth over each interval (i.e., the relation between level at each assessment point and change over the subsequent 6-month interval). Of central interest to the present study, LCS models relations between the two constructs, including estimates of the relation between the two intercepts (i.e., initial levels), estimates of the relation between the two slopes (rate of growth over the 18 months of the study), and the relation between intercept of one construct (i.e., initial level) and slope of the other construct. Finally, LCS also estimates the parameters that indicate, for each time interval in the data, the relation of level on one construct at the beginning of that interval to growth on the other construct during that interval. These parameters provide the test of whether level of vocabulary development predicts subsequent growth in grammar (i.e., vocabulary is a leading indicator of grammatical development) and/or level of grammatical development predicts subsequent growth in vocabulary (i.e., grammar is a leading indicator of vocabulary growth). In the present study, LCS was applied to four different bivariate relations over time: relations between vocabulary and grammar within English, relations between vocabulary and grammar within Spanish, relations between vocabulary in Spanish and grammar in English, and relations between vocabulary in English and grammar in Spanish. In the across-language models, caregiver estimates of each child's relative exposure to Spanish at 30 months was entered as a covariate so that the tradeoffs in relative exposure combined with the influence of relative exposure on language growth did not result in spurious negative relations across languages. (The mean levels of relative exposure were fairly constant across time [see Table 1] and individual differences were stable: pairwise correlations between adjacent time points were all significant and ranged from .65 to .81).

For each bivariate relation, four competing models of the relations between growth in the two constructs were compared for best fit to the data: (1) that growth in both constructs is correlated but uncoupled, meaning that neither construct leads the other in development, (2) that vocabulary is a leading indicator of growth in grammar, (3) that grammar is a leading indicator of growth in vocabulary, and (4) that bidirectional coupled relations exist between vocabulary and grammar, meaning that vocabulary leads growth in grammar and grammar leads growth in vocabulary. Model fit was assessed using the chi-square (χ^2) test of model fit statistic, the root mean squared error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker-Lewis Index (TLI), where lower ratios of chi square value to degrees of freedom (< 3), lower values of RMSEA (< .08), and higher values of CFI and TLI (>.90) are preferred (Kline, 2011). Nested models were compared using a chi-square difference test, where more parsimonious models were preferred. Non-nested models were compared using the Bayesian information criteria (BIC), where lower values indicated better fit and differences greater than 10 indicate model improvement (Raftery, 1995). Observed scores at each time point were converted to developmental z-scores based on the means and standard deviations at Time 1. Thus, the latent change scores are interpretable as the standardized unit change expressed in terms of variance at the first time point.

Results

Means and standard deviations for the observed measures of grammar and vocabulary at each assessment point are presented in Table 2. Skewness and kurtosis indices suggested floor effects for the *EOWPVT* measure of Spanish vocabulary at 30 months, but not for the other manifest variable indicating vocabulary size, the *IDHC* Spanish vocabulary score. Similarly, skewness and kurtosis indices suggested a floor effect for the *IDHC* measure of Spanish utterance length at 30 months, but not for the grammatical complexity score. There was no evidence of floor or ceiling effects on any other measure.

Within-Language Relations Between English Vocabulary and English Grammar

The intercorrelations among measures and sample sizes for each measure of English vocabulary and grammar are presented in Table 3. At every time point, each measure of English vocabulary was strongly and significantly correlated with each measure of English grammar.

Among the four competing models (see above), the best fitting model of the development of English vocabulary and English grammar was the a priori no-coupling model (χ^2[122] = 308.029, p < .001, CFI = .838, TLI = .841, RMSEA = .130 [95% CI: .112 – .148], BIC = 2370.851). Adding the coupling parameters from grammar to change in vocabulary knowledge resulted in non-significant improvement in fit ($\Delta\chi^2$ [3] = 1.756, $p > .5$), and estimation of the model that added the coupling parameters from vocabulary knowledge to change in grammar failed to converge. In the best fitting model, there are no cross-construct coupling relations between grammar and vocabulary development in English. Although the no-coupling model was the best fitting a priori model, the fit parameters were outside of the acceptable ranges (CFI and TLI < .900, RMSEA > .08, Kline, 2005). To uncover the source of the misfit, modification indices were consulted to determine if there were theoretically sound modifications to make to the models. A few changes were made to the *a priori* model: the estimation of the intercept was freed for grammar and vocabulary, the residual variances for the *CDI* utterance length measures at 30 and 48 months were allowed to be freely estimated, and the residuals between *EOWPVT* at 42 months and *EOWPVT* at 48 months were allowed to be correlated. These modifications significantly improved model fit to be acceptable (χ^2 [117] = 191.541, $p < .001$, CFI = .935, TLI = .934, RMSEA = .084 [95% CI: .062 – .105], BIC = 2261.081) and did not change parameter estimates from the a priori model.

Figure 1 depicts the final model of English vocabulary and English grammar with the significant relations presented in bold. The model included the following estimates for growth in each construct: the mean intercepts for English vocabulary and English grammar were not significantly different from zero, as imposed by the developmental z-scores, but there were significant individual differences as noted by the variance estimates (σ_{v0} = 0.335; σ_{g0} = 0.383). There was positive and significant growth for both vocabulary (v_1 = 0.581) and grammar $(g_1 = 0.535)$, with small but significant variation in amount of growth for both constructs, indicative of individual differences $(\sigma_{v1} = 0.021; \sigma_{g1} = 0.071)$.Proportional change parameters, which indicate the relation between initial level and amount of change holding other influences constant, were significant and positive for vocabulary between the first two time points ($\beta_{v12} = 0.679$, $p < .001$) and nonsignificant between the second and third time point ($\beta_{v23} = -0.084, p = .410$), and third and fourth time points ($\beta_{v23} = -0.107, p = .090$). This indicates there is initial fan spread of growth followed by equivalent growth. Proportional change in grammar was nearly identical in functional form as vocabulary ($\beta_{g12} = 0.654, p < .01; \beta_{g23} = -0.092 p > .20; \beta_{g34} = -0.176, p > .20$).

With respect to the relations of central interest, those between vocabulary and grammar, the only significant correlations were between the intercepts for vocabulary and grammar (r = .956) and between the slopes of vocabulary and grammar growth (and r = .761). Children who started out higher in vocabulary also were initially higher in grammar, and those who grew faster in vocabulary also grew faster in grammar, thus growth in the two domains are correlated. The evidence that vocabulary and grammar growth are uncoupled is the result that in no case did vocabulary level predict subsequent growth in grammar over the subsequent 6 months, nor did level of grammatical development predict growth in vocabulary over the subsequent 6 months.

Within-Language Relations Between Spanish Vocabulary and Spanish Grammar

The intercorrelations among measures and sample sizes for each measure of Spanish vocabulary and Spanish grammar are presented in Table 4. At every time point, each measure of vocabulary was strongly and significantly correlated with each measure of grammar.

Results of the within-language model testing for Spanish supported the a priori no-coupling model (χ^2 [122] = 353.998, p < .001, CFI = .830, TLI = .833, RMSEA = .145 [95% CI: .128 – .163], BIC = 2711.703). This model was also not a good fitting model. As was done for the model of within-English relations, modification indices were consulted to determine if there were theoretically sound modifications to make to the model to improve model fit. This resulted in a new post hoc model with the following changes: the estimation of the intercept was freed for vocabulary and grammar, the beta parameters were all constrained to be equal within construct, and the residuals of *EOWPVT* scores at adjacent time points were allowed to be correlated. These modifications significantly improved model fit to be acceptable (χ^2 [119] = 250.034, p < .001, CFI = .904, TLI = .903, RMSEA = .111 [95% CI: .091 – .130], BIC = 2611.771) and did not change parameter estimates from the *a priori* model.

Figure 2 depicts the final model of Spanish vocabulary and Spanish grammar with the significant relations presented in bold. It included the following estimates for growth in each construct: the mean intercepts were not significantly different from zero, but there were significant individual differences $(\sigma_{v0}=0.375;\sigma_{g0}=1.179)$. There was positive and significant growth for both vocabulary $(v_1=0.484)$ and grammar (g_1 = 0.588), with small but significant individual differences $(\sigma_{v1}=0.333;\sigma_g=0.454)$.Proportional change parameters for vocabulary ($\beta_v=-0.421$) and grammar ($\beta_g=-0.450$) were able to be held constant over time. These parameters were both negative, indicating significant deceleration within Spanish grammar and vocabulary learning over time.

With respect to the relations of central interest, those between vocabulary and grammar, as was the case for English, intercept of vocabulary was significantly correlated with intercept of grammar (*r* = .954) and slope of vocabulary was significantly correlated with slope of grammar (*r* = .914). Children who started out higher in Spanish vocabulary also were higher in Spanish grammar, and those who grew faster in Spanish vocabulary also grew faster in Spanish grammar. Unlike the finding for English, intercept of Spanish vocabulary was significantly correlated with both slope of Spanish vocabulary (*r* = .882) and slope of Spanish grammar (*r* = .705), and intercept of Spanish grammar was significantly correlated with both the slope of Spanish grammar (*r* = .570) and in Spanish vocabulary (*r* = .754). That is, children with initially higher Spanish skill levels, indexed either by vocabulary or grammar, grew in Spanish skill, indexed either by vocabulary or grammar, at a faster rate than children initially lower Spanish skill levels. As was the case for English, there were no significant relations between vocabulary level at any time point and growth in grammar over the subsequent 6-month interval, nor were there any significant relations between level of grammatical development at any time point and subsequent growth in vocabulary.

Across-Language Relations Between Spanish Vocabulary and English Grammar, with Input as a Covariate

The partial correlations holding the proportion of input in Spanish constant, the zero-order correlations, and sample sizes for the measures of Spanish vocabulary and English grammar are presented in Table 5. Only 2 of the 64 partial correlations were significant, and the strength of these relations (r = .388 and .432) was less than the strength of the within-language correlations between those same measures (r = .637 and .638).

The best fitting model of the development of Spanish vocabulary and English grammar, with input as a covariate, was a unidirectional coupling model from English grammar to changes in Spanish vocabulary (χ^2 [128] = 228.846, p < .001, CFI =.908, TLI =.902, RMSEA = .094 [90 % CI: .074–.113], BIC = 2645.72). Unlike the within-language models, this model did find that children's level of grammatical development in English predicted their subsequent growth in Spanish vocabulary, but the direction of the relation was negative. Children stronger in English grammar grew less in Spanish vocabulary over the subsequent 6 months. A no-coupling model significantly degraded model fit ($\Delta\chi^2$[3]=28.228, $p < .01$), the opposite unidirectional model from Spanish vocabulary to changes in English grammar did not improve model fit (ΔBIC = 26.91), and a bidirectional coupling model did not improve model fit ($\Delta\chi^2$[3]=2.47, $p > .05$). As in the previous modeling of within-language relations between vocabulary and grammar, modification indices were consulted to improve model fit, resulting in correlated residual variance terms and a freed loading estimate for the *EOWPVT* score at 30 months.

Figure 3 depicts the final model of Spanish vocabulary and English grammar with the significant relations presented in bold. It included the following estimates for growth in each construct: the mean intercepts for both constructs were significantly different from zero ($(\sigma_{h0}=-0.579;\sigma_{k0}=1.401)$, a reflection of the covarying of home language input at time 1 (30 months). There were significant individual differences in initial skill levels at 30 months $(\sigma_{v0}=0.208;\sigma_{g0}=0.563)$. There was positive and significant growth for both Spanish vocabulary $(v_1=0.430)$and English grammar $(g_1=0.790)$, with small but significant individual differences $(\sigma_{v1}=0.070;\sigma_{g1}=0.104)$.Proportional change parameters changed from Figures 1 and 2 in that the parameters for Spanish vocabulary were no longer significant due to the leading influence of English grammar, and the final two proportional change parameters for English grammar were significant in this model ($\beta_{g23}=-0.183, p<.01;\beta_{g34}=-0.197, p<.01$).

With respect to the relations of central interest, those between vocabulary and grammar controlling for relative exposure to English and Spanish, there was no significant relation between initial levels of Spanish vocabulary and English grammar ($r = -.248$, $p > .10$), and a moderate relation between the slopes of Spanish vocabulary and English grammar growth (r = .432, $p < .01$). Intercept of Spanish vocabulary was unrelated to slope of English grammar, while the intercept of English grammar was positively related to the slope of Spanish grammar (r = .518, $p < .01$)—in this model which also included negative relations between levels of English grammar and subsequent Spanish growth for each 6-month interval. That is, unlike the parallel but uncoupled growth in vocabulary and grammar seen with English and Spanish, in this case there were relations between level on one construct and growth in the other—only from English to Spanish. For each 6-month interval, level of grammatical development in English was a significant negative predictor of subsequent vocabulary growth in Spanish grammar, with effects of home language use held constant.

Across-Language Relations Between English Vocabulary and Spanish Grammar, with Input as a Covariate

The partial correlations holding the proportion of input in Spanish constant, the zero-order correlations, and sample sizes for the measures of English vocabulary and Spanish grammar are presented in Table 6. None of the partial correlations was statistically significant.

The best fitting model of the development of English vocabulary and Spanish grammar, with input as a covariate, was a unidirectional coupling model from English vocabulary to changes in Spanish grammar (χ^2 [129] = 207.579, p < .001, CFI =.932, TLI =.929, RMSEA = .082 [90 % CI: .061–.102], BIC = 2467.31). As was the case for the previous model of English grammar and Spanish vocabulary, English skill levels were a negative predictor of subsequent growth on the Spanish measure. A no-coupling model significantly degraded model fit ($\Delta\chi^2$[3]=21.50, $p < .01$), the opposite unidirectional model from Spanish grammar to changes in English vocabulary did not improve model fit (ΔBIC = 17), and a bidirectional coupling model did not improve model fit ($\Delta\chi^2$[3]=3.07, $p > .05$). Additionally, modification indices were consulted again to improve model fit, resulting in correlated residual variance terms and a freed loading estimate for the *CDI* measure of vocabulary at 30 months.

Figure 4 depicts the final model of relations between English vocabulary and Spanish grammar with the significant relations presented in bold. It included the following estimates for growth in each construct: The mean intercepts were significantly different from zero $(\sigma_{v0}=0.840;\sigma_{g0}=-0.810)$ due to the partialing of input at 30 months, and there were significant individual differences $(\sigma_{h0}=0.210;\sigma_{k0}=0.693)$. There was positive and significant growth for both English vocabulary $(v_1=0.571)$ and Spanish grammar $(g_1=0.533)$, with small but significant individual differences $(\sigma_{v1}=0.032;\sigma_{g1}=0.104)$. Proportional change parameters for Spanish grammar were not significant (unlike the model of within Spanish relations) because the model also included a significant leading influence of English vocabulary on growth in Spanish grammar. Also different from the within language models, the second and third proportional change parameters for English vocabulary were significant ($\beta_{v23}=-0.115 p<.01;\beta_{v34}=-0.115, p<.01$).

With respect to across domain relations, initial levels of Spanish grammar and English vocabulary were weakly related (r = .237), and the slopes of Spanish grammar growth and English vocabulary growth were not related (r = .100). Relations between initial level and change over each interval were similar to those in the model of Spanish vocabulary and English grammar–that level of English skill was a negative predictor of subsequent growth in Spanish grammar. In this case, the negative leading relation was between English vocabulary and Spanish grammar.

Discussion

The aim of the present study was to apply latent change score modeling to longitudinal data from bilingually developing children in order to test hypotheses concerning the paths of influence underlying the relation between lexical and grammatical development. This relation has been widely attested in both monolingual and bilingual children. At stake are the answers to three questions: (1) Are there developmental dependencies between growth in the lexicon and grammar, or are developmental levels in both domains related because of the common influence of a third variable, (2) If there are developmental dependencies, what is their direction? and (3) if there is a third variable influencing growth in both domains, what is it? The empirical tests that pertain to these theoretical issues are two: (1) Are the ties between the lexicon and grammar language specific, operating only within but not across the two languages bilingual children are acquiring, or are they language general? Language specific ties argue against the influence of a common language learning ability as the explanation for the correlation between lexical and grammatical development within each language because a common ability should equally affect development in both languages. (2) Does lexical development precede grammatical development or does grammatical development precede lexical development. Temporal precedence has been argued to indicate the direction of influence between two related domains. The results of the present study revealed strong evidence of language specificity and no evidence of temporal precedence.

With respect to language specificity, the present study replicated previous findings of strong concurrent relations between vocabulary size and the grammatical complexity of speech within each language the children were acquiring at four different points—30, 36, 42, and 48 months. The present study found, in addition, that the slopes of vocabulary and grammar growth during this time period were strongly and positively related within languages. In contrast, across languages both the concurrent correlations and the correlations between slopes were weak to nonexistent. The modest across-language correlations that did appear suggest that there is such a thing as a language learning ability that applies across languages and across domains within a language, and that evidence is consistent with arguments that a common learning mechanisms can support both lexical and grammatical development (Saffran & Wilson, 2003; Seidenberg, MacDonald, & Saffran, 2002). However, a general language learning ability cannot fully account for the ties between lexical and grammatical development because those ties are, to a substantial degree, specific to each language in children acquiring two languages. There must either be direct dependencies between lexical and grammatical development within each language or lexical and grammatical development must share a common reliance on some other, language specific factor.

With respect to temporal precedence, the same models that revealed the strong correlations between growth in vocabulary and grammar found no evidence that level of vocabulary predicted subsequent growth in grammar or that level of grammar predicted subsequent growth in vocabulary. Growth in these two domains was correlated but uncoupled—within the limits of this design to identify such relations. Those limits are important. The measures of vocabulary and grammar were coarse-grained measures designed to estimate total vocabulary and overall level of grammatical development. The time interval over which relations were tested was six months. It is entirely possible that vocabulary supports grammar and/or grammar supports vocabulary in more local way and on a shorter time scale. It may be that vocabulary growth in a narrower domain, say causative verbs, results in subsequent growth in utterance length because causative verbs often take direct objects, and, in turn, command of Subject-Verb-Object argument structure may support the child's interpretation and thus acquisition of newly encountered verbs when they appear in such structures. Such a view is consistent with Dionne et al.'s conclusion that there were bi-directional relations between vocabulary and grammar in development. Dixon and Marchman (2007) similarly allowed that although their analysis found no evidence of developmental ordering between the lexicon and grammar, fine-grained influences might still exist. The present data also do not contradict the notion that a certain threshold of vocabulary knowledge may be necessary in order to begin to profit from illustrations in input of the grammatical patterns that apply across lexical items (Marchman & Bates, 1994; Rispoli & Hadley, in press) or that a certain level of grammatical development may be necessary in order to make any use of syntactic clues to word meaning (Hollich, Hirsh-Pasek, Golinkoff, et al., 2000). The children in the present study were likely past those thresholds in both their languages.

In this study, there is no way to estimate what the explanatory power of local and fine grained relations between lexical and grammatical development might be. But unless such relations fully account for the correlated rates of lexical and grammatical growth, the present findings call for additional explanation of that correlation in terms of sources of influence that are specific to each language but that, within each language, affect both vocabulary and grammar. An obvious candidate for such an influence is children's language input. Input is language specific: input in English benefits English language growth; input in Spanish benefits Spanish language growth. Input is domain general: it provides a model of both words and structures.

The argument that effects of input on both lexical and grammatical development account for their correlated rates of growth is consistent with other findings. In a behavioral genetic analysis of lexical and grammatical development among 2 year old twins, Dale et al. (2000) found shared environmental effects played the largest role in accounting for their strong correlation. Dixon and Marchman (2007) similarly suggested a role for input in explaining the synchronous growth pattern they observed. The effect of input that explains correlated lexical and grammatical development is not likely to be just an effect of relative amount of input, however, because in the present study and in Marchman et al. (2004) effects of relative amount of input were statistically removed and correlations were still observed within each of bilingual children's two developing languages. The input effect that explains the correlation between lexical and grammatical development must have its source either in the absolute amount of input, which the present measures may not have captured, or in unmeasured qualities of input that support both lexical and grammatical development, or in qualities of input that separately support lexical and grammatical development but that are themselves correlated.

There is evidence that the properties of input that support lexical and grammatical development are sometimes the same properties. Lexical richness in input clearly supports lexical development (e.g., Hoff, 2003), and lexical variety in certain grammatical slots may support grammatical inductions (Mintz, 2003; Naigles & Hoff-Ginsberg, 1998; Rispoli & Hadley, 2015). Grammatical complexity of input supports both children's grammatical development (Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010) and children's vocabulary growth (Hoff, 2003). And there is also evidence that the lexical richness and grammatical complexity of input are themselves correlated (Hoff, 2003). Statistically removing effects of the relative amount of input in each language as was done in the present study and in Marchman et al. (2004) would leave untouched the variability in the lexical richness and grammatical complexity of input in each language (Grüter, Hurtado, Marchman, & Fernald, 2014), which would then operate as a language specific influences.

There was an additional, unanticipated finding in the across-language models, which is not relevant to the question of whether and why there are ties between the lexicon and grammar in development but which does reveal something else about bilingual development. In both models of across-language relations, there were negative leading relations such that levels of English achievement (either vocabulary or grammar) were negative predictors of subsequent growth in Spanish. There were no across-language relations in which Spanish levels affected subsequent English growth. We interpret these findings not as reflections of cross language influences in the mental processes that underlie bilingual development, but rather as reflections of social influences. Given the correlation between vocabulary and grammar within each language, we expect that this suppressing influence of English skill on Spanish growth does not depend on whether vocabulary or grammar is measured, but that could be tested in further research. Rather, we expect that these findings reflect a process in which growing skills in the language of the majority culture threaten children's continued acquisition of a minority language. These Spanish-English bilingual children lived in the U.S., and as many other studies have documented, the acquisition of Spanish is vulnerable and English frequently supplants Spanish.

Limitations

In addition to the limitations imposed by the nature of the measures and the interval between measurements, there are limitations arising from our application of latent change score modeling. LCS modeling imposes strict invariance criteria to model changes and growth in skill, rather than changes in the measures over time. As such, this criterion had to be relaxed for some models. For instance, residual variances for English grammar measured by the CDI utterance length measures at 30 and 48 months were freely estimated separately from the measurements at 36 and 42 months (see Figures 1–4). Additionally, some residual variances were allowed to be correlated between time points in these models. This is an additional criterion of LCS modeling that was not met. We speculate that these correlated errors are due to the same measure being used at all four time points. And finally, although the addition of an examiner-administered test of vocabulary and the use of latent variables based on two manifest variables is an advance over previous studies, these findings are very dependent on the MacArthur-Bates inventories.

Conclusion

To answer the question with which we began, the present findings indicate that growth in vocabulary and growth in grammar are correlated in part because both depend on a common source of influence that is language specific. We speculate that that common source is the correlated lexical richness and grammatical complexity of children's language input. This evidence and the interpretation we offer adds to the growing empirical and theoretical literature that seeks–and to a degree has found–explanations of multiple acquisition phenomena in the nature of children's input and their processing of input. There is evidence that children's capacities to extract regularities from input can account for many acquisition phenomena (e.g. Saffran & Wilson, 2003; Seidenberg et al., 2002). There is evidence that input is a source of individual differences in language growth and a source of socioeconomic disparities in children's language skills (e.g., Cartmill, Armstrong, Gleitman, Goldin-Meadow, Medina, & Trueswell, 2013; Hart & Risley, 1995; Rowe, 2012). There is also evidence that input is a source of individual differences in the speed with which children process and thus learn from new input (Weisleder & Fernald, 2013). Recent theoretical work from a usage-based approach has suggested that acquiring language is driven by the need to chunk input for processing in real time and that learning a language is learning what the chunks are and how to identify them in input (Christiansen & Chater, in press). Recent theoretical work from a generative approach has suggested that the innate contribution to language acquisition consists in part of guiding uptake and inferences from input (Lidz & Gagliardi, 2015). Here we suggest that the correlation between lexical and grammatical development also has an explanation in the input-dependent nature of language acquisition.

Acknowledgments

This research was supported by NICHD grants HD060718 and HD068421 to E. Hoff, NICHD Grant P50 HD052120 to Richard K. Wagner, and an IES Predoctoral Fellowship awarded to the second author (R305B04074 and R305B090021). We thank Richard Wagner for statistical guidance and comments on an earlier version of this manuscript.

References

Anthony JL, Solari EJ, Williams JM, Schoger KD, Zhang Z, Branum-Martin L, Francis DJ. Development of bilingual phonological awareness in Spanish-speaking English language learners: The roles of vocabulary, letter knowledge, and prior phonological awareness. Scientific Studies of Reading. 2009; 13:535–564. DOI: 10.1080/10888430903034770

Bates, E., Bretherton, I., Snyder, L. From first words to grammar. New York: Cambridge University Press; 1988.

Bresnan, J. The mental representation of grammatical relations. Vol. 1. The MIT Press; 1982.

Brown RW. Linguistic determinism and the part of speech. The Journal of Abnormal and Social Psychology. 1957; 55:1–5.

Brownell, R. Expressive One-Word Picture Vocabulary Test—Spanish-English Bilingual Edition. Novato, CA: Academic Therapy Publications; 2001.

Cartmill EA, Armstrong BF, Gleitman LR, Goldin-Meadow S, Medina TN, Trueswell JC. Quality of early parent input predicts child vocabulary 3 years later. Proceedings of the National Academy of Sciences. 2013; 110:11278–11283. DOI: 10.1073/pnas.1309518110

Caselli C, Casadio P, Bates E. A comparison of the transition from first words to grammar in English and Italian. Journal of Child Language. 1999; 26:69–111. [PubMed: 10217890]

Christiansen MH, Chater N. The now-or-never bottleneck: A fundamental constraint on language. Behavioral & Brain Sciences. (in press).

Conboy BT, Thal DJ. Ties between the lexicon and grammar: Cross-sectional and longitudinal studies of bilingual toddlers. Child Development. 2006; 77:712–735. DOI: 10.1111/j.1467-8624.2006.00899.x [PubMed: 16686797]

Dale PS, Dionne G, Eley TC, Plomin R. Lexical and grammatical development: A behavioural genetic perspective. Journal of Child Language. 2000; 27:619–642. DOI: 10.1017/S0305000900004281 [PubMed: 11089341]

Dionne G, Dale PS, Boivin M, Plomin R. Genetic evidence for bidirectional effects of early lexical and grammatical development. Child Development. 2003; 74:394–412. DOI: 10.1111/1467-8624.7402005 [PubMed: 12705562]

Dixon JA, Marchman VA. Grammar and the lexicon: Developmental ordering in language acquisition. Child Development. 2007; 78:190–212. DOI: 10.1111/j.1467-8624.2007.00992.x [PubMed: 17328700]

Fenson, L., Marchman, VA., Thal, DJ., Dale, PS., Reznick, JS., Bates, E. MacArthur-Bates Communicative Development Inventories: User's Guide and Technical Manual. 2nd. Baltimore, MD: Paul H. Brookes Publishing Company; 2007.

Goldberg, AE. The emergence of the semantics of argument structure constructions. In: MacWhinney, B., editor. The emergence of language. Mahwah, NJ: Erlbaum; 1999. p. 197-212.

Grüter, T., Hurtado, N., Marchman, VA., Fernald, A. Language exposure and online processing efficiency in bilingual development: Relative versujs absolute measures. In: Grüter, T., Paradis, J., editors. Input and experience in bilingual development. Amsterdam: John Benjamins Publishing Company; 2014. p. 15-36.

Hart, B., Risley, TR. Meaningful differences in the everyday experience of young American children. Baltimore; Brookes: 1995.

Hoff E. The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. Child Development. 2003; 74:1368–1379. DOI: 10.1111/1467-8624.00612 [PubMed: 14552403]

Hoff E, Core C, Place S, Rumiche R, Señor M, Parra M. Dual language exposure and early bilingual development. Journal of Child Language. 2012; 39:1–27. DOI: 10.1017/S0305000910000759 [PubMed: 21418730]

Hollich GJ, Hirsh-Pasek K, Golinkoff RM, Brand RJ, Brown E, Chung HL, Bloom L. Breaking the language barrier: An emergentist coalition model for the origins of word learning. Monographs of the Society for Research in Child Development. 2000:65. (3, Serial No. 262).

Huttenlocher J, Waterfall H, Vasilyeva M, Vevea J, Hedges LV. Sources of variability in children's language growth. Cognitive Psychology. 2010; 61:343–365. DOI: 10.1016/j.cogpsych.2010.08.002 [PubMed: 20832781]

Jackson-Maldonado, D., Thal, DJ., Fenson, L., Marchman, VA., Newton, T., Conboy, B. El inventario del desarrollo de habilidades comunicativas: User's guide and technical manual. Baltimore, MD: Paul H. Brookes; 2003.

Kline, RB. Principles and practice of structural equation modeling. 3rd. New York, NY: Guilford Press; 2011.

Lidz, J., Gagliardi, A. How nature meets nurture: Universal grammar and statistical learning. The Annual Review of Linguistics. 2015. linguistics.annualreviews.org

Marchman VA, Bates E. Continuity in lexical and morphological development: A test of the critical mass hypothesis. Journal of Child Language. 1994; 21:339–366. DOI: 10.1017/S0305000900009302 [PubMed: 7929685]

Marchman VA, Martínez LZ, Hurtado N, Grüter T, Fernald A. Caregiver talk to young Spanish-English bilinguals: comparing direct observation and parent-report measures of dual-language exposure. Developmental Science. 2016; :1–13. DOI: 10.111/desc.12425

Marchman VA, Martínez-Sussmann C, Dale PS. The language-specific nature of grammatical development: Evidence from bilingual language learners. Developmental Science. 2004; 7:212–224. DOI: 10.1111/j.1467-7687.2004.00340.x [PubMed: 15320381]

McArdle JJ. Latent variable modeling of longitudinal data. Annual Review of Psychology. 2009; 60:577–605. DOI: 10.1146/annurev.psych.60.110707.163612

Mintz TH. Frequent frames as a cue for grammatical categories in child directed speech. Cognition. 2003; 90:91–117. [PubMed: 14597271]

Muthén, LK., Muthén, BO. Mplus User's Guide: Seventh Edition. Los Angeles, CA: Muthén & Muthén; 1998–2015.

Naigles LR, Hoff E, Vear D. Flexibility of early verb use; Evidence from a multiple-N diary study. Monographs of the Society for Research in Child Development. 2009; 74(2) Serial No. 293.

Naigles LR, Hoff-Ginsberg E. Why are some verbs learned before other verbs? Effects of input frequency and structure on children's early verb use. Journal of Child Language. 1998; 25:95–120. [PubMed: 9604570]

Naigles, L., Swensen, LD. Syntactic supports for word learning. In: Hoff, E., Shatz, M., editors. Blackwell handbook of language development. Oxford, UK: Blackwell; 2007. p. 212-231.

Parra M, Hoff E, Core C. Relations among language exposure, phonological memory, and language development in Spanish–English bilingually developing 2-year-olds. Journal of Experimental Child Psychology. 2011; 108:113–125. DOI: 10.1016/j.jecp.2010.07.011 [PubMed: 20828710]

Raftery AE. Bayesian model selection in social research. Sociological Methodology. 1995; 25:111–164.

Rispoli M, Hadley P. Input subject diversity enhances early grammatical growth: Evidence from a parent-implemented intervention. Language Learning and Development. (in press).

Rowe ML. A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. Child Development. 2012; 83:1762–1774. [PubMed: 22716950]

Saffran JR, Wilson DP. From syllables to syntax: multilevel statistical learning by 12-month-old infants. Infancy. 2003; 4:273–284.

Seidenberg MS, MacDonald MC, Saffran JR. Does grammar start where statistics stop? Science. 2002; 298(5593):553–554. [PubMed: 12386323]

Tomasello, M. Constructing a language: A usage-based theory of language acquisition. Cambridge, MA: Harvard University Press; 2003.

Weisleder A, Fernald A. Talking to children matters: Early language experience strengthens processing and builds vocabulary. Psychological Science. 2013; 24:2143–2152. DOI: 10.1177/0956797613488145 [PubMed: 24022649]

Author Manuscript

Author Manuscript

Author Manuscript

Research Highlights

- In Spanish-English bilingually developing children, the slopes and intercepts of vocabulary and grammatical development were correlated within but not across languages.
- There was no evidence of direct dependencies between vocabulary and grammatical development.
- We propose that language input is the third variable accounting for the language-specific correlation between vocabulary and grammar.
- A consistent pattern of negative across-language relations suggested the development of Spanish in U.S. Spanish-English bilingual children is vulnerable to take-over as children's English skills develop.

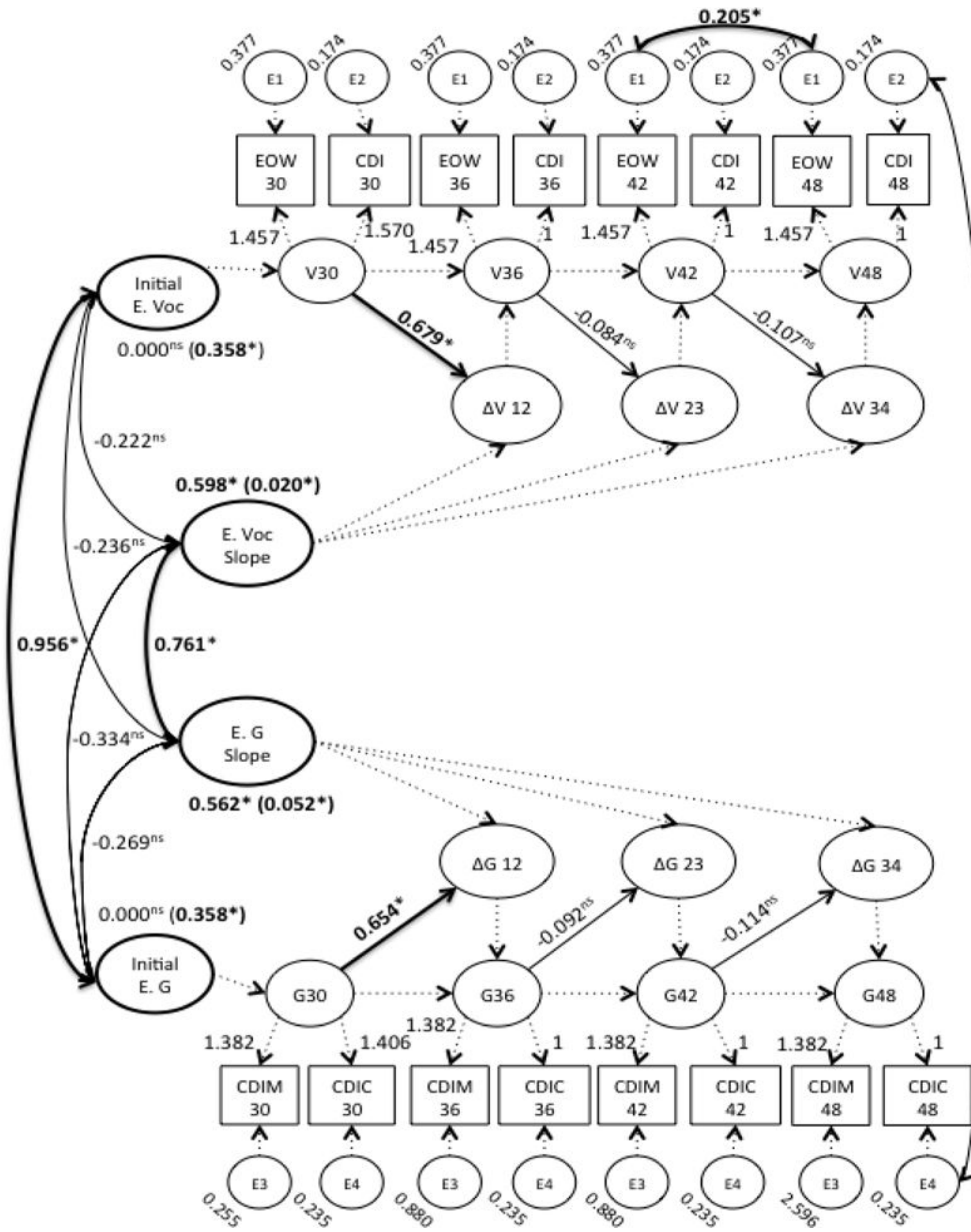

Figure 1.

Bivariate LCS model within English. E. Voc = English Vocabulary; E. G = English grammar. EOW = Expressive One Word Vocabulary; CDI V = CDI Vocabulary; CDIM = CDI M3L; CDI C = CDI Grammatical Complexity. V30–V48= Vocabulary at 30, 36, 42, and 48 months respectively. G30–G48 = Grammar at 30, 36, 42, and 48 months respectively. Pathways with a dotted line indicate a constraint (1) for model estimation. Bold pathways indicate significance. * = p < .01.

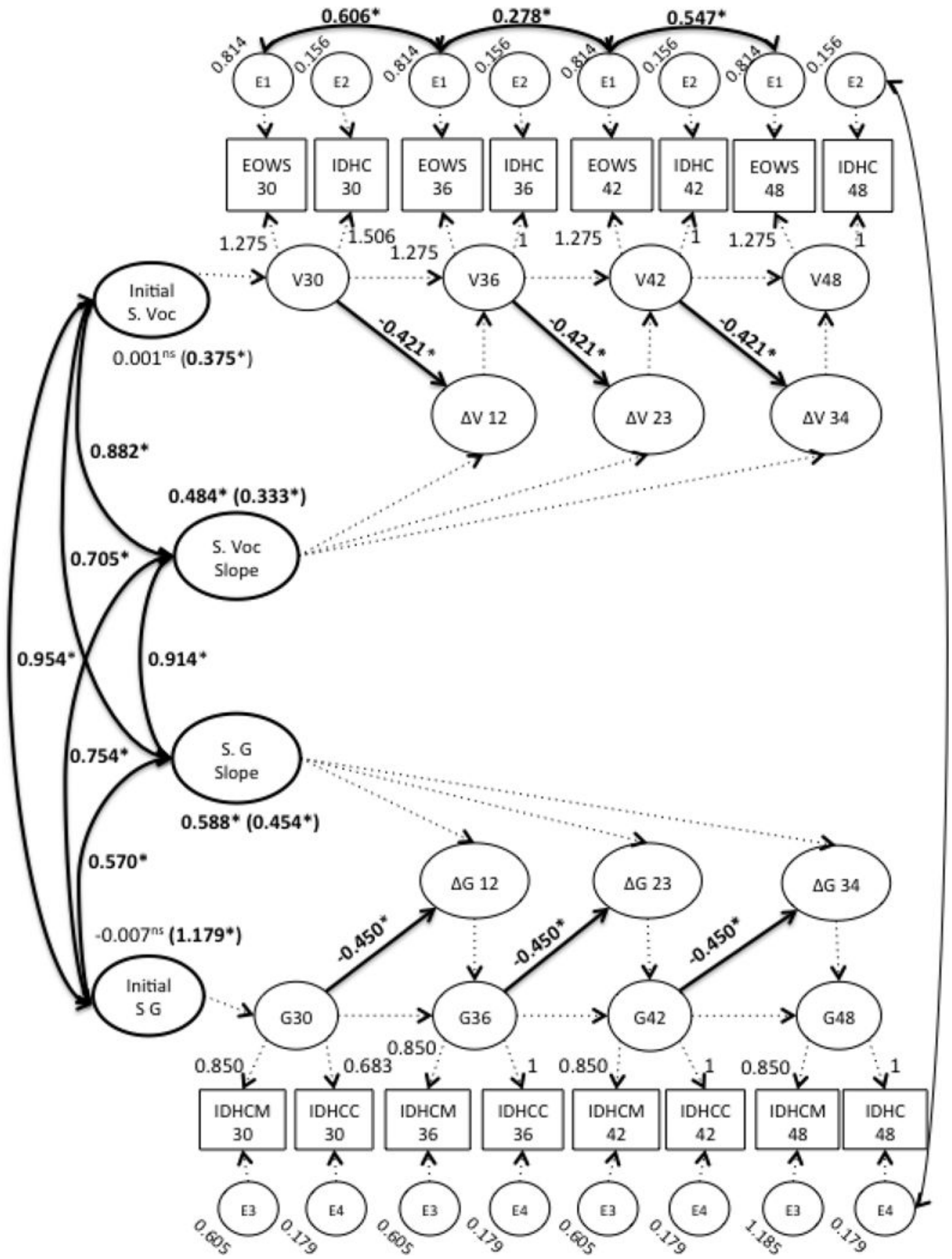

Figure 2.

Bivariate LCS model within Spanish. S. Voc = Spanish Vocabulary; S. G = Spanish grammar. EOW = Expressive One Word Vocabulary; IDHC V = IDHC Vocabulary; IDHCM = IDHC M3L; IDHC C = IDHC Grammatical Complexity. V30–V48= Vocabulary at 30, 36, 42, and 48 months respectively. G30–G48 = Grammar at 30, 36, 42, and 48 months respectively. Pathways with a dotted line indicate a constraint (1) for model estimation. Bold pathways indicate significance. * = p < .01. ns = not significant.

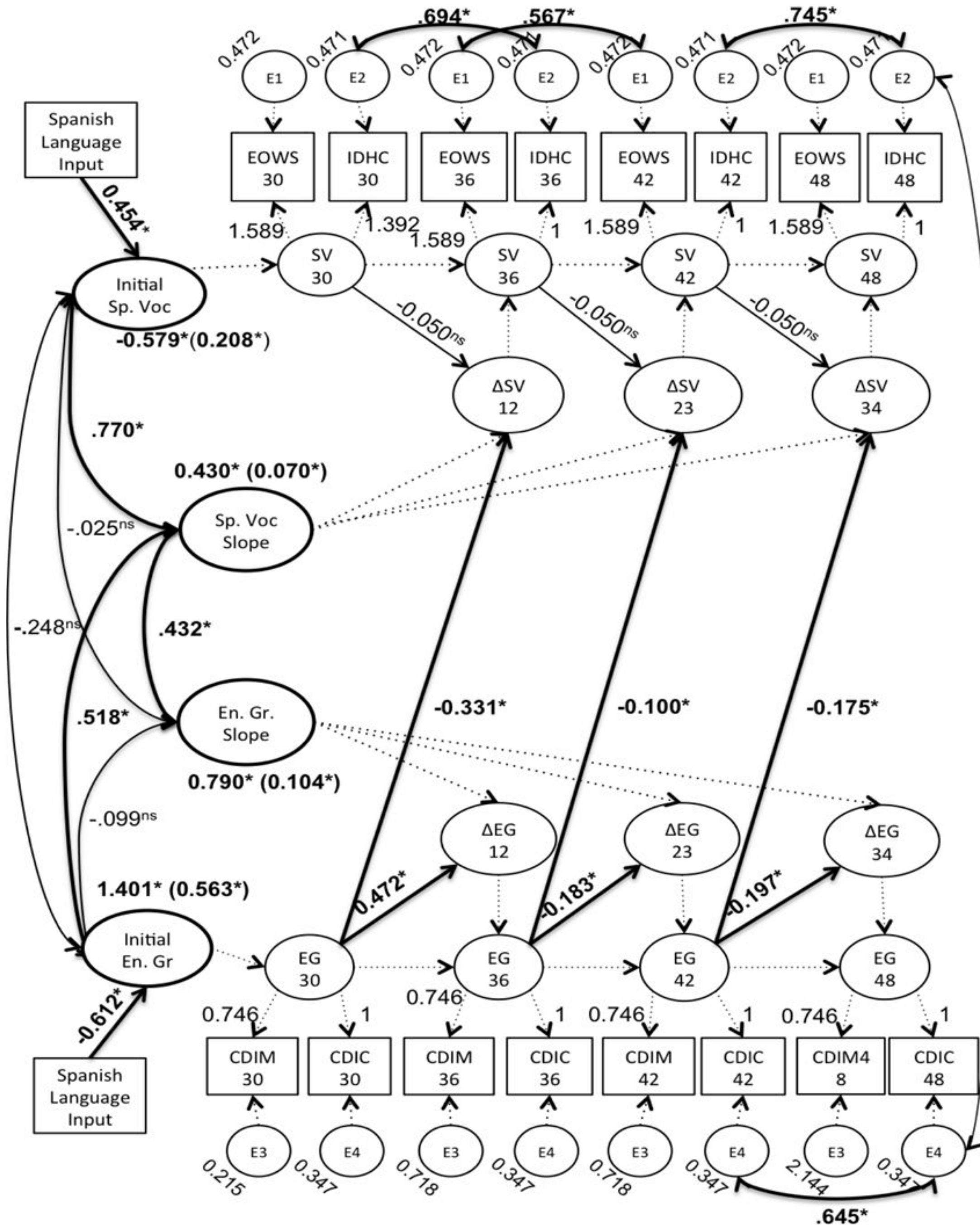

Figure 3.

Bivariate LCS model of English Grammar and Spanish Vocabulary with Spanish Language Input as a covariate. See Figure 2 for further caption explanations.

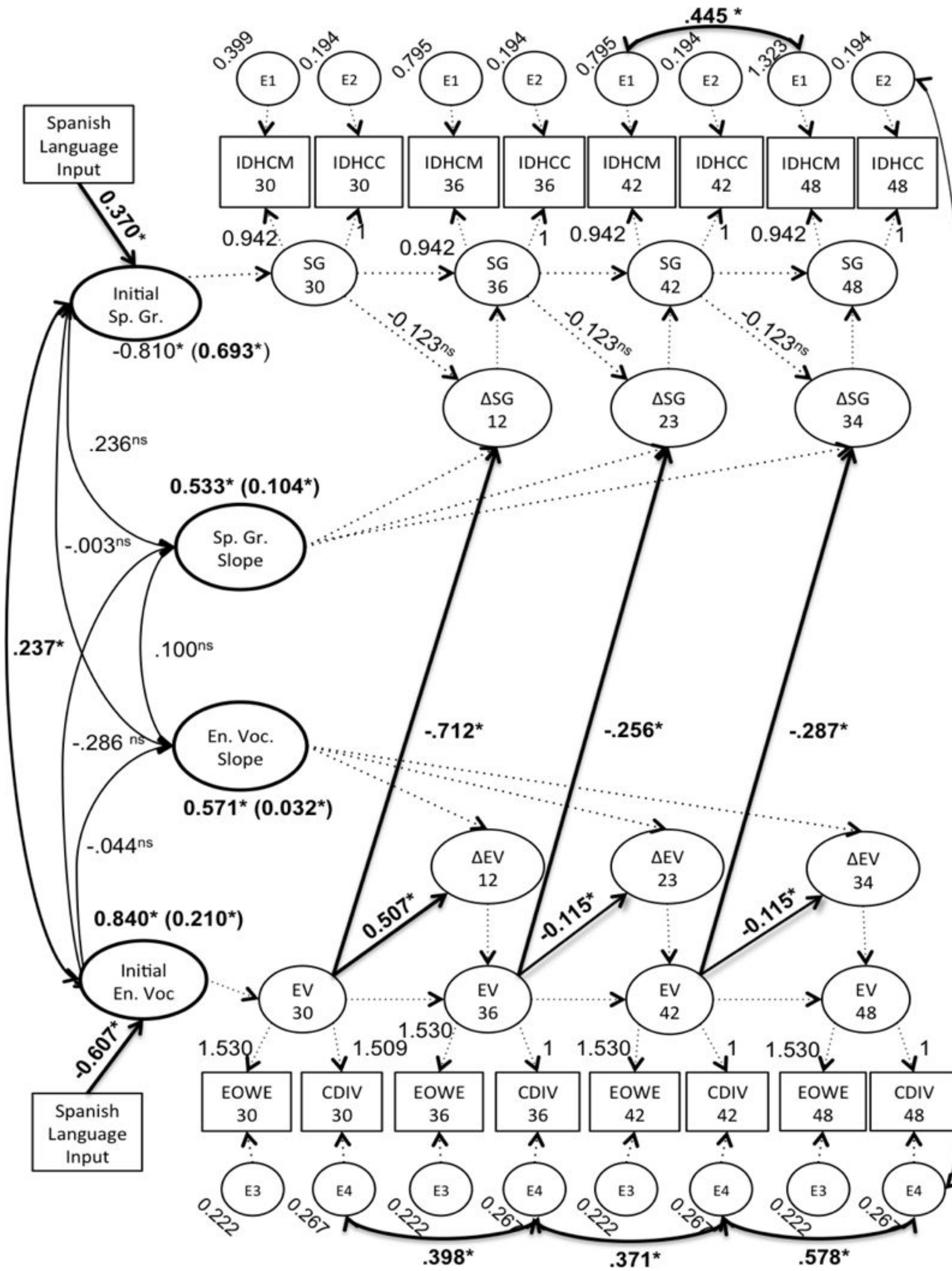

Figure 4.

Bivariate LCS model of English Vocabulary and Spanish Grammar with Spanish Language Input as a covariate. See Figure 3 for further caption explanations.

Author Manuscript

Author Manuscript

Author Manuscript

Table 1

Means (Standard Deviations) for Child Age, Spanish Exposure, and English Exposure, and Sample Size

	Time 1	Time 2	Time 3	Time 4
Age (in months)	30.6 (.40)	36.5 (.41)	42.4 (.39)	48.4 (.40)
% Spanish input	62.0 (25.9)	63.6 (27.4)	61.1 (28.2)	58.2 (27.7)
% English input	37.9 (25.8)	36.2 (27.4)	38.7 (28.1)	41.4 (27.7)
Sample size	90	59	72	82

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Means (Standard Deviations) for Measures of Lexical and Grammatical Development in English and Spanish

	30 months	36 months	42 months	48 months
English vocabulary (CDI)	228 (176)	334 (194)	456 (177)	512 (151)
English vocabulary (EOWPVT)	11.2 (10.5)	18.9 (14.2)	28.4 (15.1)	36.0 (14.2)
English grammar (CDI grammatical complexity)	9.1 (11.6)	14.3 (13.4)	22.9 (12.3)	26.7 (11.8)
English grammar (CDI M3L)	3.6 (2.0)	5.1 (3.5)	7.0 (2.9)	7.9 (3.9)
Spanish vocabulary (IDHC)	234 (159)	317 (171)	363 (195)	279 (210)
Spanish vocabulary (EOWPVT)	5.1 (7.5)	10.1 (10.2)	14.6 (13.8)	16.0 (14.2)
Spanish grammar (IDHC grammatical complexity)	10.6 (12.0)	17.5 (13.9)	21.9 (15.3)	23.2 (15.3)
Spanish grammar (IDHC M3L)	3.6 (1.9)	5.0 (2.9)	5.7 (2.9)	5.8 (3.4)

Table 3

Correlations Among Measures of Lexical and Grammatical Development Within English

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. EV CDI 3O																
2. EV EOWPVT 30	**.808**															
3. EV CDI 36	**.852**	**.709**														
4. EV EOWPVT 36	**.757**	**.823**	**.745**													
5. EV CDI 42	**.798**	**.768**	**.889**	**.817**												
6. EV EOWPVT 42	**.745**	**.762**	**.761**	**.887**	**.780**											
7. EV CDI 48	**.713**	**.630**	**.765**	**.753**	**.866**	**.767**										
8. EV EOWPVT 48	**.661**	**.646**	**.732**	**.815**	**.704**	**.892**	**.737**									
9. EG GCS 30	**.888**	**.742**	**.755**	**.686**	**.693**	**.658**	**.637**	**.574**								
10. EG M3L 30	**.790**	**.658**	**.696**	**.677**	**.710**	**.661**	**.649**	**.499**	**.772**							
11. EG GCS 36	**.735**	**.596**	**.852**	**.571**	**.790**	**.621**	**.732**	**.598**	**.733**	**.706**						
12. EG M3L 36	**.699**	**.625**	**.700**	**.611**	**.745**	**.539**	**.625**	**.490**	**.721**	**.744**	**.725**					
13. EG GCS 42	**.669**	**.653**	**.673**	**.682**	**.822**	**.727**	**.802**	**.687**	**.617**	**.699**	**.782**	**.646**				
14. EG M3L 42	**.637**	**.638**	**.645**	**.676**	**.665**	**.581**	**.662**	**.549**	**.633**	**.668**	**.663**	**.803**	**.697**			
15. EG GCS 48	**.570**	**.501**	**.593**	**.554**	**.710**	**.684**	**.683**	**.645**	**.552**	**.529**	**.685**	**.503**	**.860**	**.633**		
16. EG M3L 48	**.457**	**.467**	**.608**	**.464**	**.408**	**.473**	**.404**	**.411**	**.466**	**.470**	**.579**	**.506**	**.372**	**.598**	**.476**	
N	90	88	46	56	53	69	67	77	90	90	46	46	52	52	64	66

Note. Bold numbers are significant at $p < .01$; V = English vocabulary; EG = English grammar; CDI = MacArthur-Bates Communicative Development Inventories; EOWPVT = Expressive One-Word Picture Vocabulary Test; GCS = Grammatical complexity score; M3L = Mean length of 3 longest utterances; EV 30 – EV 48 = English vocabulary scores at 30, 36, 42 and 48 months respectively. EG 30–48 = English grammar at 30, 36, 42 and 48 months respectively.

Table 4

Correlations Among Measures of Lexical and Grammatical Development Within Spanish

Measure	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1. SV IDHC 30																
2. SV EOWPVT 30	**.632**															
3. SV IDHC 36	**.825**	**.526**														
4. SV EOWPVT 36	**.597**	**.731**	**.683**													
5. SV IDHC 42	**.854**	**.540**	**.860**	**.636**												
6. SV EOWPVT 42	**.736**	**.690**	**.781**	**.911**	**.728**											
7. SV IDHC 48	**.800**	**.564**	**.864**	**.712**	**.924**	**.733**										
8. SV EOWPVT 48	**.655**	**.693**	**.714**	**.860**	**.689**	**.887**	**.698**									
9. SG GCS 30	**.828**	**.658**	**.688**	**.560**	**.708**	**.675**	**.697**	**.623**								
10. SG M3L 30	**.707**	**.496**	**.523**	**.423**	**.628**	**.539**	**.569**	**.508**	**.724**							
11. SG GCS 36	**.802**	**.538**	**.866**	**.660**	**.859**	**.756**	**.800**	**.700**	**.777**	**.530**						
12. SG M3L 36	**.611**	**.547**	**.623**	**.711**	**.596**	**.766**	**.648**	**.781**	**.587**	**.537**	**.663**					
13. SG GCS 42	**.733**	**.547**	**.794**	**.621**	**.840**	**.665**	**.850**	**.700**	**.603**	**.496**	**.846**	**.671**				
14. SG M3L 42	**.758**	**.489**	**.709**	**.738**	**.794**	**.744**	**.764**	**.695**	**.607**	**.617**	**.745**	**.654**	**.751**			
15. SG GCS 48	**.683**	**.526**	**.832**	**.676**	**.844**	**.678**	**.860**	**.693**	**.576**	**.468**	**.795**	**.669**	**.917**	**.729**		
16. SG M3L 48	**.653**	**.505**	**.640**	**.701**	**.687**	**.788**	**.720**	**.684**	**.565**	**.542**	**.677**	**.727**	**.715**	**.781**	**.704**	
N	90	90	54	59	63	71	77	82	90	89	54	.52	63	63	77	77

Note. Bold numbers are significant at $p < .01$; SV = Spanish vocabulary; SG = Spanish grammar; IDHC = Inventario del Desarrollo de Habilidades Comunicativas; EOWPVT = Expressive One-Word Picture Vocabulary Test; GCS = Grammatical complexity score; M3L = Mean length of 3 longest utterances; SV 30–SV 48 = Spanish vocabulary scores at 30, 36, 42 and 48 months respectively. SG 30–48 = Spanish grammar at 30, 36, 42 and 48 months respectively.

Table 5

Correlations Between Measures of Spanish Lexical Development and English Grammar Development Controlling for Spanish Input (Zero Order Correlations Between Spanish Lexical and English Grammar Development)

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. SV IDHC 30																
2. SV EOWPVT 30	**.669 (.632)**															
3. SV IDHC 36	**.808 (.825)**	**.571 (.526)**														
4. SV EOWPVT 36	**.654 (.597)**	**.678 (.731)**	**.673 (.683)**													
5. SV IDHC 42	**.848 (.854)**	**.683 (.540)**	**.780 (.860)**	**.703 (.636)**												
6. SV EOWPVT 42	**.644 (.736)**	**.655 (.690)**	**.686 (.781)**	**.954 (.911)**	**.753 (.728)**											
7. SV IDHC 48	**.786 (.800)**	**.644 (.564)**	**.805 (.864)**	**.744 (.712)**	**.875 (.924)**	**.762 (.733)**										
8. SV EOWPVT 48	**.547 (.655)**	**.706 (.693)**	**.598 (.714)**	**.898 (.860)**	**.653 (.689)**	**.905 (.887)**	**.681 (.698)**									
9. EG GCS 30	.341 (−.100)	.110 (−.151)	.271 **(−.323)**	−.011 **(−.306)**	.285 (−.213)	.059 (−.160)	.333 **(−.225)**	.088 (−.180)								
10. EG M3L 30	.238 (−.132)	.076 (−.143)	.152 **(−.406)**	.023 **(−.307)**	.233 **(−.238)**	.027 **(−.238)**	.246 **(−.233)**	.136 **(−.227)**	**.827 (.772)**							
11. EG GCS 36	.279 (.029)	.039 (−.111)	.203 (−.116)	−.098 (−.257)	.237 (−.059)	−.071 (−.183)	.124 (−.232)	−.023 (−.213)	**.779 (.733)**	**.763 (.706)**						
12. EG M3L 36	.311 (.003)	.219 (.014)	.260 (−.182)	.076 (−.177)	.349 (−.034)	.054 (−.139)	.301 (−.216)	.146 (−.125)	**.598 (.721)**	**.688 (.744)**	**.711 (.725)**					
13. EG GCS 42	.357 (−.005)	.228 (−.105)	.233 (−.192)	.135 (−.171)	.242 (−.079)	.049 (−.188)	.238 (−.120)	.223 (−.090)	**.481 (.617)**	**.652 (.699)**	**.725 (.782)**	**.605 (.646)**				
14. EG M3L 42	.259 (−.002)	.241 (.042)	.104 (−.234)	.174 (−.072)	.286 (−.093)	.136 (−.073)	.256 (−.111)	.248 (−.013)	**.472 (.633)**	**.691 (.668)**	**.598 (.663)**	**.768 (.803)**	**.661 (.697)**			
15. EG GCS 48	**.388** (−.072)	.321 (−.045)	**.432** (−.172)	.222 (−.134)	.346 (−.150)	.240 (−.109)	.342 (−.126)	.322 (−.079)	**.496 (.552)**	**.596 (.529)**	**.669 (.685)**	**.462 (.503)**	**.797 (.860)**	**.546 (.633)**		
16. EG M3L 48	.023 (−.077)	.017 (−.046)	.201 (−.125)	−.004 (−.179)	.056 (−.124)	.078 (−.008)	.028 (−.176)	.005 (.037)	**.371 (.466)**	**.457 (.470)**	**.503 (.579)**	.310 **(.506)**	.198 **(.372)**	**.393 (.598)**	**.447 (.476)**	
N	90	90	54	59	63	71	77	82	90	90	46	46	52	52	64	66

Note. SV = Spanish vocabulary; EG = English Grammar; See Table 3 for further explanations.

Table 6

Correlations Between Measures of English Lexical Development and Spanish Grammatical Development Controlling for Spanish Input (Zero Order Correlations Between Measures of English Lexical Development and Spanish Grammatical Development)

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. EV CDI 30																
2. EV EOWPVT 30	**.664 (.808)**															
3. EV CDI 36	**.788 (.852)**	**.660 (.709)**														
4. EV EOWPVT 36	**.609 (.757)**	**.672 (.832)**	**.761 (.745)**													
5. EV CDI 42	**.743 (.798)**	**.656 (.768)**	**.866 (.889)**	**.749 (.817)**												
6. EV EOWPVT 42	**.608 (.745)**	**.600 (.762)**	**.588 (.761)**	**.717 (.887)**	**.623 (.780)**											
7. EV CDI 48	**.637 (.713)**	**.539 (.630)**	**.675 (.765)**	**.584 (.753)**	**.759 (.866)**	**.609 (.767)**										
8. EV EOWPVT 48	**.641 (.661)**	**.683 (.646)**	**.636 (.732)**	**.703 (.815)**	**.599 (.704)**	**.829 (.892)**	**.694 (.737)**									
9. SG GCS 30	.246 (−.014)	−.003 (−.125)	.067 (−.051)	.012 (−.216)	.199 (−.049)	.175 (−.056)	.149 (−.093)	.255 (−.026)								
10. SG M3L 30	.302 (.085)	−.015 (−.012)	.188 (−.040)	.103 (−.087)	.304 (.202)	.179 (.059)	.177 (.022)	.264 (.112)	**.838 (.724)**							
11. SG GCS 36	.096 (−.243)	−.075 **(−.341)**	−.093 (−.266)	−.194 **(−.423)**	.069 (−.181)	.078 **(−.291)**	.028 (−.255)	.151 (−.204)	**.869 (.777)**	**.670 (.530)**						
12. SG M3L 36	−.035 **(−.285)**	.013 **(−.289)**	−.075 **(−.312)**	−.063 **(−.332)**	−.090 (−.294)	−.095 **(−.390)**	−.181 **(−.483)**	.144 (−.262)	**.575 (.587)**	**.485 (.537)**	**.628 (.663)**					
13. SG GCS 42	−.034 **(−.266)**	−.163 **(−.303)**	−.184 **(−.376)**	−.262 **(−.437)**	−.063 (−.228)	−.157 (−.421)	−.107 **(−.304)**	.022 **(−.312)**	**.651 (.603)**	**.570 (.496)**	**.868 (.846)**	**.659 (.671)**				
14. SG M3L 42	−.104 (−.179)	−.079 (−.123)	−.186 **(−.325)**	−.141 (−.281)	−.085 (−.118)	.010 (−.116)	−.092 (−.162)	.134 (−.025)	**.622 (.607)**	**.673 (.617)**	**.702 (.745)**	**.751 (.654)**	**.708 (.751)**			
15. SG GCS 48	−.020 (−.357)	−.158 **(−.386)**	−.169 **(−.472)**	−.324 **(−.541)**	−.144 **(−.317)**	−.128 **(−.437)**	−.138 **(−.353)**	−.006 **(−.328)**	**.628 (.576)**	**.530 (.468)**	**.824 (.795)**	**.605 (.669)**	**.930 (.917)**	**.625 (.729)**		
16. SG M3L 48	−.071 (−.119)	−.045 (−.096)	−.201 **(−.438)**	−.275 **(−.455)**	−.216 (−.156)	−.145 (−.164)	−.293 (−.176)	.088 (−.118)	**.564 (.565)**	**.510 (.542)**	**.668 (.677)**	**.856 (.727)**	**.703 (.715)**	**.748 (.781)**	**.713 (.704)**	
N	90	88	46	56	53	69	67	77	90	89	54	52	63	63	77	77

Notes. EV = English vocabulary; SG = Spanish Grammar; See Table 3 for further explanations.