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Maternal education revisited: Vocabulary growth in English and Spanish from 16 to 30 months of age☆

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ABSTRACT

This paper reports on a cross-language longitudinal study in which we extend previous research on the effects of maternal education on vocabulary growth in Spanish- and English-dominant children at three time points: 16 months, 22 months, and 30 months of age. This study addresses recent conflicting evidence regarding the role of maternal education in children's acquisition of Spanish. Participants were 62 English-dominant children, 47 Spanish-dominant children, and their mothers. Growth curve models were constructed separately for English and Spanish vocabulary. Strong growth rate reliability and effect sizes were evinced for vocabulary across samples. As expected, in English-dominant children, maternal education predicted English vocabulary and growth from 16 to 30 months of age. However, in Spanish-dominant children, there was no significant effect of maternal education on vocabulary or growth, although there was a descriptive advantage for children of college-educated mothers at 30 months of age. In conjunction with prior evidence, we conclude that the effect of maternal education on maternal input and child vocabulary does not generalize readily to children whose first language is Spanish. Our findings contribute to a literature that suggests that focusing on maternal beliefs, input, and the home literacy environment are more fruitful approaches in the study of children learning Spanish in the U.S. Further, the importance of maternal beliefs highlights the need to support parent investment in the quantity and quality of input in the home language.

1. Introduction

Characterizing the early learning environment is crucial to understanding how it supports the cascade from children's earliest cognitions to their first word-to-world mappings to the preliteracy and numeracy skills that support school readiness: developments

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that occur within the first five years of life (Leffel & Suskind, 2013). Early language exposure is central to this environment and, as such, of critical importance not only to these early achievements but to life trajectory (e.g., achievement and employment). During the first three years there is a rapid expansion in early vocabulary (Samuelson & McMurray, 2017) and vocabulary in this period is a strong predictor of later skill (Rowe, 2012). Approaches to studying early language exposure (referred to hereafter as input) concern both its quantity and quality. These characteristics distinguish families of lower- versus higher-socioeconomic status (SES), families within the same SES, and correlate with children's word processing and expressive vocabulary (see Schwab and Lew-Williams, 2016 for a review).

For example, Weisleder and Fernald (2013) found the quantity of input directed to children at 19 months to be associated with expressive vocabulary size at 24 months of age and Hirsh-Pasek et al. (2015) found the quality of parent-child interactions at 24 months predicted children's expressive language at 36 months of age. There is also a broad literature in which the relation between input and vocabulary is studied in the context of the home literacy environment (HLE), which incorporates the number of books in the home, frequency of shared book-reading, and other opportunities for language input (e.g., storytelling or singing; Schmitt et al., 2011; Kim et al., 2015). Variation in the quantity and quality of input as a function of SES is reflected downstream in an academic achievement gap that persists throughout schooling (Leffel & Suskind, 2013) and early vocabulary growth has a greater impact on outcomes for lower-SES children relative to their higher-SES peers (Rowe, 2012).

Since SES is positively associated with vocabulary size (e.g., Hart & Risley, 1995; Hoff, 2003; Place & Hoff, 2015; Vernon-Feagans, Pancsofar, Willoughby, Odom, Quade & Cox, 2008), some researchers have also considered how maternal education is related to maternal speech (Hoff, 2003) and in turn to early vocabulary acquisition in English. Many studies report relations between maternal education and early English vocabulary (Beitchman et al., 2008; Bohman, Bedore, Peña, Mendez-Perez & Gillam, 2010; DeAnda, Bosch, Poulin-Dubois, Zesiger & Friend, 2016; Friend, DeAnda, Arias-Trejo, Pouline-Dubois & Zesiger, 2017; Hoff, 2003).

One possibility is that maternal education confers knowledge about child development leading to richer maternal language (Rowe, 2008). Alternatively, college education, in particular, may influence maternal language proficiency and thus the quality of maternal language (Hoff-Ginsberg, 1991). One study evaluated the relative importance of SES (maternal education and income), maternal input, and early vocabulary growth in the first 30 months as predictors of vocabulary skill at 54 months in monolingual English children. As expected, early SES and input were associated with later vocabulary skill, and early child vocabulary growth emerged as the strongest predictor (Rowe, 2012).

Of interest in the present paper is how well the link between maternal education and early vocabulary generalizes across languages and cultures. Whereas the proximal link between maternal input and early vocabulary is empirically robust (e.g., Goldin-Meadow, Levine, Hedges, Huttenlocher, Raudenbush & Small, 2014; Golinkoff, Hoff, Rowe, Tamis-LeMonda & Hirsh-Pasek, 2019; Tamis-LeMonda et al., 2014), it is less clear whether this is true of the more distal relation between maternal education and early vocabulary. Richman et al. (1992) proposed two hypotheses regarding the relation between culture, maternal education, and maternal responsiveness. First, maternal responsiveness reflects cultural conventions in parent-child interaction and second, within cultures, maternal responsiveness is influenced by maternal education.

In the United States, Spanish is the second most frequently spoken language in the home. Of the 21.3% of the population who speak a language other than English, 13.2% speak Spanish (i.e., ~40 million Spanish speakers; US Census, 2017, *Language Spoken At Home*). In Florida, California, and Texas, states with large Latino populations, the proportion of Spanish speakers is higher (21, 28, and 29.5%, respectively). Yet, our understanding of the indirect link between maternal education and child vocabulary acquisition in Spanish is limited. Mitigating well-documented educational disparities among children in the US (Toppelberg & Collins, 2010) makes clarifying those factors most central to quality early learning environments in Spanish-speaking children imperative.

In two studies of English-dominant and Spanish-dominant toddlers, DeAnda et al. (2016) and Friend et al. (2017) found that English-dominant children of mothers who completed college had larger receptive and expressive vocabularies at 16 and 22 months of age than peers whose mothers had not. However, this effect was not observed in Spanish-dominant children. Indeed, few studies find an effect of maternal education on Spanish vocabulary prior to 30 months of age in contrast to the many studies reporting positive effects of maternal education on English vocabulary at this age. In one exception, a study of toddlers from 15 to 37 months of age found a small but significant relation between maternal education and child vocabulary and processing speed (Hurtado et al., 2007). However, Weisleder and Fernald (2013) found that maternal *input*, but not maternal *education*, was associated with vocabulary across languages by 24 months of age. In another study of 18- to 24-month-olds, maternal *input* was associated with vocabulary size but not with SES suggesting that the expected link between maternal education and input may not hold in these samples (Hurtado et al., 2008).

By kindergarten age, maternal education influences English, but not Spanish, acquisition in Spanish-English bilingual children (Bohman et al., 2010) and although maternal education contributes to mother-child reading with toddlers and preschoolers (Raikes et al., 2006), when income, education, and family size are controlled, differences in reading practices by ethnicity remain (Yarosz & Barnett, 2001). For example, Leyva, Reese, Grolnick, and Price (2009) report that Hispanic mothers engage in less elaboration when reminiscing with their children than do White or Black mothers with equivalent education. In a study of Dominican and Mexican children two through five years of age, changes in maternal input over time predicted child vocabulary growth in both English and Spanish but maternal education did not (Tamis-LeMonda et al., 2014). The absence of maternal education effects on child vocabulary in these studies cannot be fully explained by dual language exposure, developmental stage, or immigration status. In studies of functionally monolingual (80-100% exposure) English- and Spanish-speaking cohorts, maternal education was positively associated with English, but not Spanish, vocabulary at 16 and 22 months of age and this latter finding holds for fully monolingual Spanish-speaking children living in Mexico (De Anda et al., 2016; Friend et al., 2017). DeAnda et al. (2016) suggest that there may be genuine cultural differences in maternal input in Spanish that is unrelated to maternal education.

In contrast to these studies, Gonzalez et al. (2016) observed effects of income and maternal education on vocabulary size in Latino four- and five-year-old children: these effects were fully mediated by proximal predictors including maternal beliefs about reading, the

home literacy environment, and books available in the home. Similarly, in a large-scale study of four-year-olds in Chile (n=1418), Coddington et al. (2014) found maternal education to account for modest, significant variance in child vocabulary as well as in proximal variables such as standard of living and cognitive stimulation. To contextualize this finding, in contrast to the U.S., Chile provides universal access to childcare and education beginning at three months of age and kindergarten enrollment is slightly higher in Chile than in the U.S. From a bioecological perspective, this represents a policy initiative that supports parental investment in children that varies across Chile and the U.S. (Mistry & Wadsworth, 2011). This contrast highlights an important sociocultural difference in support of parent investment in the quantity and quality of input in the child's home language. Both Gonzalez et al., (2016) and Coddington et al., (2014) point to the contribution of the language environment of the child (both local such as parent beliefs and books in the home and sociocultural) to the relation between maternal education and child vocabulary acquisition.

Hammer et al. (2012) emphasize the importance of maternal language use and proficiency to account for variation in the effect of maternal education across languages. Specifically, parent English usage and proficiency is negatively associated with Spanish acquisition and positively associated with English acquisition. Following this reasoning, Hoff, Burridge, Ribot, and Giguere (2018) proposed that the influence of maternal education is language-specific: level of education in English should support children's English vocabulary and level of education in Spanish should support Spanish vocabulary. Maternal education in English (dichotomously coded as college completion) was associated with English vocabulary size at 30 months and with growth from 30 to 60 months of age. Maternal education in Spanish was marginally associated with Spanish vocabulary size at 30 months, but not with vocabulary growth.

Only one study to our knowledge has explicitly attempted to extend or replicate this finding. In a small study (N=20) of low-SES bilingual Latino children between three and four years of age, Montanari et al. (2020) asked whether maternal education (in this case, high school attainment) in Spanish influenced other aspects of Spanish language acquisition (i.e., phonological skill, lexical diversity, and utterance length). Maternal education was related to all outcomes in English but, in Spanish, child age was the only significant predictor. This is consistent with a recent larger study (N=277) in Guadalajara finding no effects of maternal education on syntactic measures of oral narrative production in monolingual Spanish-speaking preschoolers (Mendoza, Beltran-Navarro, Matute & Rosselli, 2021). The present paper extends the longitudinal evidence on maternal education effects in Spanish-speaking children downward to 16 to 30 months of age, a period of accelerated vocabulary acquisition (Samuelson & McMurray, 2017), creating a point of overlap at 30 months with the Hoff et al. (2018) data.

Because effects of maternal education on early English vocabulary are found consistently in the literature, we predict an association of maternal education in English with early English vocabulary. This serves as a manipulation check on our method and analyses. Hoff et al.'s (2018) language-specificity hypothesis remains untested in young Spanish-speaking children during the acceleration in vocabulary acquisition. Considering their argument for this hypothesis, that mothers will provide the highest quality input in the language in which they are most educated, we predict an association between maternal education in Spanish and early Spanish vocabulary. If both predictions are supported, this would suggest that the effect of maternal education is similar across the languages and cultures assessed here when we consider maternal education in the child's dominant language. If, on the other hand, we observe an effect of maternal education on English-dominant vocabulary only, this would suggest that the effect of maternal education on early vocabulary operates differently across languages and cultures. The methodology follows and extends De Anda et al. (2016), Friend et al. (2017), and Hoff et al. (2018) to harmonize our data with those prior studies.

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2. Method

2.1. Participants

Participants were 62 English-dominant children (36 female) and 46 Spanish-dominant children (21 female) and were tested at three timepoints at roughly 16, 22, and 30 months of age. Seventy-eight of these 108 participants contributed data at the first and second timepoints to reports by DeAnda, Arias-Trejo, Poulin-Dubois, Zesiger, and Friend (2016) and Friend et al., (2017). This constitutes a reanalysis of those data sets with 36 new additional participants and an additional measurement occasion at 30 months to harmonize this dataset with Hoff et al. (2018). This allows us to extend prior findings to evaluate evidence for the role of maternal education in early vocabulary during the period of rapid vocabulary acquisition. For English-dominant children, 96.7% of fathers and 98.4% of mothers were native English speakers (American, n=58, British, n=4); mothers were the primary source of language input for 78% of children. For Spanish-dominant children, 75.5% of fathers and 90.6% of mothers were native Spanish speakers (Mexican, n=43, Colombian, n=2, Honduran, n=1); mothers were the primary source of input for 77% of children. All children were exposed to either English or Spanish as their L2 and all families were residents of Southern California.

Participants were recruited from birth records, flyers, and family-oriented community events. English-dominant children were exposed to English from birth between 52 and 100% of the time (M =.95, SD =.11) and Spanish-dominant children were exposed to Spanish from birth between 52 and 100% of the time (M =.83, SD =.14). Most children were functionally monolingual (=> 77% exposure) in either English (n=56 of 62) or Spanish (n=38 of 46). Mean exposures for English and Spanish were 93% and 84%, respectively.

2.2. Procedure

Prior to each laboratory visit, the Language Exposure Assessment Tool (LEAT; DeAnda et al., 2016), a language background questionnaire, was administered via telephone to estimate children's exposure to their languages from birth. At each visit, primary caregivers completed a demographic questionnaire about family background with a researcher fully proficient in the parent's preferred language. Children's expressive vocabulary was assessed in their dominant language via parent report on the MacArthur Communicative Development Inventory (English; Fenson et al., 2007) or the Inventarios del Desarrollo de Habilidades Comunicativas (Spanish; Maldonado et al., 2003). For bilingual children, each inventory was completed by the parent most proficient in that language. Children whose parents had proficiency in both languages completed both inventories.

2.3. Measures

2.3.1. Maternal education

Mothers were queried about the languages in which they attended formal schooling and about the highest grade-level achieved in each language. Maternal education ranged from 12 to 18 years in mothers of English-dominant children and from 8 to 18 years in mothers of Spanish-dominant children. All of our mothers received their education in English, Spanish, or both. For each mother, we collected the highest grade-level achieved in each language.

Following Hoff et al. (2018), maternal education was rescaled to create two dichotomous variables: (1) English education (less than a 4-year degree, or a 4-year degree or more and (2) Spanish education (less than a 4-year degree, or a 4-year degree or more). This theoretically motivated index of maternal education was necessary to assess differences in vocabulary growth (i.e., slope) as a function of education. In addition, the pattern of zero-order correlations between vocabulary and maternal education was identical for both the dichotomous and continuous measure and the two measures were strongly correlated in both English and Spanish ($r(59)=0.798$, $p<0.001$ and $r(45)=0.666$, $p<0.001$, respectively).

College completion confers benefits to early vocabulary in English (DeAnda et al., 2016; Friend et al., 2017; Hoff, 2003), has been suggested to do the same in Spanish by 30 months of age (Hoff et al., 2018) and is strongly associated with higher SES (Fernald et al. 2013). Further, it is associated, in Latino mothers, with differences in parent-child teaching (Tamis-LeMonda, Sze, Ng, Kahana-Kalman & Yoshikawa, 2013). Conceptualizing maternal education in terms of college completion and taking language specificity into account allowed us to extend Hoff et al.'s approach to new, younger samples. In the English-dominant sample, 30 mothers had completed college in English and 31 had not. In the Spanish-dominant sample, 15 mothers had completed college in Spanish and 32 had not. Without regard to language of education, in the English-dominant sample, 41 mothers had completed college and 21 mothers had not whereas in the Spanish-dominant sample, 23 mothers had completed college and 24 mothers had not. Following Hoff et al., 2018), we modeled maternal education using the highest level of education in the child's dominant language.

2.3.2. The Language Exposure Assessment Tool (LEAT)

Language exposure was estimated on the LEAT (DeAnda et al., 2016) prior to the initial visit. For each individual who regularly interacts with the child, the languages they speak, their native language, and the number of hours talking to/overheard by the child in each language per day are queried. Hours of exposure are weighted by duration of exposure across the child's life for each interlocutor to obtain an estimate of relative exposure. LEAT percent relative exposure accounts for variance in concurrent vocabulary size in each language (R^2 =.36) beyond maternal education, age, and raw parent estimates (DeAnda et al., 2016). Further, parent-reported exposure corresponds well to estimates based on language samples in the home (Orena et al. 2020). Internal consistency is excellent (Cronbach's alpha =.96). Dominance was determined by children's language exposure at 30 months of age. In all cases, the language of greatest exposure was also the most proficient language.

2.3.3. MacArthur Communicative Development Inventories (MCDI)

The MCDI is a parent report measure of early comprehension and production (Fenson et al., 2007) consisting of two forms: Words and Gestures (WG), for children from 8 to 18 months of age, and Words and Sentences (WS), for children from 16 to 30 months. Parents completed the WG form, a checklist of 396 words at 16 months and the WS form, a vocabulary checklist of 680 words, at 22 and 30 months of age. Words parents indicated that their child could say was taken as a measure of expressive vocabulary at each time point. Children were assessed in their dominant language on either the MCDI (English) or its Spanish adaptation, the Inventarios del Desarrollo de Habilidades Comunicativas (IDHC).

2.4. Data analysis

Sample sizes in the present research are comparable to previous growth curve analyses of language data (Huttenlocher, Vasilyeva, Waterfall, Vevea & Hedges, 2007; Huttenlocher, Waterfall, Vasilyeva, Vevea & Hedges,; 2010; Ribot et al., 2018). Growth curve models are statistically more sensitive than traditional Generalized Linear Models and less prone to Type II error for assessing linear growth (Xitao & Xiaotao, 2005). Reliability metrics provide the most useful information regarding statistical power to detect differences in slope in these models. Because we were interested in whether measuring maternal education and vocabulary in the same language improved prediction over simply taking mother's highest level of education without regard to language, our primary concern was establishing the reliability of the vocabulary estimates over time in each language. If these reliability metrics are robust, then we can ask whether maternal education exerts comparable effects on early vocabulary across languages. We calculated four metrics for

each sample: Intraclass correlation coefficient (ICC; variance attributable to individual differences relative to total variance), ICC2 (variance attributable to true score variance), Growth Rate Reliability (GRR, reliability of the slope; Bliese, 2000; Rast & Hofer, 2014) and the magnitude of linear growth (*d,* a measure of effect size; Xitao & Xiaotao, 2005).

We began by constructing unconditional means and repeated measures models to assess reliability. For English-dominant children, covariance across measurements was.88. Reliability estimates were: ICC_1=0.96, ICC_2=0.99, and GRR=0.95. Magnitude of linear growth was *d*=0.89. For Spanish-dominant children, covariance across measurements was.80. Reliability estimates were: ICC_1=0.89, ICC_2=0.87, and GRR=0.93. Magnitude of linear growth was *d*=.76. In Monte Carlo simulations, as GRR increases, the sample size necessary to achieve power =.80 decreases, reaching asymptote at GRR =0.6 to 0.8 (Rast & Hofer, 2014). Our GRR metrics are well above this threshold at 0.95 and 0.93, respectively. Similarly, for magnitude of linear growth (*d*), *d* =>0.40, power=0.8 can be achieved with a sample size of 50 (Xitao & Xiaotao, 2005). Again, our estimates at *d* =.89 and.76, respectively, exceed this threshold. Assessing change across three timepoints with brief inter-test intervals enabled us to achieve high concordance across timepoints and high growth curve reliability across samples.

Analyses proceeded similarly for each language group. We first constructed an intercept only model to confirm that sufficient variability existed to justify more complex models in both samples before proceeding to the models of interest. Next, we conducted model comparisons to evaluate variability in intercept and slope to determine appropriate effect specifications. These comparisons revealed that a mixed effects model with random intercept and fixed slope provided the best fit to the data (Bryk & Raudenbush, 1987; Curran et al., 2010). We identified final models by removing nonsignificant variables and evaluating increments in fit over prior models. In addition to likelihood ratio significance testing, we utilized Akaike and Bayesian information criteria (AIC and BIC) to ensure that our final models provide good fit to the data. Final models represent the best balance between these metrics. Models were run in IBM Statistical Package for the Social Science (SPSS) Statistics Version 24 using maximum likelihood estimation. Convergence was achieved in all models.

3. Results

Means and standard deviations for vocabulary scores at each age are presented as a function of age and demographic variables in Table 1. The intercept-only models confirmed that intercepts and residual error terms were significant, necessitating more complex models to characterize the data (all *ps* <.001). We next constructed a model (Model 1) in which we added Age, centered at the first wave of testing, to evaluate its fit relative to the intercept-only model. Next, we constructed a model with Age and dominant Language Exposure (Model 2) and this model was compared in fit to Model 1. We then added Maternal Education to the model (Model 3). Finally, all two-way interactions of Age, Language Exposure, and Maternal Education were added to create Model 4 and the relative fits of Models 3 and 4 were compared. Fit indices are presented by language group in Tables 2 and 3 and coefficients and significance for the terms in each model are presented in Tables 4 and 5.

3.1. Maternal education

In the first two models, we evaluated the role of age and language exposure as control variables predicting vocabulary size. In the third model, we evaluated the effect of maternal education controlling for age and exposure.

English-Dominant Children. Age, exposure, and maternal education (Model 3) were all significantly associated with vocabulary size, indicating the expected increase in vocabulary size with age, relative exposure to the dominant language, and maternal college completion and the model containing these predictors yielded an improvement in fit over previous models according to the likelihood significance test (Δ -2LL = 6.09, > $\chi^2_{(1)}$ = 5.02, *p*=0.025; see Tables 2 and 4) and a modest improvement in the AIC fit index (Δ AIC = 4.09) with no appreciable change in BIC suggesting an improvement in fit with no loss of parsimony (see Fig. 1).

Spanish-Dominant Children. Models including exposure and maternal education did not show good fit by any metric (see Table 3),

Table 1
Vocabulary Size Means (and SD) by wave and demographic characteristics.

Dominant Language	Wave	Maternal Education					
		< 4 years college			> 4 years college		
		Age in Months	Dominant Language Exposure	Expressive Vocabulary	Age in Months	Dominant Language Exposure	Expressive Vocabulary
		Partitioned by mothers' level of education in English					
English							
	1	16.80 (0.77)	0.91 (0.15)	30.63 (26.50)	16.68 (0.65)	0.97 (0.08)	40.53 (39.28)
	2	23.09 (0.91)	0.91 (0.17)	193.30 (132.28)	22.99 (0.75)	0.98 (0.08)	270.39 (164.84)
	3	30.77 (1.56)	0.91 (0.15)	417.09 (183.20)	30.46 (1.15)	0.97 (0.08)	523.78 (172.29)
		Partitioned by mothers' level of education in Spanish					
Spanish							
	1	17.40 (0.97)	0.85 (0.13)	23.97 (33.98)	17.12 (0.96)	0.83 (0.15)	28.63 (54.35)
	2	23.99 (1.15)	0.83 (0.12)	120.65 (106.92)	23.61 (1.35)	0.83 (0.16)	117.67 (138.24)
	3	31.65 (1.77)	0.84 (0.12)	240.13 (175.71)	31.06 (1.83)	0.83 (0.16)	300.11 (201.24)

Table 2
Fit indices for growth curve models for English-dominant 16- to 30-month-olds.

Models	-2LL	*p*	AIC	BIC
Intercept Only	2808.07		2812.07	2818.71
Model 1	2599.57	<0.001	2605.58	2615.54
Model 2	2592.57	0.01	2600.57	2613.86
Model 3	2586.48	0.03	2596.48	2613.10
Model 4	2578.62	0.01	2594.62	2621.20
Final Model	2582.94	ns	2590.94	2608.23

Table 3
Fit indices for growth curve models for Spanish-dominant 16- to 30-month-olds.

Models	-2LL	*p*	AIC	BIC
Intercept Only	2052.04		2056.04	2062.16
Model 1	2008.94	<0.001	2014.94	2024.16
Model 2	2005.68	ns	2013.68	2025.98
Model 3	2005.23	ns	2015.23	2030.61
Model 4	2001.21	ns	2017.21	2041.81
Final Model	2003.60	ns	2009.60	2018.83

Table 4
Predictor significance for vocabulary growth curve models in English-dominant 16- to 30-month-olds.

Predictor	Model 1		Model 2		Model 3		Model 4		Final Model	
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*t*	*p*
Intercept	2.16	0.032	-2.18	0.030	-1.12	0.263	-0.63	0.529	3.08	0.002
Age	19.02	0.000	19.22	0.000	19.58	0.000	0.74	0.458		
English Language Exposure			2.67	0.008	1.83	0.068	0.89	0.375		
Maternal Education in English					-2.47	0.008	1.05	0.293	2.26	0.025
Age X Education							-1.26	0.208		
Age X Language Exposure							1.85	0.066	20.037	0.000
Exposure X Education							-1.17	0.243		

Table 5
Predictor significance for vocabulary growth curve models in spanish-dominant 16- to 30-month-olds.

Predictor	Model 1		Model 2		Model 3		Model 4		Final Model	
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*t*	*p*
Intercept	1.42	0.156	-1.37	0.173	-1.13	0.261	-0.61	0.543	1.48	0.140
Age	9.23	0.000	9.21	0.000	9.20	0.000	0.49	0.626		
Spanish Language Exposure			1.81	0.072	1.78	0.077	0.74	0.463		
Maternal Education in Spanish					-0.67	0.502	0.80	0.424		
Age X Education							-1.13	0.260		
Age X Language Exposure							1.38	0.170	9.66	0.000
Exposure X Education							-0.70	0.483		

in contrast to the pattern in English-dominant children. There was no difference in vocabulary size as a function of maternal education at any point across the age range from 16 to 30 months (all *p*s =>.186) although vocabulary trajectories diverged descriptively as a function of maternal education, such that children whose mothers attended college produced about 60 more words, on average, than their peers by 30 months. Age was the only significant predictor, consistent with an expected age-related increase in vocabulary size and the model evaluating age alone showed a significant improvement in fit over an intercept only model by all indices (Δ -2LL = 43.1, $> \chi^2_{(1)} = 10.828$, $p < .001$; Δ AIC = 41.1; Δ BIC = 38). See Tables 3 and 5 and Fig. 2.

3.2. Interactions and final model

To evaluate the possibility that the effect of maternal education on child vocabulary size might interact with age and relative language exposure, we introduced interaction terms into the fourth, full, model. To derive a final model, we progressively eliminated predictors beginning with those that accounted for the least variance until we had a model with good fit and only significant predictors.

English-Dominant Children. No single predictor was significant in the full model. The predictors in the final model were maternal education (p=.025) and an interaction of age X language exposure (p<.001; see Table 4). Maternal education did not interact with

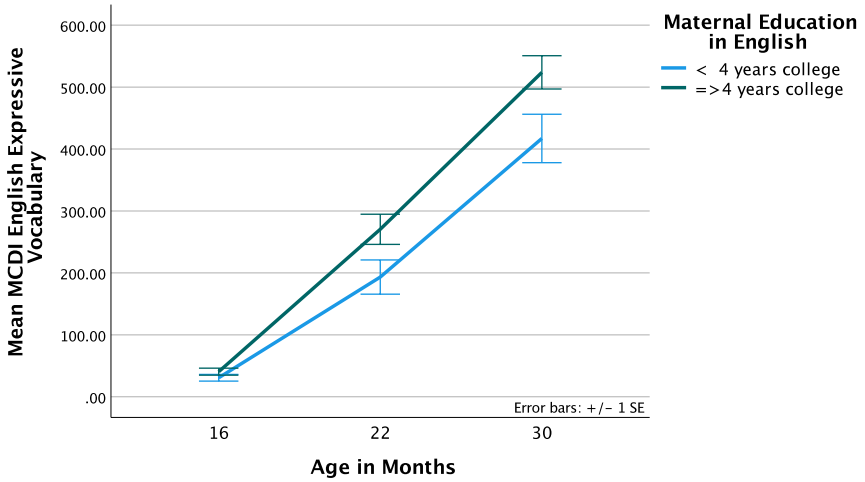

Fig. 1. Mean expressive vocabulary scores by age and by maternal education in English. Note. Vocabulary growth varied as a function of maternal education (p <.02).

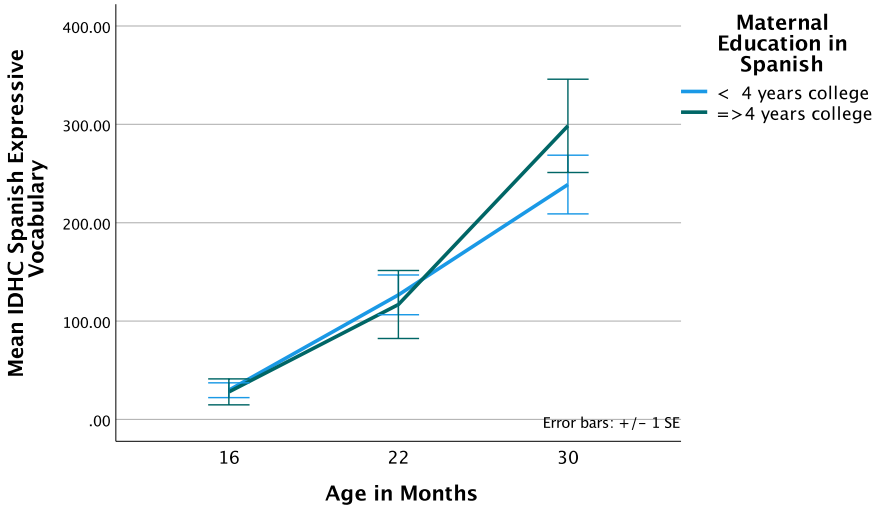

Fig. 2. Mean expressive vocabulary scores by age and by maternal education in Spanish. Note. Vocabulary growth did not vary as a function of maternal education (p >0.18).

either age or exposure. The final model did not differ in fit from the full model by either likelihood or AIC index but evinced a substantial improvement in parsimony (Δ BIC = 12.56, see Table 2). As expected, there was a significant main effect of maternal education across the age range from 16 to 30 months. At 16 months, English-dominant children whose mothers completed college produced nearly 50 words more than peers whose mothers did not complete college and this difference was stable over time. Children of college-educated mothers produced 270 words to their peers' 226 words at 22 months and 491 words to their peers' 447 words at 30 months ($F_{(1,202)} = 5.029$, p=.026).

To clarify the age X exposure interaction, we binned language exposure into quartiles. Follow-up Bonferroni-corrected contrasts revealed that by 22 months children in the lowest quartile (82% exposure to English or less) produced about 85 words fewer than peers in the next quartile (82% to 96% exposure; p=.014) and about 99 words fewer than peers in the top quartile (=>96% exposure; p=.001). By 30 months of age, these differences in expressive vocabulary size approached 200 words (p=.014 and p=.001, respectively, $F_{(2,\ 205)}$ =6.902, p=.001). See Fig. 3.

Since most children were functionally monolingual, mean exposure to English was high. This suggests, unsurprisingly, that children with relatively more balanced language exposure have smaller vocabularies in their L1 than monolingual peers. To evaluate this possibility, we repeated the analyses using total vocabulary as the outcome variable. For children whose parents did not report L2 vocabulary (n=57), this variable was L1 vocabulary but, for children whose parents reported on both languages (n=5), it was the sum of words across languages. Using total vocabulary as the outcome eliminated this interaction. Maternal education (p=0.023) and age (p<0.001) were the only significant predictors in the final model.

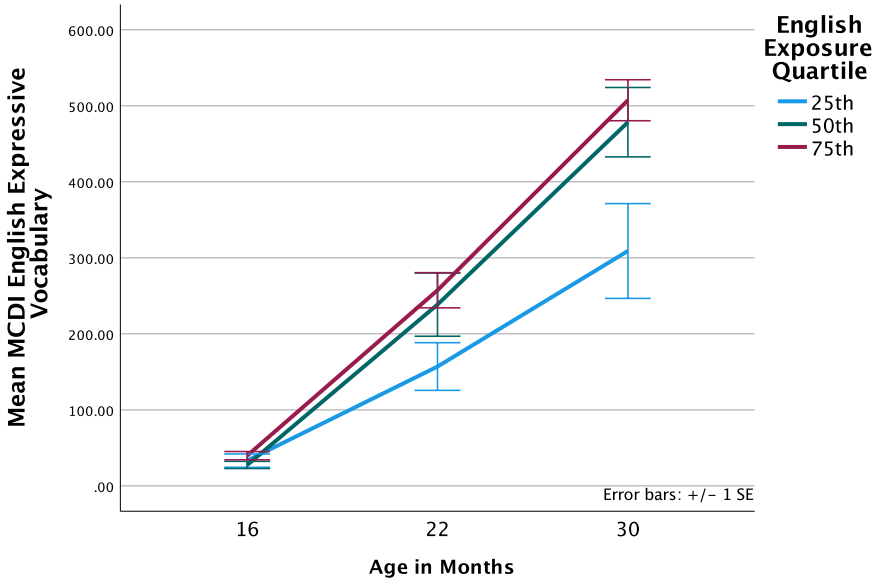

Fig. 3. Mean expressive vocabulary scores by age and English exposure. Note. The growth curve at the 25th quartile differed from the 50th and 75th quartiles (p =.002) at 24 and 30 months.

Spanish-Dominant Children. As in the English-dominant children, there were no significant effects or interactions in the full model. The only significant predictor in the final model was the interaction of age X language exposure (p <0.001; see Table 5). This model did not differ significantly from the full model by likelihood test but evinced large improvements in fit and parsimony (Δ AIC = 7.61; Δ BIC = 22.98). Follow-up Bonferroni-corrected contrasts revealed that, like their English-dominant peers, all children started out with comparable expressive vocabulary size however, by 24 months children in the lowest two quartiles (< 96% exposure to Spanish) produced between 60 and 70 fewer words than peers at the highest quartile (exposure => 96%; p=0.007 and p=0.015, respectively). By 30 months of age, this reduction in expressive vocabulary size was over 100 words for the two lowest quartiles (p=0.007 and p=0.015, respectively, $F_{(2, 155)}$ =4.776, p=0.010). See Fig. 4.

Repeating the analyses using total vocabulary as the outcome variable eliminated this interaction. Twelve parents reported child vocabulary in both languages whereas most parents (n=34) reported vocabulary in one language only. Age was the only significant predictor in the final model (p <.001) and vocabulary size at each age differed significantly from every other age (all ps < 0.01). Visual inspection of the raw data suggests that there was greater variability in the association between maternal education and vocabulary in Spanish-dominant, relative to English-dominant, children.

4. Discussion

The early learning environment and in particular, the quantity and quality of language input, supports children's early word learning which, in turn, supports preliteracy and numeracy skills in the first five years of life. This early environment is critical to mitigating well-documented educational disparities among children in the US (Leffel & Suskind, 2013; Schwab and Lew-Williams, 2016; Toppelberg & Collins, 2010). When characterizing the language environments of young children, it is imperative that we take cultural variation into account.

The present paper evaluated whether a language-specific effect of maternal education on child vocabulary acquisition (Hoff et al., 2018) generalized to the early toddler period. We further sought to clarify the role of maternal education, an important indicator of maternal input and, indirectly, of vocabulary acquisition in English to Spanish-dominant children from 16 to 30 months of age. We extended the DeAnda et al. (2016) and Friend et al. (2017) findings by including a third timepoint and assessing growth and we extended Hoff et al. (2018) by extending the age range to incorporate the early toddler period. As expected, in the English-dominant sample, we found a significant effect of maternal education such that children whose mothers completed college in English had larger English vocabularies than children of mothers who did not, and we extended this finding to 30 months of age. In line with that work, and in contrast to our hypothesis, we did not find a significant effect of maternal education in Spanish in the Spanish-dominant sample.

Whereas Hoff et al. (2018) found a marginal effect of language-specific maternal education on child Spanish vocabulary at 30 months but not on growth, the present study found a descriptive effect at 30 months of age but not in younger children. Together, these studies suggest that the effects of maternal education observed in English-speaking children do not generalize well to Spanish-speaking children.

These findings call into question assumptions about how maternal education supports child vocabulary across languages during the first five years of life, which are foundational to skills that support school readiness (Leffel & Suskind, 2013). Although several studies report a relation between maternal education and English vocabulary (Beitchman et al., 2008; Bohman et al., 2010; DeAnda et al.,

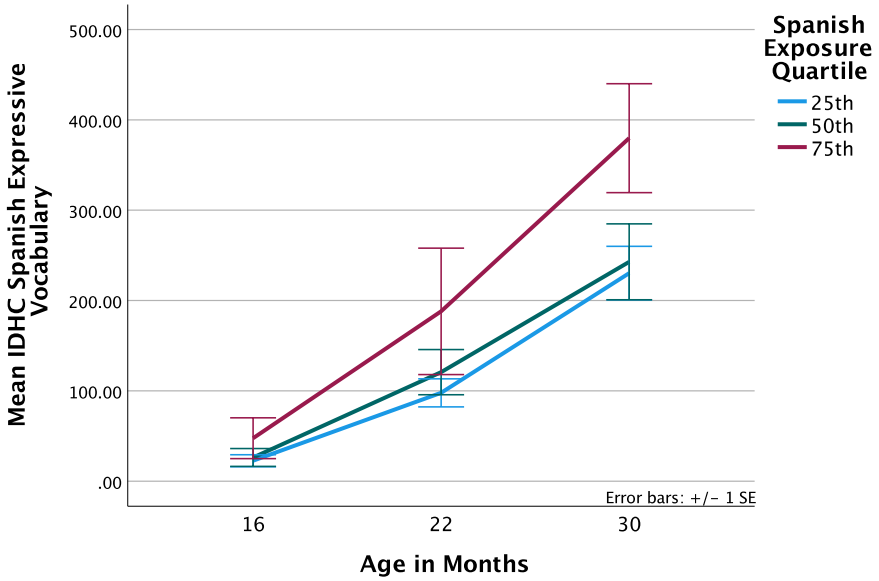

Fig. 4. Mean expressive vocabulary scores by age and English exposure. Note. The growth curve at the 75th quartile differed from the 25th (p =.007) and 50th quartiles (p =0.015) at 24 and 30 months.

2016; Friend et al., 2017; Hoff, 2003), this finding shows limited generalization to Spanish vocabulary (DeAnda et al., 2016; Friend et al., 2017; Tamis-LeMonda et al., 2014; Weisleder & Fernald, 2013; cf. Coddington et al., 2014; Gonzalez et al., 2016). However, a consistent finding is that parent beliefs, input, and the home literacy environment are central to child vocabulary acquisition in both Spanish and English (Coddington et al., 2014; Gonzalez et al., 2017; Weisleder & Fernald, 2013). Further, the importance of maternal beliefs to child outcomes highlights a potential policy implication: we must give parents reason to believe that high quality input and acquisition in Spanish matters. Initiatives that bridge the gap between home languages and language of schooling may be important to parent investment in the quantity and quality of input in the home language (Mistry & Wadsworth, 2011) and ameliorate language differences in the effect of maternal education.

4.1. *Considerations and future directions*

We sampled three timepoints, allowing us to evaluate linear, but not more complex, trajectories. A broader longitudinal dataset would be ideal to best characterize these functions but would require a continuous measure of vocabulary from early toddlerhood through early childhood that, at present, does not exist. We also chose to treat maternal education dichotomously. This was necessary to assess differences in slope as a function of maternal education to extend prior work (Hoff et al., 2018). Further, continuous and categorical measures of maternal education were strongly and significantly correlated in each language and data visualizations indicate larger and more consistent estimates of vocabulary growth for mothers who have completed 16 years of formal education. Finally, continuous measures of maternal education have led to similar null findings in this population (Hurtado et al., 2008; Weisleder & Fernald, 2013). For these reasons, we do not think our use of this dichotomous measure can account for the absence of an effect in Spanish-speaking children. A final consideration is whether the present study was sufficiently powered. We note here that growth curve reliability and effect sizes for vocabulary across samples were robust and that an effect of maternal education was evident among English-dominant children. Nevertheless, relations between maternal education and early vocabulary in Spanish-speaking children were more variable than in English-speaking counterparts. To detect an effect likely requires greater power in Spanish than in English (e.g., Coddington et al., 2014). This is consistent with the fact that, in the literature, an effect of maternal education on early child vocabulary in Spanish is elusive.

4.2. *Conclusion*

We return to Richman et al.'s (1992) two hypotheses: that maternal responsiveness reflects cultural conventions in parent-child interaction and that, within cultures, maternal responsiveness is influenced by maternal education. The weight of the evidence offers stronger support for the first, relative to the second, hypothesis. This has important research, clinical, and policy implications. Extending DeAnda et al., 2016, Friend et al., 2017, and Hoff et al., 2018, and harmonizing our data with theirs, we have shown that, whereas maternal education supports the vocabulary growth of English-learning children from 16 to 30 months of age, its effect on Spanish vocabulary is more limited. Spanish-speaking, Latino children represent the single largest immigrant population in the U.S. Our findings contribute to a literature that suggests we can better study and support children acquiring Spanish in the U.S. by focusing on parent beliefs, input, and the home literacy environment. This highlights the importance of fostering parent investment in the

quantity and quality of input in the child's home language in the U.S.

CRediT authorship contribution statement

Margaret Friend: Conceptualization, Methodology, Analyses, Writing – original draft and preparation. **Oliver Lopez**: Data curation, Data review, Writing – assistance in preparation of original draft. **Stephanie DeAnda**: Data curation, Conceptualization, Writing – review and conceptual contribution. **Roberto Abreu–Mendoza**: Preparation of figures, Writing – review and conceptual contribution. **Natalia Arias-Trejo**: Writing – review and conceptual contribution..

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