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Pathways for learning two languages: lexical and grammatical associations within and across languages in sequential bilingual children*

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This study examines the strength and direction of lexical-grammatical associations within and between first and second languages (L1 and L2) in a longitudinal sample of sequential bilinguals. Thirty-three children who spoke Vietnamese (L1) and English (L2) completed picture-naming and story-telling tasks in each language at four yearly intervals. Hierarchical linear modeling across Years 1–4 revealed bidirectional within-language associations and a unidirectional cross-language association from the L1 to L2. Results suggest a conditional relationship between languages in which the L1 supports L2 growth, but not vice versa. Findings contribute to defining pathways for L1 and L2 learning across domains and languages.

Keywords: cross-language transfer, longitudinal, vocabulary development, language samples, dynamic systems

The overall goal of the present study is to contribute to the knowledge base on the patterns and parameters for dual language learning. The study is framed within the Dynamic Systems Theory (DST), in which language is a complex system that emerges through interactions of simpler components found within and across language domains (lexicon and grammar), first and second languages (L1 and L2), and between language, social, and cognitive systems (de Bot, Lowie & Verspoor, 2007). Within DST, interactions between languages or language domains can be unidirectional or bidirectional; and the nature of interactions can be supportive or competitive (van Geert, 1991). DST motivates the measurement of multiple language components across time points in order to understand how a complex system develops over time (Smith & Samuelson, 2003). Accordingly, the present study measures lexical and grammatical skills in children's L1 and L2 over four yearly time points to empirically examine the presence, nature, and directionality of cross-domain and cross-language relationships.

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DST posits that the development of a complex system is highly dependent on its initial state, and that changes in initial state can substantially change later outcomes (de Bot et al., 2007); therefore, initial skills at Year 1 are entered into hierarchical linear models as predictors of later outcomes in the L1 and L2. The study focuses on lexical and grammatical domains to build on previous work with younger children, monolingual and simultaneous bilingual toddlers, that has found strong cross-domain associations within a language (e.g., Bates & Goodman, 1997) and minimal cross-domain, cross-language associations (e.g., Marchman, Martínez-Sussmann & Dale, 2004). The following is a review of the literature that focuses on early school-age bilingual children and examines (a) cross-language relationships in a single domain (lexical or grammatical), (b) cross-domain relationships within and between the L1 and L2, and (c) L1-L2 relationships over time.

Cross-language associations within a single domain

Several studies have examined L1-L2 associations within either the lexical or grammatical domain. Branum-Martin, Mehta, Francis, Foorman, Cirino, Miller, and Iglesias (2009) found that the presence and nature of cross-language associations in the lexical domain were task dependent. Within a large sample of 1,300 kindergarten and first grade students from 247 classrooms in Texas and California, researchers measured expressive

vocabulary in each language using Picture Vocabulary subtests of the Woodcock Language Proficiency Battery – Revised (Woodcock, 1991; Woodcock & Sandoval, 1996) and the total number of different words (NDW) from narrative elicitation procedures (Heilmann, Miller, Iglesias, Fabiano-Smith, Nockerts & Andriacchi, 2008). Using hierarchical linear modeling to isolate student-level outcomes from classroom-level variability, researchers found no relationship between Spanish and English Picture Vocabulary (i.e., student-level correlations near zero) and positive relationships between Spanish and English NDW (i.e., student-level correlations ranging between .45 to .51).

Findings suggest that different measures tap into different aspects of vocabulary knowledge. Standardized tests measure vocabulary knowledge that is specific to each language such as producing labels that do not overlap in form (e.g., *la mesa* in Spanish, and *table* in English). In contrast, narrative elicitation requires children to use their vocabulary knowledge for a communicative purpose. The ability to use a variety of words to tell a story (i.e., NDW from narratives) may reflect a general language ability that is shared across languages (Branum-Martin et al., 2009). Narratives serve as a snapshot of how children simultaneously use their lexical and grammatical skills (Simon-Cereijido & Gutierrez-Clellen, 2009), and therefore are included in the present study to identify cross-domain and cross-language associations.

In the grammatical domain, positive cross-language correlations have been found using measures of syntactic complexity and mean length of utterance (MLU). Pearson (2002) examined narrative samples from 240 Spanish–English bilingual children in grades 2 and 5 and found positive correlations between Spanish and English MLU ($r = .59$) and Spanish and English complex syntax scores based on the inclusion of modals, aspect, and elaborated noun and verb phrases ($r = .53$). Similarly, Bedore, Pena, Gillam, and Ho (2010) found positive correlations between Spanish and English MLU ($r = .26$, $p < .001$) using narratives from 170 bilingual kindergarteners. Although cross-language associations varied in magnitude across measures and samples, correlations were consistently positive in nature, indicating a supportive relationship between L1 and L2 grammar. It is noted that the studies reviewed thus far have focused on Spanish–English bilinguals. Cross-language associations may differ for language pairs that are highly distinct, such as Vietnamese and English, the focus of the present study.

Cross-domain associations within and between the L1 and L2

Although there is a growing literature on cross-language relationships within a single language domain, fewer studies have examined relationships between domains and languages. In a study of Spanish–English bilingual children, ages 3 to 7, Simon-Cereijido and Gutierrez-Clellen (2009) measured NDW and MLU using narratives in Spanish ($n = 136$) and English ($n = 104$). Correlation analyses revealed strong cross-domain associations within each language between Spanish NDW and MLU ($r = .71$, $p < .001$) and between English NDW and MLU ($r = .64$, $p < .001$). There were no significant cross-domain, cross-language associations. Using similar methods of narrative elicitation, Bedore and colleagues (2010) also found positive cross-domain associations in each language (Spanish NDW and MLU, $r = .65$, $p < .001$; English NDW and MLU $r = .57$, $p < .001$) and no cross-domain, cross-language associations.

Consistent with previous findings, Kohnert, Kan, and Conboy (2010) found stronger associations within each language than between languages among a sample of 19 Hmong–English preschoolers. However, researchers also found differences in the strength of cross-domain associations for each language. Using narrative measures, there were strong cross-domain associations within each language (Hmong NDW and MLU: $r = .54$, $p < .05$; English NDW and MLU: $r = .86$, $p < .01$) and no cross-domain, cross-language associations. Associations between the independent measure of vocabulary, picture identification, and MLU continued to be significant in English (L2, $r = .74$, $p < .01$) but not in Hmong (L1, $r = .29$, n.s.). For this sample of sequential bilingual preschoolers, fewer cross-domain associations in the L1 may have reflected the relatively advanced stage of L1 development (compared to the initial stages of L2-learning), during which lexical and grammatical domains have become more differentiated (Kohnert et al., 2010).

Associations between the L1 and L2 over time

The number of studies with longitudinal data that examine relationships between domains and languages is highly limited. Verhoeven (1994) collected oral language measures of Turkish (L1) and Dutch (L2) for 98 children at ages 6, 7, and 8. Lexical skills were measured using receptive and expressive vocabulary tasks, and grammatical skills were measured using sentence imitation tasks in each language. Using linear structural relations analysis (LISREL), Verhoeven (1994) found strong longitudinal associations within each language, with correlations between time points ranging from .85 to 1.00 in the lexical domain and .79 to .92 in the grammatical domain. Cross-language associations were weak, ranging between .10 to .14 in the lexical domain and .11 to .25 in the grammatical domain. Analysis focused on each domain separately, and therefore cross-domain, cross-language associations were not reported.

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Given the paucity of longitudinal studies that focus on lexical-grammatical associations, results from Uccelli and Páez (2007) are included here, which examined the direction of associations between lexical and discourse domains. Participants completed Picture Vocabulary subtests of the Woodcock Language Battery – Revised (Woodcock, 1991; Woodcock & Muñoz-Sandoval, 1996), and narrative tasks at the end of kindergarten and end of first grade. Narrative tasks yielded NDW in each language and narrative quality scores, which totaled scores for language (vocabulary, syntax) and story structure. English (L2) narrative quality in first grade was predicted by Spanish story scores in kindergarten, even after controlling for English Picture Vocabulary and English NDW. In contrast, Spanish narrative quality in first grade was solely predicted by Spanish Picture Vocabulary in kindergarten (i.e., no English measures). Findings indicated one-way transfer from the L1 to the L2.

Finally, as part of a longitudinal study on linguistic cue use among Vietnamese–English bilinguals, Pham and Ebert (2015)[1] reported correlations between L1 and L2 picture naming and sentence repetition at three time points. Picture naming and sentence repetition were associated at each time point for Vietnamese (r = .53 to .75) and English (r = .58 to .83). Cross-language correlations at each time point were not significant between Vietnamese and English picture naming tasks (r = -.07 to .20, ns); Vietnamese and English sentence repetition tasks were positively related (r = .11 to .48) with only the correlation at Time 3 reaching statistical significance. There was a single cross-domain, cross-language association between Vietnamese sentence repetition and English picture naming at Time 3 (r = .63). However, caution must be taken when interpreting bivariate correlations of longitudinal data because the assumption of independence is violated (Long, 2012). The present study extends previous work through the inclusion of lexical and grammatical measures derived from narrative elicitation (NDW and MLU), the use of hierarchical linear modeling to statistically account for correlated data (Long, 2012), and testing of initial state predictors to account for longitudinal outcomes.

Study purpose and predictions

The purpose of this study is to examine cross-domain and cross-language relationships among sequential bilingual children who speak Vietnamese (L1) and English (L2). Growth trajectories for the L1 and L2 of this longitudinal sample have been reported previously (Pham & Kohnert, 2014; Pham & Ebert, 2015). There are two sets of predictions that correspond to cross-sectional data at the first time point and longitudinal data over four years:

1. CROSS-SECTIONAL: Based on previous studies with sequential bilingual children (e.g., Kohnert et al., 2010; Simon-Cereijido & Gutierrez-Clellen, 2009), lexical-grammatical associations are predicted to be positive in nature. The number of associations found within each language will be greater than the number of associations found between the two languages; and no cross-domain, cross-language associations are anticipated.

2. LONGITUDINAL: Based on the few longitudinal studies available that include multiple time points, associations within each language are predicted to be stronger over time than associations between languages (e.g., Verhoeven, 1994). Lexical-grammatical associations may be stronger in the L2 than in the L1 (Kohnert et al., 2010). Previous longitudinal studies of lexical and grammatical skills have not provided a basis to predict the directionality of associations, which may be unidirectional or bidirectional.

Method

Participants

A total of 33 children (18 girls, 15 boys) participated in this study. Participants lived in the United States, and spoke Vietnamese (L1) as the primary home language and English (L2) at school and in the larger community. Table 1 displays demographic information. All participants passed hearing screenings and scored within the normal range of the Test of Nonverbal Intelligence, 3rd edition (Brown, Sherbenou & Johnsen, 1997), which has previously been used with culturally and linguistically diverse populations (e.g., Kohnert & Windsor, 2004). There was no history of special education services, cognitive or sensory impairment, and no parent concern for language development or learning.

Participants were recruited from a public elementary school in the southeastern region of the US, in which students received school instruction in English and an additional class in a second language. Vietnamese American students comprised 20% of the school population and received 90 minutes per day of Vietnamese language and literacy instruction in addition to the English curriculum. Participants on average began speaking English at age 4 years; 8 months and had an average of 32 months of English exposure at the start of the study. When asked to rate their children's speaking, listening, reading, and writing in each language (e.g., "Please select one of the following options: My child speaks Vietnamese very well, well, poorly, or very poorly": Pham, 2011),

[1] There were overlapping participants in Pham and Ebert (2015) and the present study.

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Table 1. *Participant Demographics.*

Variable	Mean	SD	Range
Initial chronological age (years: months)	7:4	0:10	6:0 – 9:3
TONI standard score	111	13	85 – 140
Age of English onset (years: months)	4:5	1:2	1:0 – 6:6
Years of English exposure (years: months)	2:8	1:3	1:0 – 7:1
Parent Rating of Vietnamese: Average of Four Areas	3.45	0.60	2.5 – 4.0
1. Vietnamese speaking	3.75	0.44	3 – 4
2. Vietnamese listening	3.75	0.44	3 – 4
3. Vietnamese reading	3.13	0.90	2 – 4
4. Vietnamese writing	3.17	0.87	2 – 4
Parent Rating of English: Average of Four Areas	3.61	0.70	1.5 – 4.0
1. English speaking	3.75	0.53	2 – 4
2. English listening	3.65	0.65	2 – 4
3. English reading	3.52	0.85	1 – 4
4. English writing	3.48	0.84	1 – 4

Note. Parent ratings were based on a four-point scale, with 4 = very well and 1 = very poor (Pham, 2011). TONI = Test of nonverbal intelligence, 3rd edition (Brown et al., 1997).

parents reported that their children had high proficiency in Vietnamese and English (see parent ratings in Table 1). The majority of participants qualified for reduced lunch (58%), a gross measure of low socioeconomic status.

Procedures and tasks

As part of a larger longitudinal project (Pham & Kohnert, 2014), participants completed a set of language measures in the L1 and L2 at yearly intervals for a maximum of four years. Participants worked individually in a quiet area of their school or home with examiners fluent in the target language. Languages were separated by examiner, and the first language of administration was counterbalanced across participants. The present study consists of two tasks in each language: story-telling and picture naming.

Story-telling

Spontaneous language samples were collected using two wordless picture books: *A Boy, A Dog, and A Frog* (Mayer, 1967) for Vietnamese and *One Frog Too Many* (Mayer & Mayer, 1975) for English. The two books were comparable in length and have been used interchangeably in narrative assessment (Strong, Mayer & Mayer, 1998). Consistent with previous cross-linguistic story-telling procedures (Berman & Slobin, 1994), participants were asked to look through every page of the picture book and then tell the story to the examiner while turning the pages at their own pace. Language samples were digitally audio-recorded and transcribed by native speakers of Vietnamese and English using the Systematic Analysis of Language Transcripts software (SALT: Miller & Iglesias, 2012). Transcribers segmented language samples into modified communication units (c-units) as recommended for bilingual samples when one of the languages – Vietnamese in the present study – permits subject omission (Heilmann et al., 2008). Analysis excluded incomplete or unintelligible utterances and word or phrase repetitions.

In addition to procedures for segmenting modified c-units outlined in Miller and Iglesias (2012), the following rules were applied to Vietnamese language samples, consistent with previous transcription work with isolating Asian languages such as Cantonese (To, Stokes, Cheung & T'sou, 2010) and Hmong (Kohnert et al., 2010):

- Serial verbs remained within the same modified c-unit: *Con ếch đứng coi đứa bé* [Frog stand look boy] "The frog is standing (and) looking at the boy".
- Utterances that consisted of a topic + descriptive clause were considered one modified c-unit: *Còn cái xô thì nó rớt xuống* [Remaining the bucket it fall down] "And the bucket, it fell down".

Two independent raters reviewed all language samples for accuracy and correspondence with audio recordings. Point-by-point reliability was conducted for modified c-units for 20% of the language samples by an independent and trained second rater, one for each language. Inter-rater reliability was calculated to be >90% for each language.

Dependent measures were total number of different words (NDW) and mean length of utterance (MLU). Vietnamese and English MLU were calculated in words, which is recommended when the language pair includes one language that does not use bound morphemes (Yip

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& Matthews, 2006). NDW and MLU in words are difficult to calculate in Vietnamese because multisyllabic words are written as monosyllables separated by spaces (Nguyen, 1997), and there is considerable debate as to what constitutes a word versus a syllable (cf. Cao, 1988). In order to calculate Vietnamese NDW and MLU in words, multisyllabic words were manually identified, connected with an underscore, and marked with a word code [comp] in SALT. Examples include *bực_mình* "upset", *chuẩn_bị* "prepare", and *bây_giờ* "now". Multisyllabic words were then re-checked in all Vietnamese language samples using the Explore Multiple Transcripts - Word and Code List function of the SALT 2012 Research version (Miller & Iglesias, 2012). First, a list of all the words with the word code [comp] was generated. The list of multisyllabic words was then used to identify coding errors that needed to be manually corrected in individual transcripts. These two steps were repeated until all multisyllabic words were properly connected with an underscore and coded with the word code [comp].

Picture naming

Individual participants were presented with black-and-white line drawings on a computer screen and asked to name them as quickly as possible. Word stimuli consisted of 40 objects and 40 actions that were matched for high word frequency across languages using corpora databases in English (Baayen, Piepenbrock & Gulikers, 1995) and Vietnamese (Pham, Kohnert & Carney, 2008). Picture stimuli were from the International Picture Naming Project (Szekely, Jacobsen, D'Amico, Devescovi, Andonova, Herron, Lu, Pechmann, Pléh, Wicha, Federmeier, Gerdjikova, Gutierrez, Hung, Hsu, Iyer, Kohnert, Mehotcheva, Orozco-Figueroa, Tzeng, Tzeng, Arévalo, Vargha, Butler, Buffington & Bates, 2004). Children completed the same 80 items in Vietnamese and English, arranged in a different order for each language. Accuracy and response time data for these tasks were reported previously in Pham and Kohnert (2014). The present study focuses on accuracy data (i.e., proportion correct) and includes picture naming tasks as an independent measure of vocabulary knowledge.

Data analysis

There were a total of 6 dependent variables (3 in each language): two measures from language sampling (NDW and MLU) and one measure from picture naming (proportion correct). Cross-sectional analysis consisted of bivariate correlations at Year 1 and partial correlations controlling for chronological age and the number of years of systematic exposure to English. Longitudinal analysis consisted of hierarchical linear modeling (HLM: Long, 2012) to examine predictive relationships between initial performance at Year 1 and language outcomes at Year 4. The time variable was centered on the fourth year (Year – 4) in order to capture language outcomes at the last yearly interval. Predictor variables consisted of language performance measures at Year 1. Age at Year 1 was used as a covariate to control for initial differences based on age. Models identified as "best fitting" had a relatively low AIC fit index, large total effect size (R^2) and were considered the most parsimonious (i.e., included only the significant language predictors that accounted for unique variance - ΔR^2). Statistical modeling was conducted using the lmer function of the lme4 package (Bates & Sarkar, 2005) and summary function of the lmerTest package (Kuznetsova, Brockhoff & Christensen, 2014) in R software. Participant attrition occurred over the course of the four-year study with 33 children at Year 1 and 12 children by Year 4 due to family relocation. Missing data were accounted for using maximum likelihood estimation (Widaman, 2006).

Results

Table 2 displays descriptive statistics of the dependent measures. Picture naming increased in Vietnamese and English each year. On average, English NDW increased each year. In contrast, average Vietnamese NDW remained the same over time, indicating a plateau in Vietnamese lexical diversity, at least based on this measure. MLU increased over time in Vietnamese and English, indicating that participants on average were producing lengthier sentences with age. It is noted that while MLU can be compared over time within each language, absolute values of MLU cannot be compared between two highly distinct languages (cf. Thordardottir, 2005). Instead, the following analyses focus on the association between variables, such as whether increases in one are related to increases in the other.

Bivariate and partial correlations are displayed in Table 3. Positive cross-domain relations were found within each language. Vietnamese MLU was positively related to Vietnamese NDW ($r = .58$, $p < .01$) and to Vietnamese picture naming ($r = .42$, $p < .05$); English MLU was positively related to English NDW ($r = .66$, $p < .01$) and English picture naming ($r = .60$, $p < .01$). Cross-domain relations within each language remained significant and positive even after controlling for age and years of English exposure (see bottom of Table 3).

In contrast to the strong within-language associations found between lexical and grammatical domains, there were few cross-language associations. In the lexical domain, there were positive associations between Vietnamese and English picture naming ($r = .51$, $p < .01$) and Vietnamese and English NDW ($r = .58$, $p < .01$). However, after controlling for the effects of age and years of English exposure, only the relation between Vietnamese and English NDW remained significant ($r = .45$, $p < .01$).

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Table 2. *Descriptive Statistics of Dependent Measures.*

			Vietnamese		English	
Variable	Year	n	M (SD)	Range	M (SD)	Range
Picture Naming	1	33	.72 (.10)	.53–.91	.66 (.16)	.13–.89
	2	27	.77 (.09)	.58–.94	.76 (.13)	.33–.94
	3	21	.77 (.10)	.61–.91	.83(.12)	.45–.98
	4	12	.82 (.10)	.61–.94	.90 (.05)	.80–.98
Total Number of Different Words (NDW)	1	33	65.12 (16)	38–108	69.09 (17)	33–101
	2	27	66.56 (17)	32–124	76.59 (16)	48–124
	3	21	63.95 (10)	41–76	79.62 (12)	50–102
	4	12	64.00 (10)	45–81	80.58 (13)	60–100
Mean Length of Utterance in Words (MLU)	1	33	6.29 (0.79)	4.93–8.13	6.82 (1.23)	3.25–9.23
	2	27	6.53 (0.96)	4.19–7.92	7.29 (0.95)	5.28–8.80
	3	21	6.82 (0.76)	5.27–8.03	7.35 (1.07)	5.29–10.21
	4	12	6.76 (1.38)	3.52–8.54	7.60 (1.02)	5.91–9.00

Note. While MLU can be compared across time within each language, absolute values cannot be compared between languages as Vietnamese and English differ greatly in sentence structure. Picture naming is calculated as proportion correct out of 80 items (Pham & Kohnert, 2014).

Table 3. *Correlations at Year 1.*

Variable	1	2	3	4	5	6	7	8
1. Age	–	.45**	.74**	.33	.30	.72**	.49**	.44*
2. Yrs of Eng		–	.31	.05	.44*	.47**	.31	.33
3. Nam.V			–	.56**	.42*	.51**	.39*	.30
4. NDW.V			.49**	–	.58**	.12	.51**	.30
5. MLU.V			.34*	.62**	–	.34	.43*	.32
6. Nam.E			−.04	−.15	.12	–	.47**	.60**
7. NDW.E			.05	.45**	.32*	.18	–	.66**
8. MLU.E			−.02	.21	.18	.44**	.56**	–

Note. Bivariate correlations are displayed above the diagonal. Partial correlations controlling for age and years of English exposure are displayed below the diagonal. Yrs of Eng = Years of English exposure. Nam = Picture naming. NDW = Number of different words. MLU = Mean length of utterance in words. V = Vietnamese. E = English.
* $p < .05$; ** $p < .01$

Regarding cross-domain, cross-language associations, there was an association between Vietnamese MLU and English NDW ($r = .43$, $p < .05$) that remained significant after controlling for age and years of English exposure ($r = .32$, $p < .05$).

Longitudinal analysis consisted of four sets of HLMs with Vietnamese NDW, Vietnamese MLU, English NDW, or English MLU as separate dependent measures. Tables 4 and 5 display models for Vietnamese NDW and MLU, respectively. Vietnamese NDW was not predicted by initial age or yearly interval (Table 4), reflecting zero growth over time for this variable. The best fitting model (Model 3) included a within-language predictor, initial Vietnamese MLU, which accounted for 8% of unique variance in Vietnamese NDW, and no cross-language (English) predictors. As shown in Table 5, initial age and yearly interval were significant predictors of Vietnamese MLU, indicating positive growth for this variable over time. The best fitting model (Model 3) included a within-language predictor, initial Vietnamese NDW, which accounted for 8% of unique variance, and no cross-language (English) predictors.

Tables 6 and 7 display models for English NDW and MLU, respectively. For both English variables, initial age and yearly interval were positive predictors, reflecting growth over time. The best fitting model for English NDW (Table 6, Model 4) included initial English MLU, accounting for 2% of unique variance (as shown in Model 3), and a cross-language predictor, initial Vietnamese NDW, which accounted for 4% of unique variance. The best fitting model for English MLU (Table 7, Model 4) included initial English picture naming, which accounted

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Table 4. *Longitudinal Models with Vietnamese NDW as the Dependent Measure.*

Parameter	Model 1	Model 2	**Model 3**	Model 4	Model 5
Intercept	62.10***	34.16*	**11.86**	17.85	11.74
	(3.09)	(16.61)	**(17.34)**	(17.37)	(17.33)
Year - 4	−1.15	−1.02	**−1.24**	−1.30	−1.23
	(1.19)	(1.20)	**(1.20)**	(1.19)	(1.20)
Initial Age		3.87	**1.88**	0.32	1.67
		(2.24)	**(2.21)**	(2.39)	(2.38)
Initial Vietnamese MLU			**5.78***	4.61	5.65*
			(2.25)	(2.32)	(2.31)
Initial English NDW				0.18	
				(0.12)	
Initial English MLU					0.37
					(1.54)
AIC	756	755	**751**	751	753
Total R^2	.001	.071	**.15**	.18	.15
ΔR^2	ns	ns	**.08**	ns	ns

Note. The best fitting model is in boldface. Fixed effects estimates are displayed with SE in parentheses. Year is the time variable and is centered on the fourth year of data collection. ΔR^2 corresponds to the unique variance accounted for by the last variable in the model. ns = not significant. * $p < .05$; ** $p < .01$

Table 5. *Longitudinal Models with Vietnamese MLU as the Dependent Measure.*

Parameter	Model 1	Model 2	**Model 3**	Model 4	Model 5	Model 6	Model 7
Intercept	6.81***	4.21***	**3.88*** **	3.85***	4.31***	3.95***	3.67***
	(0.22)	(0.94)	**(0.82)**	(0.92)	(0.84)	(0.81)	(0.79)
Year - 4	0.16	0.18*	**0.16**	0.17	0.16	0.16	0.16
	(0.08)	(0.08)	**(0.09)**	(0.08)	(0.09)	(0.09)	(0.08)
Initial Age		0.36**	**0.19**	0.15	0.01	0.15	0.13
		(0.13)	**(0.12)**	(0.17)	(0.16)	(0.13)	(0.12)
Initial Vietnamese NDW			**0.02*** **		0.02***	0.02**	0.02**
			(0.01)		(0.01)	(0.01)	(0.01)
Initial Vietnamese Naming				2.58			
				(1.51)			
Initial English Naming					1.26		
					(0.80)		
Initial English NDW						0.005	
						(0.001)	
Initial English MLU							0.13
							(0.08)
AIC	244	239	**230**	238	229	231	230
Total R^2	.05	.18	**.26**	.21	.30	.28	.31
ΔR^2	ns	.13	**.08**	ns	ns	ns	ns

Note. The best fitting model is in boldface. Fixed effects estimates are displayed with SE in parentheses. Year is the time variable and is centered on the fourth year of data collection. ΔR^2 corresponds to the unique variance accounted for by the last variable in the model. ns = not significant. * $p < .05$; ** $p < .01$

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Table 6. *Longitudinal Models with English NDW as the Dependent Measure.*

Parameter	Model 1	Model 2	Model 3	**Model 4**	Model 5
Intercept	82.95***	37.83*	26.55	**20.90**	14.68
	(2.98)	(15.02)	(14.38)	**(13.62)**	(15.76)
Year - 4	4.29**	4.57**	4.61**	**4.39****	4.47**
	(1.40)	(1.44)	(1.49)	**(1.50)**	(1.49)
Initial Age		6.28**	5.13*	**3.83**	4.41*
		(2.02)	(2.14)	**(2.12)**	(2.16)
Initial English MLU			2.91*	**2.62**	2.51
			(1.39)	**(1.34)**	(1.39)
Initial Vietnamese NDW				**0.25***	
				(0.11)	
Initial Vietnamese MLU					3.11
					(2.10)
AIC	769	765	763	**760**	763
Total R^2	.08	.19	.22	**.26**	.24
ΔR^2	.08	.11	.02	**.04**	ns

Note. The best fitting model is in boldface. Fixed effects estimates are displayed with SE in parentheses. Year is the time variable and is centered on the fourth year of data collection. ΔR^2 corresponds to the unique variance accounted for by the last variable in the model. ns = not significant. * $p < .05$; ** $p < .01$

Table 7. *Longitudinal Models with English MLU as the Dependent Measure.*

Parameter	Model 1	Model 2	Model 3	**Model 4**	Model 5	Model 6	Model 7
Intercept	7.69***	4.42***	4.17***	**5.14*****	5.09***	4.96***	4.80***
	(0.20)	(1.18)	(1.10)	**(1.13)**	(1.16)	(1.10)	(1.31)
Year - 4	0.27**	0.29**	0.28**	**0.29****	0.30**	0.29**	0.29**
	(0.09)	(0.09)	(0.10)	**(0.10)**	(0.10)	(0.10)	(0.10)
Initial Age		0.45**	0.28	**0.11**	0.08	−0.03	0.09
		(0.16)	(0.17)	**(0.21)**	(0.25)	(0.22)	(0.21)
Initial English NDW			0.02*				
			(0.01)				
Initial English Naming				**2.79***	2.78*	3.21**	2.72*
				(1.07)	(1.07)	(1.05)	(1.08)
Initial Vietnamese Naming					0.33		
					(1.80)		
Initial Vietnamese NDW						0.01	
						(0.01)	
Initial Vietnamese MLU							0.08
							(0.16)
AIC	269	264	262	**261**	263	260	263
Total R^2	.06	.19	.26	**.28**	.28	.30	.29
ΔR^2	.06	.13	.07	**.09**	ns	ns	ns

Note. The best fitting model is in boldface. Fixed effects estimates are displayed with SE in parentheses. Year is the time variable and is centered on the fourth year of data collection. ΔR^2 corresponds to the unique variance accounted for by the last variable in the model. ns = not significant. * $p < .05$; ** $p < .01$

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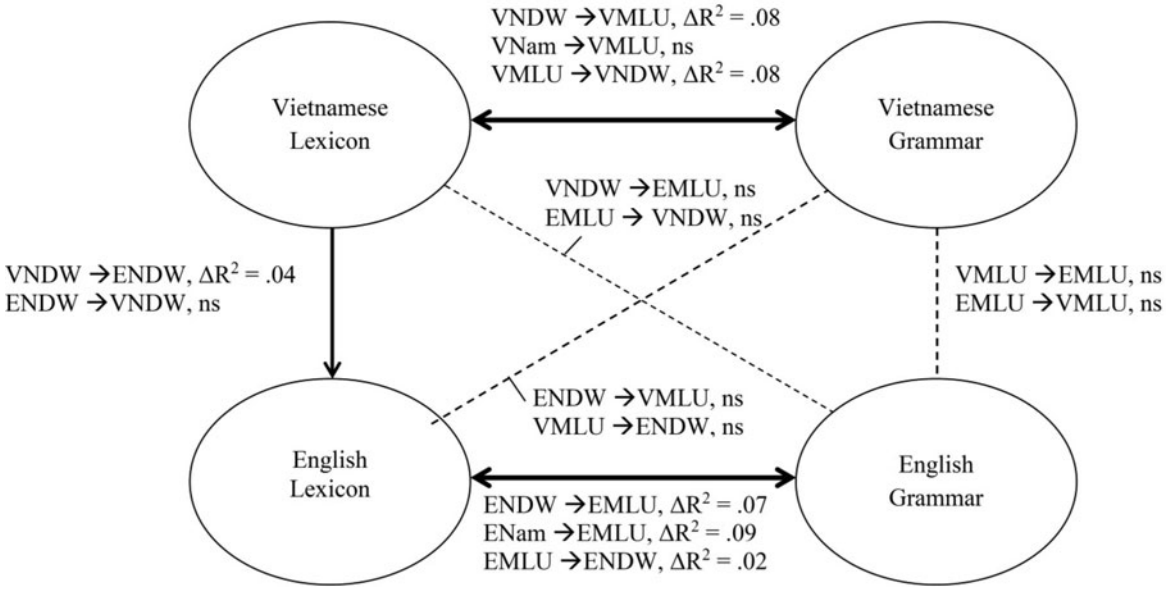

Figure 1. Longitudinal Pathways for L1 and L2 Learning. Predictive longitudinal associations were calculated using hierarchical linear modeling. Solid lines (vs. dotted lines) depict the presence of longitudinal associations. Line thickness and arrows depict the strength and direction of associations, respectively. All associations shown are positive in nature. See Tables 4–7 for full models and corresponding fixed effects estimates. V=Vietnamese; E=English; Nam=Picture naming; NDW=Number of different words; MLU=Mean length of utterance; ns=not significant.

for 9% of unique variance, and no cross-language predictors.

Figure 1 displays results from HLMs to visually represent the direction and relative strength of cross-domain relationships and relationships between the two languages. Collectively, data analyses suggest (a) stronger relationships within each language than between languages, (b) bidirectional associations between lexical and grammatical domains within each language, and (c) one-way transfer from the L1 to the L2 in the lexical domain.

Discussion

This study identified associations within each language and between languages in a longitudinal sample of sequential bilingual children. There were two main findings. First, there were bidirectional within-language associations between lexical and grammatical domains. In the L1, initial Vietnamese NDW accounted for 8% of unique variance in later Vietnamese MLU, and vice versa. In the L2, initial English NDW accounted for 7% of unique variance in later English MLU, and initial English MLU accounted for 2% of unique variance in later English NDW. Findings are consistent with domain-general theories of language acquisition, including Dynamic Systems Theory (DST: de Bot et al., 2007), in which language learning processes are shared across lexical and grammatical domains (e.g., Bates & Goodman, 1997; Kohnert et al., 2010; Marchman et al., 2004). Within DST, positive associations between lexical and grammatical domains indicate a supportive relationship in which growth in one domain supports growth in the other and vice versa.

It was noted that lexical-grammatical associations were relatively stronger within the L2 than within the L1. Initial English Picture Naming accounted for 9% of variance in later English MLU, while Picture Naming and MLU were not related in Vietnamese. Fewer cross-domain associations in the L1 than in the L2 replicate Kohnert et al., (2010) and extend findings to a longitudinal design and a school-age sample of sequential bilinguals. In contrast to simultaneous bilinguals who learn two languages from birth, sequential bilinguals start learning the L1 and L2 at different ages and stages of development (for review, see Kohnert, 2013). Differences in the number and strength of within-language associations may indicate differences in how lexical and grammatical domains are connected within the L1 compared to the L2. Future studies that measure more language domains or more fine-tuned measures of lexical and grammatical domains are needed to identify "connected growers" (de Bot et al., 2007) in the process of learning each language.

The second main finding was the presence and direction of cross-language associations. Based on longitudinal analysis, initial Vietnamese NDW predicted later English NDW, even after controlling for the effects of age and English MLU. In contrast, there were no cross-language (English) predictors for later Vietnamese outcomes. The finding of a unidirectional, longitudinal association from the L1 to the L2 is consistent with theories of language

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interdependence (Cummins, 1979), in which a strong foundation in children's L1 contributes to strong skills in the L2. Cummins' theory was originally proposed for Spanish (L1) speakers in the US who are in the process of learning English (L2), and more transfer between the L1 and L2 may be anticipated for children learning two typologically similar languages. This study extends theories of linguistic interdependence to a language pair that does not share lexical or grammatical structures. Even in two highly distinct languages, the influence of the L1 on the L2 is evident. Future studies are needed to identify underlying cognitive mechanisms for cross-language transfer, particularly in the absence of structural overlap.

Within DST, the lack of bi-directional transfer suggests a conditional relationship (van Geert, 1991) in which growth in the L1 may contribute to growth in the L2, but not vice versa. Transfer, here, is defined as an overall, long-term influence of one language on the other, rather than in-the-moment priming effects in which the L2 can influence the L1 (e.g., Su, 2001). A long-term, conditional relationship between the L1 and L2 underscores the imbalance between a minority L1 and majority L2. While there are multiple pathways to support the majority L2, continued development of a minority L1 can be more challenging due to reduced contexts for L1 use outside of the home environment (Kohnert, 2013). Findings with a longitudinal sample of Vietnamese–English bilinguals in the present study that are consistent with the literature on cross-language associations among Spanish–English bilinguals (e.g., Uccelli & Páez, 2007) suggest that long-term unidirectionality from the L1 to the L2 may be a common pattern for children who speak two languages of unequal sociolinguistic status.

The finding of one-way transfer from the minority L1 to the majority L2 has educational and clinical implications. First, L2-only instruction may facilitate growth in the L2, but may not promote development in the L1. Indeed, a meta-analysis of bilingual vs. English-only school programs in the US indicates that both program types show comparable outcomes in English, but only bilingual programs show continued development in the L1 (Rolstad, Mahoney & Glass, 2005). One-way transfer effects have also been found among clinical child populations. Treatment studies with Spanish–English bilingual children with language impairment have found similar English outcomes for English-only and bilingual treatments; however, increases in Spanish were only found following bilingual treatment (Ebert, Kohnert, Pham, Disher & Payesteh, 2014; Restrepo, Morgan & Thompson, 2013). Second, the finding of a longitudinal association from the minority L1 to the majority L2 motivates educational programming that supports vocabulary growth in the L1 in order to promote positive change in L1 grammar and in the L2. Consistent with previous studies of typical bilinguals (Rolstad et al., 2005) and bilinguals with language impairment (e.g., Ebert et al., 2014; Restrepo et al., 2013), programs that incorporate children's L1 and L2 will promote bilingual growth, whereas programs that solely target the L2 will not provide adequate support for continued development in the L1.

Finally, it should be noted that this longitudinal sample of sequential bilinguals showed positive trajectories for the L1 and L2, most likely related to their bilingual schooling experiences (Pham & Kohnert, 2014). The question is open as to whether bilingual children who experience L1 loss show the same within- and cross-language associations. Systematic study of within- and cross-language relationships is needed to examine how creating change in a specific component(s) can facilitate cascading effects across components. Naturalistic and experimental studies with repeated measures of multiple components are needed to test the robustness of within- and cross-language relationships outlined here and to ultimately build the knowledge base on how two languages are interconnected within a developing child.

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