Dual Language Development among Vietnamese-English Bilingual Children: Modeling Trajectories and Cross-Linguistic Associations within a Dynamic Systems Framework

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Kathryn Kohnert, Ph.D.

June 2011

Acknowledgements

I would like to acknowledge my faculty adviser, Kathryn Kohnert, Ph.D., whose guidance, support, and wisdom have fundamentally shaped my thinking and writing. Dr. Kohnert has taught me by example how to integrate the personal and professional, the heart and mind, and how to be a scholar, teacher, and mentor.

I would like to thank my dissertation committee for their thoughtful input on this study and in the writing process including Richard Lee, Ph.D., Peggy Nelson, Ph.D., Joe Reichle, Ph.D., and Moin Syed, Ph.D. I would like to thank Jennifer Windsor, Ph.D. for her input on preliminary projects, Edward Carney, Ph.D. for technical support, and Jeffrey Long, Ph.D. for assistance with R software.

I am grateful for my five-year collaboration with Hillcrest Foreign Language Academy in Orlando, Florida, and in particular for my good friend and colleague, Mrs. Hai Anh Nguyen, Vietnamese language teacher, for her essential help with coordinating communication between Hillcrest staff, students, and parents. I would like to thank all the children and their families for their participation in this study.

I would like to acknowledge all of the hard work contributed by graduate and undergraduate students who have helped with data collection and entry including Amelia Medina, Irene Hien Duong, Kelann Lobitz, Kimson Nguyen, Ellyn Dam, Bao Dang, Ly Nguyen, Samantha Yang, Maura Arnoldy, Renata Solum, and Jamie Wennblom. I am thankful for the camaraderie and friendship of fellow doctoral students including Kelly Nett Cordero, Ph.D., Pui Fong Kan, Ph.D., Kristina Blaiser, Ph.D., Kerry Ebert, Christine Wing, Jill Rentmeester, Bita Payesteh, Alisia Tran, and Mary Joyce Juan.

Last but certainly not least I am most appreciative for the love and kindness of my husband, Tien Pham, my parents, Xuan and Francis Tang, and my family and close friends including Van Tang, Bogonko Siko, Fr. Nguyen The Vien, Sabrina Dycus, and Janet Calderón. All have played a vital role in providing social, emotional and spiritual support.

This project was funded by a predoctoral fellowship from the National Institute of Child Health and Human Development (F31HD055113, PI: G. Pham). Additional funding was provided by the American Speech-Language and Hearing Foundation New Century Scholars Doctoral Scholarship, Center for Advanced Research on Language Acquisition Fellowship, Community of Scholars Program Travel Grant, College of Liberal Arts Student Dissertation Research Activity Award, and Speech-Language-Hearing Sciences Bryng Bryngelson Research Award.

Dedication

This dissertation is dedicated to my grandfather, Ông Nội Phanxicô Tăng Văn Phốc, who passed away in 2010 at the age of 90. Ông Nội was a lifelong learner and instilled in each of his five sons and four daughters the importance of education, an unwavering optimism, and dedicated faith. His spirit lives on in his 22 grandchildren and six great grandchildren.

Abstract

The purpose of this longitudinal study was to mathematically model first and second language trajectories and interactions among developing sequential bilingual school-age children. Language data were collected in four waves, with a one-year interval between each wave. Participants (N = 34, mean age of 7.3 at Wave 1) lived in the US, spoke Vietnamese as a first and home language (L1) and began learning the majority community language, English (L2), in early childhood. Children completed measures in the L1 and L2 at lexical, grammatical, and discourse subsystems each year for four consecutive years. Multivariate hierarchical linear models were calculated to examine the shape and rates of change for the two languages nested within individual children. Associations within and between languages were examined across different language subsystems at each wave and over time in a series of correlational and longitudinal analyses. Results showed (a) positive growth across all language subsystems for the L1 and L2 with relatively more rapid gains in the L2, (b) moderate to strong positive associations between languages at each wave and over time, (c) bidirectional cross-linguistic transfer, and (d) changes in the nature of L1-L2 relationships with age. Findings are interpreted within a Dynamic Systems framework in which a child's language system emerges from multiple interactions across cognitive, social and language systems as well as interactions within and between languages (de Bot, Lowie, & Verspoor, 2007; Kohnert, 2007).

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CHAPTER 1 INTRODUCTION

This study investigated the development and interdependence of languages among school-age bilingual children living in the US who speak Vietnamese as a first language (L1) and began learning English as a second language (L2) in early childhood. Unlike monolingual language development that follows an overall upward trajectory, the development of two languages may consist of fluctuations in relative and absolute proficiency in the L1 and L2 as a function of developmental stage, age of L2 onset, social context, language attitudes, and language-learning opportunities (Kohnert, 2007; 2010; Pearson, 2007 for reviews). There are (at least) three characteristics of bilingual development that are pertinent to a broader understanding of language learning: uneven proficiencies in the L1 and L2, cross-linguistic interactions, and individual variation (Kohnert, 2010). This study addresses these key features with a Vietnamese American sample to contribute to the body of knowledge on the process of learning two languages and in particular how these languages may interact over time. Methodologically, this study contributes to the empirical literature through the use of longitudinal design and analysis, multiple measures of L1 and L2, and the addition of a new language pair, Vietnamese and English. Early school-age years were targeted given that this time period consists of rapid increases in vocabulary and narrative skills due to the onset of literacy and increased use of academic language (Clark, 1995). For sequential bilingual learners who speak a minority L1 and learn the majority community language as an L2, this dynamic period consists of fluctuations in relative proficiencies of the L1 and L2 with gains in one language often coinciding with instability in the other (Kohnert, 2002).

Prior to the presentation of this study, I outline the theoretical framework, Dynamic Systems, and how it relates to dual-language learning in Chapter 2, review the literature on language development and interdependence among school-age sequential bilingual children who speak a minority L1 in Chapter 3, and discuss issues of language proficiency, use, and linguistic features specific to Vietnamese-English bilingualism in Chapter 4. I present the current study's research questions and design in Chapter 5, outline the methods and procedures in Chapter 6, and describe the statistical analysis and assumptions in Chapter 7. I then present the results of the study in Chapter 8 followed by a general discussion in Chapter 9.

CHAPTER 2 THEORETICAL FRAMEWORK

This study is guided by a Dynamic Systems (DS) framework that focuses on describing and explaining change in complex systems over time. Originally from the field of mathematics, DS has been posited as a potential overarching theory for development (Lewis, 2000; Thelen & Ulrich, 1991). In the past two decades, DS approaches have been applied to a wide variety of developmental areas including motor (Thelen & Smith, 1994), cognition (Spencer & Schoner, 2003; van Geert, 1991), emotion (Lewis, Lamey, & Douglas, 1999), dyadic play (van Geert & Steenbeek, 2005), and language (van Geert, 1994; 2009). Given its relative newness to the study of development, establishing the role of DS is itself a work in progress (Lewis, 2000). DS approaches have been referred to as a theory (Thelen & Smith, 1994; Spencer & Schoner, 2003), a conceptual lens (Fogel, 1993), and a set of mathematical methods to model and quantify change (van Geert, 1998; van Geert & Steenbeek, 2005). In the area of language, DS approaches have been implemented using connectionist neural networks (Elman, 1995) and mathematical modeling of L1 development (van Geert 1994; 1998). DS principles have recently been proposed as a conceptual framework for adult L2 acquisition (De Bot, 2008; De Bot, Lowie, & Verspoor, 2007) and as a critical part of a framework for understanding child bilingualism and language disorders (Kohnert, 2007). In the proposed study, DS will be utilized as a conceptual framework to inform and motivate study design, analysis, and interpretation of findings.

Within a DS framework, language can be viewed as a complex system in which multiple interactions occur between subsystems within language (e.g., lexicon and grammar) and external to language such as social interaction and cognition (van Geert, 1991; 1998). For individuals who speak two languages, interactions within each language and across languages combined with interactions across language, social, and cognitive systems have the potential to produce cascading effects that are qualitatively different from monolingual development in either language (de Bot et al., 2007). Figure 1 displays a schematic representation of language as a complex system with potential interactions occurring within language subsystems of the lexicon, grammar, and discourse as well as between first and second languages.

DS approaches seek to answer the question of "how does X change over time?" (Smith & Samuelson, 2003) by making "retrodictions" (vs. predictions) about change that has already occurred (Larson-Freeman & Cameron, 2008; Thelen & Ulrich, 1991). Empirically-derived models of previous states are the basis for understanding growth trajectories and positing potential future states (Thelen & Ulrich, 1991; Thelen & Smith, 1994). Consistent with a DS framework, a primary goal of this study is to mathematically model L1 and L2 growth trajectories among bilingual children.

Key principles of DS approaches are self-organization, system stability and instability, and changing relationships among systems and subsystems. First, self-organization is defined as "the spontaneous emergence of coherent, high-order forms through recursive interactions among simpler components" (Lewis, 2000, p. 36). This principle of self-organization challenges researchers to focus on "co-adaptations" or interactions over time that could lead to a reorganization of the system rather than a sole "silver bullet" causal factor (Larson-Freeman & Cameron, 2008). Self-organization serves as motivation for the proposed study to measure both L1 and L2, each across different language subsystems (e.g., lexicon, grammar, discourse), in order to understand how the overall system emerges as a product of interactions across languages, language subsystems, and time points. Second, system instability is reflected in increased fluctuation or variability in performance and often indicates an upcoming transition or system reorganization (van Geert & Steenbeek, 2005). A DS framework does not view variability as noise but rather as a factor itself to be investigated over time (Thelen & Ulrich, 1991; van Dijk & van Geert, 2007). For children who speak two languages, variability at one language subsystem may be an indicator of change within that language as well as across languages. For example, researchers have found that increased variability in accessing and producing words in the L1 may coincide with increases in naming speed and accuracy in the L2 (e.g., Kohnert, 2002).

Finally, DS approaches focus on "connected growers" or dynamic relationships between two or more components that, similar to an eco-system, can be supportive, competitive, or conditional (van Geert, 1991; 1994; 1998). Relationships can be supportive in that growth in one component facilitates growth in another. In contrast, components can compete for limited resources, and therefore growth in one component interferes with growth in another. Also, relationships can be conditional in that an increase in one component facilitates the onset of growth in another at which time growth in the first component decreases or ceases to continue. These types of dynamic relationships have been examined in first language acquisition (van Geert, 2009). Bassano and van Geert (2007) found that holophrases and two-word combinations were conditionally related in that the increase of holophrases contributed to the onset of two-word combinations, which coincided with a decrease in the occurrence of holophrases.

In terms of direction, relationships can be symmetric (A relates to B as B relates to A) or asymmetric in that A relates to B but B does not relate to A (van Geert, 1991; 1998).

The nature of dynamic relationships between two languages has been studied in the fields of L2 acquisition, bilingual education, sociolinguistics, and psycholinguistics under the umbrella term of *cross-linguistic transfer*, defined as the influence of one language on the other (Odlin, 1989). Transfer can be positive (i.e., supportive) and facilitate learning in the other language or negative (i.e., competitive) and delay acquisition, slow down processing, or require increased effort to meet environmental demands (MacWhinney, 2005; Odlin, 1989). L1-L2 relationships can also be conditional in cases of subtractive bilingualism in that an increase in the L1 contributes to an increase in the L2; however without continued support, L1 may decline or plateau (Wong-Fillmore, 1991). Transfer can be unidirectional or asymmetric (i.e., L1 to L2 but not L2 to L1) or symmetric and bidirectional from the L1 to the L2 and from the L2 to the L1 (Liu, Bates, & Li, 1992).

Cross-linguistic transfer has traditionally focused on the surface or structural level (Odlin, 1989), and has been documented in phonology as accelerated or delayed acquisition of speech sounds (e.g., Gildersleeve-Neumann, Kester, Davis, & Peña, 2008), at the lexical level with changes in processing efficiency for cognates (i.e., words that have similar surface features in two languages such as *elefante* in Spanish and *elephant* in English; Kohnert, Windsor, & Miller, 2004), and at the morpho-syntactic level in production (Dopke, 2000) and comprehension (Liu, Bates, & Li, 1992; Pham & Kohnert, 2010). In the field of bilingual education, cross-linguistic relationships are examined at a meta-linguistic level in which learning a skill such as reading or phonological awareness in one language facilitates skill acquisition in the other (Cummins, 1979). Finally, L1 and L2 can be related at the cognitive-linguistic interface in which the child draws on the same underlying cognitive processes of speed of processing, attention, perception, and memory to develop both languages (Kohnert, 2010).

The language pair of Vietnamese and English provides a unique forum to examine cross-linguistic relationships at "deeper" levels (i.e., non-surface) as these languages are topologically distinct and do not share surface structures such as lexical cognates (for a comparison between Vietnamese and English, see Tang, 2006). Non-structural or deep relationships across languages may underscore the role of individual differences such as personality, language-learning aptitude, or motivation (Castilla, Restrepo, & Perez-Leroux, 2009; Kohnert, 2010). Identifying symmetric and asymmetric relationships may reveal important information about the role of L1 and L2 input, proficiency, and use (Cummins, 1991; Kohnert, 2010; Pearson, 2007).

Keeping these core principles of a DS framework in mind, this study aims to "retro-cast" (Larson-Freeman & Cameron, 2008) developmental change over time to examine L1 and L2 growth trajectories and cross-linguistic relationships among school-age bilingual children. Investigating the presence and nature of cross-linguistic relationships between Vietnamese and English contributes to a better understanding of the developing dual-language system in sequential bilingual learners. In the following section, I review findings from the empirical literature on L1 and L2 development and interdependence and introduce issues that are specific to Vietnamese-English bilingualism.

CHAPTER 3 REVIEW OF THE LITERATURE

First and Second Language Development among School-Age Children

This review of the literature focuses on a specific bilingual population, namely, sequential learners of a minority L1 and majority community L2 (i.e., English in the U.S. context). Within the past two decades, there has been a surge in the number of empirical studies that have examined L1 and L2 development among bilingual school-age children using direct measures of both languages. The majority of studies have focused on Spanish-English bilingual children living in the US (e.g., Kohnert, 2002; Kohnert, Bates, Hernandez, 1999; Oller & Eilers, 2002; Pearson, 2002; Uccelli & Paez, 2007) with notable exceptions in other minority languages such as Inuttitut in Canada (Wright, Taylor, & Macarthur, 2000) and Turkish in the Netherlands (Verhoeven, 1994). Currently, there are no studies available on Vietnamese language development in monolingual or bilingual speakers with the single exception of Pham and Kohnert (2010).

L1 and L2 development has been examined in the areas of vocabulary knowledge (e.g., Cobo-Lewis, Pearson, Eilers, & Umbel, 2002ab), lexical processing (e.g., Kohnert et al., 1999), lexical diversity (e.g., Verhoeven, 1994), grammatical complexity (e.g., Uccelli & Paez, 2007), and narratives (e.g., Pearson, 2002). Kohnert and colleagues (1999) conducted a cross-sectional study investigating L1 and L2 lexical processing with 100 Spanish-English sequential bilinguals divided into five age groups: 5 to 7 years, 8 to 10 years, 11 to 13 years, 14 to 16 years, and college age. All participants lived in Southern California and spoke Spanish as their L1 in the home with formal English (L2) experience beginning at age 5. In a timed picture naming task, participants were shown a picture of a common object on the computer screen and asked to name the object as quickly as possible. The task had two conditions: blocked (Spanish-only or English-only) and mixed (trials alternating between Spanish and English). Dependent measures were naming accuracy and response latency. Most relevant for present purposes, results in the blocked condition indicated overall increases in both languages across age groups with relatively greater gains in the L2. There was a shift in relative language proficiency from the L1 to the L2 beginning in middle childhood: children ages 5 to 7 years named pictures more accurately and faster in Spanish (L1); children ages 8 to 10 years continued to be more accurate in the L1 but named pictures more quickly in English (L2); children ages 11 to 13 were "balanced" across languages in naming accuracy and response time; and participants 14 years and older were more accurate and faster in the L2. It was noted that skills in the L1 did not decrease across groups (i.e. no L1 loss in absolute terms) but rather appeared to plateau with age. The same general pattern of shift from L1 to L2 dominance, albeit at earlier or later time frames, was found in naming actions (Jia, Kohnert, Collado, & Aquino-Garcia, 2006) and in receptive lexical processing (Kohnert & Bates, 2002).

Oller, Eilers and colleagues (2002) conducted a cross-sectional study examining L1 and L2 oral and written skills with 704 Spanish-English bilinguals living in Miami, Florida, who attended kindergarten, Grade 2, and Grade 5. A sample of 248 monolingual English-speaking children was selected from the same grades and schools to serve as comparison groups. Researchers used tests that were standardized on monolingual populations to measure Spanish and English: Picture Vocabulary, Verbal Analogies, and Oral Vocabulary subtests from the Woodcock Language Proficiency

Battery (Woodcock, 1991) and Woodcock Language Proficiency Battery: Spanish - Revised (Woodcock & Muñoz-Sandoval, 1995) as well as the Peabody Picture Vocabulary Test - Revised (PPVT, Dunn & Dunn, 1981) and Test de Vocabulario en Imágenes Peabody (TVIP, Dunn, Padilla, Lugo, & Dunn, 1986). Standard scores were reported for English and Spanish separately (Cobo-Lewis, Pearson, Eilers, & Umbel, 2002ab) across independent variables of "lingualism" (monolingual or bilingual), socio-economic status (SES: low or high), language(s) spoken in the home (Spanish and English or Spanish-only), and instructional method in school (English immersion or Two-way bilingual). Using multivariate analyses of variance (MANOVAs), researchers found that English standard scores for bilingual children increased by grade level. Although lower than the English scores of the monolingual comparison group, bilingual children by Grade 5 were within one standard deviation of the published mean for monolingual English learners (Standard Score > 85) on all four oral language measures. Standard scores for Spanish measures were mixed: verbal analogy and picture vocabulary increased by grade level, oral vocabulary decreased, and scores for the TVIP remained the same. Spanish standard scores by Grade 5 ranged from 57 to 103 across oral language measures.

Ollers and colleagues found that independent variables moderated language outcomes. As anticipated, bilingual children with high SES performed better than children with low SES on all English measures. However, the opposite effect was found for Spanish skills. Children with low SES performed better in Spanish than children with high SES, at least in measures of oral language (vs. literacy). This finding may have been driven by the high correspondence of low SES and Spanish-only home language use (Cobo-Lewis et al., 2002b). The effect of school instructional model was observed solely for Spanish scores indicating that bilingual children attending two-way language instructional programs performed higher in Spanish than children in English-only programs. Collectively, this study provided empirical evidence that incorporating the L1 and L2 in school instruction (i.e., two-way model) resulted in similar English scores as English-only instructional programs. The additional benefit of two-way language programs was continued development in Spanish (Cobo-Lewis et al., 2002b).

Pearson (2002) examined narrative development of 160 bilingual and 80 monolingual children in Grades 2 and 5 who had participated in the larger cross-sectional study by Oller, Eilers, and colleagues (2002). Using the wordless picture book, *Frog Where Are You?* (Mayer, 1969), children told spontaneous narratives in Spanish and English, with languages separated by day and counterbalanced in order of administration. Narratives were transcribed and scored for Story Score, Language Score, and a composite Total Narrative Score. Story Scores consisted of possible points for story elements, sequence, reference, internal states, and engagement. Language Scores consisted of points for complex syntax, lexicon, and morpho-syntax. Overall, children in Grade 5 performed better than children in Grade 2, and bilingual children scored higher on Total Narrative Scores in English than Spanish. Within the composite score (Total Narrative Score), Language Scores (vs. Story Scores) primarily contributed to group differences, with lexicon being the strongest distinguishing factor. That is, bilingual children scored approximately the same in Story Score across languages but performed better in the Language Score in English, most likely due to a larger English vocabulary (Pearson, 2002). Moderating effects found in the original sample were replicated in this subgroup, with SES and home language(s) affecting English performance and school instructional method affecting Spanish performance. Children with high SES performed better in English than children with low SES, however SES did not affect performance on Spanish narratives. Bilingual children who spoke English and Spanish in the home had greater English vocabularies. School instructional method moderated Spanish performance in that children receiving support in both languages (i.e., Two-way) outperformed children in English immersion on the Spanish Language Score. Unlike results from the standardized measures (Cobo-Lewis et al., 2002a), children in two-way educational programs tended to score *better* on English narratives than children in English immersion (Pearson, 2002).

The studies on L1 and L2 development reviewed thus far have used cross-sectional designs. There have been only a handful of studies that have used longitudinal data (e.g., Kohnert, 2002; Uccelli & Paez, 2007; Verhoeven, 1994; Wright et al., 2000). Kohnert (2002) reported on the expressive lexical processing skills of a subset of original participants from Kohnert and colleagues (1999) one year later. Attempts were made to contact all 60 participants from the three youngest age groups, and 28 children participated in the one-year follow-up (47% attrition rate). Kohnert (2002) found rapid L2 development at the group level, which supported results from the original study. Older children were more accurate and faster in English, particularly in the most cognitively demanding mixed language condition. Results for Spanish (L1) development were mixed, with individual children increasing, decreasing, or exhibiting no change in performance across the one-year interval. There were children who increased in both languages, increased solely in English, increased solely in Spanish, and decreased in both languages depending on the dependent measure (accuracy vs. response time) and task condition (blocked vs. mixed). It was noted that an increase in one language was sometimes associated with a decrease in the other language on this lexical production task (Kohnert, 2002).

Uccelli and Paez (2007) investigated vocabulary and narrative development among 24 Spanish-English bilingual children. Participants were in kindergarten (mean age = 5.6 years) at Time 1 and in Grade 1 (mean age = 6.6 years) at Time 2. Tasks included picture vocabulary subtests in Spanish and English from the Woodcock Language Proficiency Battery- Revised (Woodcock, 1991; Woodcock & Muñoz-Sandoval, 1995), standardized expressive vocabulary tests (Woodcock, 1991; Woodcock & Muñoz-Sandoval, 1995) and a picture description task to elicit a spontaneous narrative in each language. Dependent measures included standardized vocabulary scores, total number of words (TNW), number of different words (NDW), story structure scores, and language scores. Using repeated measures MANOVAs on standardized scores, researchers found that English vocabulary increased across time, while Spanish expressive vocabulary remained the same. This group of children performed equally well across languages on measures of lexical diversity (TNW, NDW). At both time points, narrative skills were greater in English than in Spanish. Children improved in English language score and story score across time, while Spanish improved solely in the story score. Findings suggested rapid growth in English and a plateau in Spanish skills.

Wright, Taylor, and Macarthur (2000) conducted a longitudinal study investigating L1 and L2 development of children living in an arctic community of

Canada. Although the community consisted of a numerical majority of Inuit who spoke primarily Inuttitut as the L1, the official languages of Canada, English and French, were considered the socially dominant "majority" languages. A total of 96 children participated in the study: 63 Inuit, 25 mixed-heritage (Inuit & White) who spoke English as their L1, and 8 White children who spoke French as their L1. Children attended schools with instruction either exclusively in their L1 (32 Inuit, 18 mixed-heritage in English, and 8 White in French) or in their L2 (31 Inuit instructed in English or French, 7 mixed-heritage children instructed in Inuttitut or French). Performance in the L1 and L2 were measured at the beginning and end of each school year from kindergarten to Grade 2 for a total of six time points per child. Children completed a battery of tasks including picture identification, picture naming, sentence comprehension, story comprehension, letter identification, and picture description. Tasks at Grades 1 and 2 also included literacy-related tasks. At each grade level, percent correct was calculated for all tasks and combined for one composite score for each language at each time point with all tasks given the same weight. Scores for vocabulary, comprehension, and literacy were also reported separately for further information on specific language areas.

Using MANOVAs, Wright and colleagues found that Inuit children instructed in their L1 performed just as well as English-speaking and French-speaking children instructed in their L1 across time points. This finding suggested that Inuit children could develop their L1 at the same rate as children who spoke socially dominant languages (English, French) when provided appropriate educational support (Wright et al., 2000). In contrast, Inuit children instructed in an L2 exhibited slower development in their L1. Although all Inuit children started kindergarten with the same level of Inuttitut (a score of 50%), within one year, there were group differences between children instructed in their L1 (72.8%) and children instructed in an L2 (approximately 60%). This gap widened over time with children instructed in their L1 at the end of grade 2 scoring 90% versus children instructed in an L2 scoring approximately 75%. The gap was particularly large in the area of literacy with children instructed in the L1 scoring over 90% versus children instructed in an L2 scoring 25-30% by the end of Grade 2. Although within-group comparisons across time were not reported, it was noted that average L1 development increased at each time point despite language of instruction (i.e., no evidence for L1 loss). However, L1 skills developed much more slowly for children instructed in the L2, and in some areas (i.e., literacy) stagnated by the end of Grade 1. Results on L2 development were mixed. In the area of literacy, Inuit children instructed in an L2 (English or French) performed lower in their L2 (60% in English, 64% in French) than English-speaking children instructed in an L2 (88% in Inuttitut, 77% in French) by the end of Grade 2. However, this pattern was more consistent for Inuit children instructed in French and often did not hold for Inuit children instructed in English. Researchers argued that instruction in a socially dominant L2 without sufficient support of the L1 may lead to partial L2 proficiency. This explanation posits a critical co-dependence of the L2 on the L1. However, discrepancies between Inuit children in L2 programs (English and French) weaken this claim.

Verhoeven (1994) examined bilingual development among 98 children living in the Netherlands who spoke Turkish as an L1 and Dutch as an L2. Children were 6 years old at the beginning of the study and participated in two additional data collection times at ages 7 and 8. Children completed multiple measures in each language including picture description, picture identification, picture naming, sentence imitation, and phoneme discrimination. Dependent measures were combined into latent variables for each language that represented pragmatic proficiency, lexical knowledge, syntactic knowledge, phonemic discrimination, word reading efficiency, and reading comprehension. The pragmatic proficiency latent variable consisted of the number of different content words (NDW-content) and mean number of morphemes in the longest utterances (MLU-m), which may more accurately reflect lexical diversity and grammatical productivity (e.g., Uccelli & Paez, 2007). MANOVAs were conducted to compare latent variables across the three time points. Verhoeven (1994) found overall gains in both languages with greater performance in the L1 but greater increases across time points in the L2. Although this pattern held for some variables such as syntactic knowledge and phonemic discrimination, children also demonstrated greater increases in the L1 on lexical knowledge and MLU (Verhoeven, 1994).

In sum, empirical evidence indicates that school-age bilingual children who speak a minority language as an L1 experience a shift in relative dominance to the majority language, L2, during middle childhood as a function of increased school experiences, literacy, and wider contexts for L2 use as well as more social practice associated with the majority community language (e.g., Cobo-Lewis et al., 2002ab; Kohnert et al., 1999; Verhoeven, 1994). Maintenance or continued growth of the L1 may depend on support for the L1 at school (Cobo-Lewis et al., 2002b; Wright et al., 2000) and in the community (Oller & Eilers, 2002; Wright et al., 2000).

Methodologically, most studies used cross-sectional designs to examine L1 and L2 development (e.g., Cobo-Lewis et al., 2002ab). Of the few studies that incorporated longitudinal data, there were studies that used solely two time points (e.g., Kohnert, 2002; Uccelli & Paez, 2007) which may not be adequate to capture the shape of change or fluctuations over time (van Geert & Steenbeek, 2005). Studies that incorporated three or more time points (e.g., Verhoeven, 1994; Wright et al., 2000) analyzed data using group-level comparisons (i.e., MANOVAs). Longitudinal designs of three or more time points and use of growth curve modeling would greatly contribute to our understanding of the shape, direction, and nature of dual-language development within individual children over time.

L1 and L2 Interdependence

This section focuses on "deep" (i.e., non-surface) relationships within each language and across languages in bilingual learners. Particular focus is placed on the presence or absence of cross-linguistic relationships, their strength (i.e., weak, moderate, strong), nature (i.e., supportive/positive or competitive/negative) and direction (i.e., unidirectional or bidirectional). Consistent with a DS framework, cross-linguistic relationships are examined at the same language subsystem (e.g., lexical skills in the L1 and L2) and across subsystems (e.g., L1 lexicon and L2 grammar) when data are provided.

Cobo-Lewis and colleagues (2002) examined cross-linguistic relationships in oral language and literacy skills among 2nd and 5th graders who participated in a larger cross-sectional study by Oller and Eilers (2002). As participants were stratified by SES, home language(s), and school instruction in the original study design (see previous section), residualized scores were used in the analyses to remove between-group differences due to stratified sampling. Bivariate correlations of residualized scores revealed moderate to strong positive associations within each language ($r = .34$ to $.60$, $p < 0.0001$). Across languages, there were moderate positive associations for verbal academic measures, synonyms/antonyms ($r = .31$, $p < 0.0001$) and verbal analogy ($r = .45$, $p < 0.0001$). (Although not the focus here, cross-linguistic relationships for literacy were stronger than verbal academic measures.) Receptive vocabulary (PPVT/TVIP) was moderately related ($r = .33$, $p < 0.0001$), while expressive vocabulary was weakly related ($r = .10$, $p < 0.05$). No negative correlations were found within or across languages. Researchers used principal component analysis (PCA) to examine how measures were associated within individual children. Based on PCA, three factors emerged: literacy (Spanish and English measures), English oral language, and Spanish oral language, which suggested strong L1-L2 interdependence in literacy and relative autonomy of L1 and L2 oral language. Researchers found that the presence and nature of these cross-linguistic relationships did not change as a function of input-related attributes (i.e., SES, home language, school language model) (Cobo-Lewis et al., 2002).

Pearson (2002) reported mixed results for cross-linguistic relationships based on narratives from a subset of bilingual children ($n = 160$) from Oller and Eilers (2002). Global grammatical measures such as total number of clauses and MLU were highly correlated across languages ($r = .72$ and $r = .59$, respectively). Story scores were strongly correlated across languages ($r = .57$, no p-values reported), while L1 and L2 language scores were not ($r = .18$). Within the language score, complex syntax sub-scores were highly correlated ($r = .53$), while little to no evidence of links were found between the L1 and L2 lexicons (r = .14) and morpho-syntax (r = .14). Collectively, findings from Cobo-Lewis and colleagues (2002) and Pearson (2002) showed: a) no evidence of cross-linguistic interference (i.e., no negative correlations), b) a high degree of L1- L2 interdependence on literacy tasks, c) L1-L2 interdependence on verbal academic measures such as verbal analogies, narrative structure, and complex grammar, d) relatively stronger relationships in the receptive domain (PPVT/TVIP vs. picture naming), and e) relatively autonomous development (i.e., no cross-linguistic relationships) for expressive vocabulary as measured by a standardized test and morpho-syntax measured in language sampling. Ordoñez, Carlo, Snow, and McLaughlin (2002) investigated vocabulary breadth and depth with 88 Spanish-English 4th and 5th graders living in Boston, Massachusetts, and Santa Barbara, California. Participants completed the PPVT (Dunn & Dunn, 1981) and TVIP (Dunn et al., 1986) as measures of breadth of receptive vocabulary knowledge and a word definition task to measure depth of expressive vocabulary knowledge. In the word definition task, children were asked to define six concrete nouns. Definitions were scored for a) total number of superordinates, both real (e.g., an elephant is an animal) and empty (e.g., a boat is a thing); syntagmatic knowledge (nonhierarchical, e.g., an envelope is made of paper); and communicative adequacy, a global rating of the completeness of the verbal definition. Researchers posited that word definitions that included superordinates were more formal and academic than definitions that solely provided descriptions of physical characteristics (i.e., syntagmatic knowledge; Ordoñez et al., 2002). Although participant description was limited in the study, children could be viewed as having high communicative competence in both languages and relatively stronger academic vocabulary in Spanish based on group means. At the group level, children produced more real superordinates in Spanish (10 of 30) than English (2 or 30); scored slightly higher on syntagmatic knowledge in English (33) than Spanish (26); and scored the same on communicative adequacy (English 13, Spanish 12).

Within each language, all measures were positively related except receptive vocabulary and total number of superordinates ($r = .13$, ns in English; $r = .14$, ns in Spanish), suggesting that the two variables represented non-overlapping constructs. Across languages, there was a moderate positive association between L1 and L2 total number of superordinates ($r = .46$, $p < 0.01$). In contrast, cross-linguistic relationships were weak and negative for receptive vocabulary (TVIP/PPVT, $r = -.23$, $p < 0.05$), and weak or nonexistent for communicative adequacy ($r = .16$, ns) and syntagmatic knowledge ($r = .18$, $p < 0.10$).

Results indicated associations between basic components in Spanish and higher components in English. For example, there were positive associations between Spanish communicative adequacy and the total number of English superordinates and ($r = .38$, $p < 0.01$) and between Spanish syntagmatic knowledge and English superordinates ($r = .34$, $p < 0.01$). These relationships were not found from English to Spanish in that English communicative adequacy and syntagmatic knowledge did not relate to the total number of Spanish superordinates ($r = .06$, ns and $r = .07$ ns, respectively). In addition, Spanish receptive vocabulary negatively related to English communicative adequacy ($r = -.20$, $p < 0.10$), while English receptive vocabulary was not related to Spanish communicative adequacy ($r = -.05$, ns). These findings suggested unidirectional transfer from Spanish to English that either facilitated or impeded English performance.

Greater academic language in Spanish may have contributed to the unidirectional (Spanish to English) nature of these relationships. There was one bidirectional relationship in that receptive vocabulary in one language was negatively associated with syntagmatic knowledge in the other language (PPVT and Spanish syntagmatic knowledge, $r = -.25$, $p < 0.05$; TVIP and English syntagmatic knowledge, $r = -.27$, $p < 0.05$). This relationship suggested that high receptive vocabulary in one language may (at least temporarily) interfere with the ability to describe words in the other language. Longitudinal data and multiple measures are needed to examine whether the direction and nature of these relationships are intermittent and task-dependent or whether they are found across multiple language measures and persist over time.

Most studies examining L1-L2 interdependence have used cross-sectional designs. A few notable exceptions incorporate longitudinal data (e.g., Uccelli & Paez, 2007; Verhoeven, 1994). Although often not the primary focus of the study, measurements of L1 and L2 across time points contribute to our knowledge on cross-linguistic relationships by examining how they may change over time.

Verhoeven (1994) examined L1 and L2 interdependence among Turkish (L1) children living in the Netherlands who spoke Dutch as their L2. As described in the previous section, Verhoeven constructed latent variables to combine oral language measures (dependent measures in parentheses): pragmatic proficiency (NDW-content, MLU), lexical knowledge (receptive and productive vocabulary), and syntactic knowledge (three dependent measures from sentence imitation: function words, word order, word final markers). Again, the pragmatic proficiency latent variable was a combination of NDW and MLU, which elsewhere have been used as measures of lexical and grammatical complexity (e.g., Uccelli & Paez, 2007). Linear structural relations analysis (LISERAL) was used to examine predictive relationships within and across languages at Times 1, 2, and 3. Overall within-language relationships at each language subsystem were positive ranging from moderate to high (r = .28 to .95). Across languages, results revealed strong positive relationships in the latent variable that combined lexical and grammatical productivity (NDW & MLU, respectively) at Time 1 (r = .42) and Time 2 (r = .82). Syntactic knowledge, based on sentence imitation, was positively related across languages only at Time 1 (r = .25). There was no clear L1-L2 relationship for the lexical variable. However, this latent variable was comprised of vocabulary production and comprehension. Results may have been different for latent variables based on vocabulary production and comprehension separately. Recall that Cobo-Lewis and colleagues (2002) found cross-linguistic associations in receptive vocabulary based on the PPVT/TVIP (r = .33), but not in picture naming (r = .10). In sum, within-language relationships were strong and positive, while cross-linguistic relationships ranged from weak (r = .25 for sentence imitation) to strong (r = .82 for NDW/MLU) across time points. Findings extend previous results (e.g., Cobo-Lewis et al., 2002) and showed positive L1-L2 relationships (i.e., no interference) over time.

Uccelli and Paez (2007) examined relationships across languages and across two time points. As described in the previous section, 24 bilingual children completed picture vocabulary tests (Woodcock, 1991; Woodcock & Muñoz-Sandoval, 1995) and a picture description task that elicited spontaneous narratives in both languages. Dependent measures were standardized expressive vocabulary scores and measures that examined narratives quantitatively (NDW, TNW, MLU) and qualitatively (story score, language score). Within-language correlations between qualitative and quantitative narrative measures were positive at each time point. There was a change in the strength of these relationships over time. At Time 1, within-language associations were relatively stronger in Spanish ($r = .63$ to $.84$, $p < 0.01$ for Spanish; $r = .33$ to $.55$, $p < 0.05$ for English). However, by Time 2, the strength of these associations were comparable ($r = .39$ to $.79$, $p < 0.05$ for Spanish; $r = .47$ to $.76$, $p < 0.05$ for English), suggesting that English language skills became more tightly linked over time.

Across languages, there were consistent, positive associations between L1 and L2 story scores at Time 1 ($r = .59$, $p < 0.01$) and at Time 2 ($r = .59$, $p < 0.01$). In contrast to Pearson (2002), language scores in this study were positively associated between Spanish and English at Time 1 ($r = .33$) and at Time 2 ($r = .30$); however, given the sample size ($N = 24$) these correlations did not reach statistical significance. Cross-linguistic relationships on quantitative measures were positive at Time 2 for TDW ($r = .47$) and NDW ($r = .45$). Consistent with Pearson (2002) and Cobo-Lewis and colleagues (2002), no negative correlations occurred between measures within each language or across languages.

Using hierarchical regression, Uccelli and Paez found that participants' Spanish story scores at Time 1 predicted English narrative quality scores at Time 2 even after controlling for English vocabulary and lexical diversity (i.e., TDW). For Spanish, only within-language relationships were predictive in nature: Spanish vocabulary at Time 1 predicted Spanish story structure at Time 2. Based on the regression analysis, researchers posited unidirectional transfer from Spanish to English (Uccelli & Paez, 2007). However, although not the focus of the study, there was also empirical evidence for transfer in the *opposite* direction, from English to Spanish, when cross-linguistic associations across time and language subsystems were taken into account. In kindergarten (Time 1), scores in one language positively related to story scores in the other (i.e., Spanish language score - English story score, $r = .37$, ns; English language score - Spanish story score $r = .40$, ns). (Again, these correlations may have reached statistical significance with a larger sample size). In Grade 1 (Time 2), the relationship between Spanish language scores and English story scores appeared to attenuate ($r = .19$, ns), while the reverse relationship increased in magnitude (i.e., English language score - Spanish story score $r = .42$, $p < 0.05$). These results suggested a bidirectional relationship between language scores and story scores across languages in kindergarten and a shift towards a unidirectional relationship from English language to Spanish story skills in Grade 1. This change in the nature of L1-L2 relationships may reflect a shift in relative proficiency towards English (i.e., transfer from the stronger language, English, to the weaker language, Spanish). This explanation is supported by group data showing that on average, children performed equally in Spanish and English at Time 1 and better in English (but not in Spanish) at Time 2. These data underscore the dynamic nature of L1-L2 relationships over time.

In sum, empirical evidence shows the presence of relationships between subsystems within each language, between languages, and between languages and subsystems. Associations in developing sequential bilingual school-age children were stronger within each language than across languages (e.g., Cobo-Lewis et al., 2002), and the overwhelming number of relationships between languages were positive (e.g., Cobo-Lewis et al., 2002; Pearson, 2002; Uccelli & Paez, 2007; Verhoeven, 1994; although see Ordoñez et al., 2002 for an exception). Cross-linguistic relationships were found at the same language subsystem (e.g., Verhoeven, 1994) as well as across subsystems (Cobo-Lewis et al., 2002). At the lexical semantic subsystem, stronger relationships were found in the receptive than expressive domain (Cobo-Lewis et al., 2002), on measures of the depth of vocabulary knowledge vs. vocabulary breadth (Ordoñez et al., 2002), and on context-embedded tasks such as language sampling (Uccelli & Paez, 2007) vs. standardized vocabulary tests (Cobo-Lewis et al., 2002). At the grammatical subsystem, cross-linguistic relationships occurred on measures of grammatical productivity such as MLU (Pearson, 2002; Uccelli & Paez, 2007) and sentence imitation (Verhoeven, 1994). At the discourse subsystem, narrative quality was positively related across languages (Pearson, 2002; Uccelli & Paez, 2007), while results were unclear for language scores that included vocabulary and syntax skills.

Cross-linguistic relationships that occur between language subsystems may be useful for examining the direction of transfer. For example, studies have shown relationships between basic components (i.e., communicative adequacy) in one language and higher components (e.g., superordinates) in the other language (e.g., Ordoñez et al., 2002). Children who are relatively stronger in one language may demonstrate transfer from the stronger to the weaker language (e.g., Ordoñez et al., 2002; Uccelli & Paez, 2007). The direction and nature of these relationships may change over time as a function of fluctuations in absolute and relative L1 and L2 proficiencies (e.g., Uccelli & Paez, 2007). Examining deeper (i.e., non-surface level) relationships between a child's two languages can provide insight into dual-language development, particularly for languages with highly distinct typologies. This investigation contributes to this burgeoning field of study by examining dynamic relationships between the L1 and L2 across multiple measures and time points. The following section describes issues specific to Vietnamese-English bilingualism related to language proficiency, use, and linguistic features of Vietnamese.

CHAPTER 4 VIETNAMESE-ENGLISH BILINGUALISM

Vietnamese is spoken by over 94 million people around the world. The vast majority of Vietnamese speakers live in Vietnam with an estimated population of 90 million (CIA, 2009), while the Vietnamese Diaspora includes countries such as the United States, Cambodia, Australia, France, Germany, Canada, Taiwan and Japan (Overseas Vietnamese, 2010). Waves of Vietnamese migration to the US started after the fall of South Vietnam in 1975 and have continued through the early 2000s (Orange County, 2010). Currently, there are over 1.6 million Vietnamese Americans (US Census, 2007), and Vietnamese is the seventh most common language spoken in the US (Reeves & Bennett, 2004). More than 60% of Vietnamese Americans are foreign born of which 46% came to the US before 1990, 38% arrived between 1990 and 1999, and 16% arrived in 2000 or later (US Census, 2007). Approximately 82% of Vietnamese households report speaking Vietnamese at home (US Census, 2007). Although several metropolitan areas have large Vietnamese American communities such as Los Angeles, Houston, and Washington, D.C. most Vietnamese American populations are smaller and scattered throughout the 50 states (Vietnamese Americans, 2010). This study was conducted in Orlando, Florida, where the Vietnamese American community is approximately 7,600 (Vietnamese Americans, 2010) with many families arriving in 2000 or later.

Connections between Language, Identity, and Well-Being

Similar to many immigrant populations, studies on language maintenance suggest that Vietnamese Americans follow a three generation model for language shift towards English monolingualism, originally proposed by Fishman (1972). Young and

Tran (1999) conducted a survey of over 100 Vietnamese parents in California who had lived in the US for an average of 13 years (SD = 7). Most parents reported speaking primarily Vietnamese in the home (85%), while some families spoke both Vietnamese and English (15%). Children were reported to speak Vietnamese and English to each other (33%) or only English (21%). The use of English increased with length of stay in the US. Nguyen, Shin, and Krashen (2001) surveyed 588 Vietnamese elementary school students in central California; 70% were US born, and of those born outside the US, 77% had lived in the US for more than 5 years. When asked about their language proficiency, preference, and attitudes, 67% reported speaking Vietnamese "very well", while 84% reported speaking English "very well". The majority of students preferred to speak Vietnamese with parents, Vietnamese and English with siblings, and only English with friends.

Shifts in language use and proficiency may have ramifications for children's sense of ethnic identity, self esteem, and academic success. In a survey of 387 Vietnamese high school students in New Orleans, Louisiana, Bankston and Zhou (1995) found that Vietnamese literacy positively related to a strong sense of ethnic identity and academic achievement. Results suggested that strong Vietnamese language skills provided access to social support and traditional values of the students' ethnic community. In a survey of over 130 Vietnamese college students primarily in the Washington D.C. area, Pham and Harris (2001) found that young adults who participated in American as well as Vietnamese cultures had the highest self esteem as compared to Vietnamese American young adults who participated in only one culture. Using parent and adolescent surveys of 47 Vietnamese families in Los Angeles, California, Phinney and colleagues (2001) found that Vietnamese language proficiency was positively related to ethnic identity and parent cultural maintenance, defined as parents' promotion of the maintenance of Vietnamese culture. Pathway models indicated that parental cultural maintenance promoted Vietnamese language proficiency and in-group peer interactions, and in turn, Vietnamese language proficiency promoted a strong sense of ethnic identity. It was noted that in-group peer interactions were not related to ethnic language proficiency for the Vietnamese group, consistent with previous survey data showing that language use between Vietnamese children was primarily in English (e.g., Nguyen et al., 2001). In sum, sociolinguistic studies have found rapid increases in English language proficiency and use among Vietnamese American youth. Meanwhile, children and adolescents who continue to have high proficiency in Vietnamese alongside their gains in English appear to have higher self esteem, a stronger sense of ethnic identity, higher academic achievement, and are more integrated into society.

Linguistic Characteristics of Vietnamese

The following is a brief introduction to characteristics of the Vietnamese language at the lexical semantic, grammatical, and discourse subsystems as relevant for this study (for a more detailed comparison of Vietnamese and English, see Tang, 2006).

Lexical semantics

Vietnamese is a tonal language in which a change in tone can alter word meaning. Each syllable in Vietnamese contains one of the six tones of the language: rising (*sắc*), falling (*huyền*), low creaky (*hỏi*), high creaky (*ngã*), low short (*nặng*), or level (*không dấu*). To illustrate changes in word meaning by lexical tone, the word *mẹ* with a low short tone means "mother", while *me* with a level tone means "tamarind" and *mè* with a falling tone means "sesame". Vietnamese orthography uses Romanized letters with spaces between syllables giving the appearance that every syllable is a word. However, Vietnamese words can consist of one, two, three, and sometimes four syllables (D. H. Nguyen, 1997). A considerable debate in Vietnamese linguistics is the definition of a word. For instance *con mèo* "cat" can be counted as one word (Cao, 1988) or two words, a classifier and noun (D. H. Nguyen, 1957). Even for lexical items for which there is wide agreement on whether to consider them one or two words, the identification of words is a challenge for corpora linguistics as parsing Vietnamese into words currently needs to be conducted manually (i.e., connecting syllables of each word), which becomes onerous in analyzing databases of millions of words (Pham, Kohnert, & Carney, 2008). For instance, the words *bàn* "table" and *ghế* "chair" combine to form one compound word *bàn ghế* "furniture", which an automatic word parser would count as two separate words.

Similar to English, Vietnamese words have the capability to change word class. Nouns can become verbs such as *cái bó* "[a] bundle" to *bó* "to bundle", and verbs can become nouns such as *cưa* "to saw" and *cái cưa* "[a] saw" (K. L. Nguyen, 2004). Adjectives can become nouns such as *khó khăn* "difficult" and *cái khó khăn* "a struggle" in Vietnamese, and nouns can become adjectives such as *cái lý tưởng* "an ideal" to *lý tưởng* "ideal" in Vietnamese (K. L. Nguyen, 2004). In contrast to many words in English that change form to indicate a change in word class (e.g., *bore* and *boring*), Vietnamese word forms never change. Rather nouns are marked by either a number or classifier to indicate complete and separate units or entities.

Grammar

Vietnamese and English share a common canonical sentence word order of subject - verb - object (SVO). However, Vietnamese is relatively more flexible than English in that multiple word orders are commonly permissible. Pham and Kohnert (2010) examined 1,000 sentences from the Corpora of Vietnamese Texts (Pham et al., 2008) and found that 65% consisted of SVO word order, 27% consisted of VO word order, and 9% consisted of OSV word order. Vietnamese speakers, therefore, may not rely heavily on the cue of the pre-verbal noun as subject to interpret meaning at the sentence level. In fact, Vietnamese-English bilingual children, ages 6 to 8, were found to rely less on sentence word order cues than their English-only same-aged peers when interpreting meaning in English sentences (Pham & Kohnert, 2010).

In contrast to English, Vietnamese does not use bounded morphemes to mark verb tense, aspect, or plurality. Rather, verb tense (past, present, future) is optionally marked using words that precede verbs (i.e., *đã, đang, sẽ*) but are mainly understood within the sentential or discourse context such as *Hôm qua, tôi đi chợ* [Yesterday, I go-to store] "Yesterday, I went to the store". Plurality is expressed using a number prior to the noun such as *hai con chó* [two dog] "two dogs" (for detailed examples, see Tang, 2006). Vietnamese-speaking children learning English may omit word endings such as past tense -ed, plural -s, as these morphological markers do not exist in their first language (Tang, 2006).

Discourse

Research on Vietnamese discourse as related to children's fictional narratives is sparse. Pham, Kohnert, and Lobitz (2009) examined Vietnamese and English language samples of 32 children, ages 5 to 9. Children looked at pictures of wordless picture books and were asked to spontaneously tell a story in each language. English and Vietnamese tasks were separated by examiner and by picture book. Analysis revealed that Vietnamese and English narratives shared certain features in common. Children marked the beginning and end of stories in both languages and included story episodes (i.e., initiating event, action, consequence) throughout their narratives. There were two issues related to discourse analysis that differed between the languages: referents as a marker of cohesion and calculating mean length of utterance (MLU). First, as previously described, the subject in Vietnamese sentences is often omitted if it is understood within the context. Although story cohesion scoring in English was based on the inclusion of the appropriate noun or pronoun as the subject/referent in each utterance, a subject for each utterance was not required for Vietnamese. Rather, a story was considered cohesive in Vietnamese when *obligatory* subjects were included to indicate a change in story character or differentiation of two story characters. Second, MLU calculations were based on the average number of syllables per utterance in Vietnamese and the average number of words per utterance in English. Vietnamese syllables were chosen instead of words to avoid ambiguity as to whether two syllables should be counted as one or two words (see previous Lexical Semantic section). Additionally, utterances were designated as one communication unit (c-unit), defined as a main clause and all of its subordinating clauses (Loban, 1963). Since Vietnamese allows sentences with omitted subjects, c-units in Vietnamese were operationally defined to consist of up to two main clauses with omitted subjects connected by a conjoining word as illustrated in the following example:

C-unit 1: *Con trai chạy xuống và bị vấp một cành cây*.

"The boy ran and fell over a tree branch."

C-unit 2: *Và té xuống hồ.*

"And fell into the water."

Continued empirical evidence is needed to examine whether using English words versus Vietnamese syllables as well as slight differences in the definition of an utterance affects the ability to compare MLU calculations across languages (cf., Kohnert, Kan & Conboy, 2010).

In sum, Vietnamese and English differ in a variety of features across lexical semantic, grammatical, and discourse subsystems. The development of two highly distinct languages within individual children provides the unique opportunity to explore language interactions at "deeper" (i.e., nonstructural) levels. The following section presents the purpose of the current study, research questions, and study design.

CHAPTER 5 THE PRESENT STUDY

The overall goals of the study were to account for change in the L1 and L2 of sequential bilingual learners over time and to investigate dynamic relationships found within and across languages. Findings from this study contribute to the body of knowledge on the process of dual-language learning. This study targeted two typologically distinct languages (Vietnamese and English), which challenges our theoretical knowledge on the nature of cross-linguistic associations. This study contributes to the literature in methodology through the use of longitudinal design and multiple measures for each of three language subsystems.

Research Questions

The first set of research questions addressed L1 and L2 development: Do L1 and L2 increase, decrease, or remain the same over time? What is the shape of change (linear or nonlinear)? Is the rate of change the same across language subsystems (lexicon, grammar, discourse)? Across languages (Vietnamese, English)?

Based on previous research (Jia et al., 2006; Kohnert, 2002; Kohnert & Bates, 2002; Kohnert et al., 1999), the following six predictions were posited regarding absolute and relative proficiencies in the L1 and L2:

1. Both languages will demonstrate overall gains over time (i.e., no L1 loss).
2. The L2 will increase more rapidly than the L1.
3. There will be an overall shift in relative dominance from the L1 to the L2 during middle childhood.
4. The shift in relative dominance will occur earlier in language production than comprehension.

5. Response time measures will be more sensitive to this shift than accuracy.
6. There may be uneven performance in which the "dominant" language fluctuates as a function of time, task and modality (production vs. comprehension).

The second set of research questions addressed L1 and L2 interdependence. This portion was exploratory and sought to capture the "presence, nature, and meaning" (Kohnert, 2010) of cross-linguistic relationships: Is L1 performance related to performance in the L2? Are L1-L2 relationships supportive (positive) or competitive (negative)? Does the nature of L1-L2 relationships change over time? Are L1-L2 relationships bidirectional or unidirectional? The following predictions were posited based on the limited existing empirical evidence (e.g., Cobo-Lewis et al., 2002; Ordoñez et al., 2002; Pearson, 2002; Uccelli & Paez, 2007; Verhoeven, 1994).

1. Stronger relationships will be found within each language than between languages.
2. Relationships in the receptive domain may be stronger than in the expressive domain.
3. The presence of cross-linguistic associations depends on the measure.
4. Most cross-linguistic relationships will be positive during this dynamic period during the school-age years.
5. The nature and direction of cross-language relationships may change as a function of relative proficiency.

Study Design

This study incorporated an accelerated cohort design that followed cohorts of children of heterogeneous age over a set period of time (Singer & Willett, 2003). The benefit of an accelerated cohort design is the ability to model change over a longer temporal period with fewer waves of data. A disadvantage of this design is that data tend to be sparser at youngest and oldest ages (Singer & Willett, 2003). Starting in 2008, a cohort of children participated in the study for the first of four waves of data collection. In 2009, children from the original cohort as well as a new cohort participated in the study for Waves 2 and 1 respectively. In 2010, children from the first two cohorts as well as a third cohort of children participated for Waves 3, 2, and 1 respectively. In 2011, children from all three cohorts participated for the final year for a total of four waves of data. Developmental trajectories were modeled based on chronological age (vs. wave).

The design was timed structured meaning that children were assessed during the same yearly intervals. Waves of data collection were equally spaced as children participated in January of each year. The design was unbalanced in that individual participants had different number of waves. Children had a minimum of one wave and a maximum of four waves of data. Missing data were considered missing at random (Widaman, 2006) in that data were not missing because children refused to participate in the study or because children refused to respond to certain items. Missing data were due to natural attrition as children transferred to different schools and could no longer be contacted to complete the study at home.

CHAPTER 6 METHODS

Participants

A total of thirty four typically developing children (19 girls, 15 boys) participated in this longitudinal study. All children lived in the United States and learned Vietnamese as a first language (L1) at home and English as their second language (L2) and the primary language of education and the broader community. Nineteen of 34 (56% of sample) were born in the US, and of the 15 foreign born, the average age of arrival was 3.4 years (SD = 2, range of 0.7 to 6.5).

Participant exclusionary criteria included (a) living in the US for less than one year, (b) cognitive impairments, (c) language or learning disabilities, (d) hearing loss, and (e) neurological complications. Children who were currently receiving special education services with language/learning goals (vs. speech only) in their Individualized Education Plans were excluded from the study. Additionally, in the absence of normative data on Vietnamese populations, teacher or parent concern was used as an indicator of possible language impairment (Restrepo, 1998) and study exclusion. All children scored within the age-expected range on the Test of Nonverbal Intelligence, 3rd edition, (TONI-3; Brown, Sherbenou, & Johnsen, 1997) with an average standard score of 111 (SD = 13, range of 85 to 140). School records indicated that all children passed vision and hearing screenings at the beginning of each year. Nineteen children (56% of the sample) were reported to receive free or reduced lunch at school, an indicator of low SES.

Participants were recruited from Hillcrest Foreign Language Academy in Orlando, Florida, at which Vietnamese children comprised approximately 20% of the total student population. Hillcrest was the only public elementary school in the US that offered Vietnamese language and literacy class for heritage speakers as part of the school curriculum. Children were instructed primarily in English and received 90 minutes per day of Vietnamese (L1) language and literacy. Children who originally attended Hillcrest and in later years attended their neighborhood school were invited to continue participating in the study. In addition, one participant never attended Hillcrest and was a sibling of a former Hillcrest student. Participant attrition occurred over the course of the four-year study enrollment period. The number of participants consisted of 34 at Wave 1, 28 at Wave 2, 22 at Wave 3, and 13 at Wave 4 with an average annual attrition rate of 26% and total attrition rate of 62% over four years. At the first wave of data collection, children were on average 7.3 years old (SD = 0.9).

Nearly all participants (97%) reported speaking Vietnamese to parents and grandparents; Vietnamese and English (40%) or mainly Vietnamese (32%) to siblings; and Vietnamese and English (41%) or only English (35%) to friends. Most participants had siblings (74%), and 39% reported having at least one grandparent living at home. Nearly all children reported understanding Vietnamese (93%) and English (97%) "well" or "very well" and speaking Vietnamese (93%) and English (93%) "well" or "very well". The parents of a subset of participants (n = 25) completed background questionnaires. Table 1 summarizes participants' educational, home, and language experiences based on these questionnaires. Most children (84%) lived with both parents. Most children attended daycare or preschool prior to entering kindergarten with the average age of systematic exposure to English (L2) at 4.4 years (SD = 1.4, range of 1 to 6). Overall parents reported that children used Vietnamese and English approximately the same amount of time in their daily lives and spoke both languages either "well" or "very well". The nine families who did not respond to the background questionnaire had children who no longer attended Hillcrest the year the questionnaire was sent home through their classroom teacher and could no longer be contacted by phone.

General Procedures

Children were tested on the same set of tasks at one-year intervals for a total of four years. Children completed tasks individually in a quiet room at the elementary school or in the child's home. Two examiners (a native speaker in each language) administered Vietnamese and English language tasks to each child. Languages were separated by examiner, and the first language of administration was counterbalanced across participants and across time points.

Language Measures

Table 2 displays the four language tasks used in this study to examine lexical, syntactic, and discourse subsystems: (1) picture word verification (dependent measures of accuracy and response time), (2) timed picture naming (accuracy, response time), (3) sentence repetition (accuracy) and (4) story tell (mean length of utterance, story quality score). Combined, these four tasks yielded seven dependent measures in each language. The following is a description of task procedures and stimuli.

Picture word verification.

This task measured receptive lexical processing skills, specifically how accurately and quickly participants could verify whether or not a picture corresponded to a single-word vocabulary item. During the task, participants saw a picture on a computer screen and listened to a word presented at a comfortable loudness via headphones. Then they pressed one of two buttons on a response box with the index finger of their dominant hand to indicate whether the picture and word were congruent (e.g., child saw a picture of a chair and heard the word "chair") or incongruent (e.g., child saw a table and heard "chair").

This task consisted of a set of 40 objects followed by a set of 40 actions with 8 training items and 3 practice items before each set. Within each set, 20 items were congruent and 20 items were incongruent. The task was administered using E-Prime 2.0 software. The order of items was block randomized with congruency alternating on every first, second, or third trial. The separate English and Vietnamese tasks used the same items presented in a different order. Picture and auditory stimuli were presented one time each. Children passed a criterion of 6 of 8 training items before completing the task. If needed, training items were administered more than once to meet criterion.

Dependent measures were accuracy and response time (RT). Accuracy consisted of the number of objects and actions correctly verified in the congruent condition (out of 40 total). RTs were measured solely for accurate responses and defined as the time between the presentation of the picture/word stimuli and child response. RTs were individually trimmed for each participant, in each language, for objects and actions separately. For example for each participant, RTs for Vietnamese picture-object verification, English picture-object verification, Vietnamese picture-action verification, and English picture-action verification were trimmed separately. RT trimming consisted of two steps: (1) RTs <50 ms and >5000 ms were omitted, and (2) RTs $\pm$ 2 SDs from the individual child's mean were omitted. Across all time points, an average of 1.1 RTs (range of 0 - 3) for Vietnamese and an average of 1.1 RTs (range of 0 - 4) for English were trimmed per participant for objects and actions separately. Composite RTs, one for each language, reflected the average time in milliseconds it took a child to correctly respond to object or action stimuli and was calculated using the following equation: $RT = (SUM_{objectRTs} + SUM_{actionRTs}) / [(\#correct_{objects} - \#trimmed_{objects}) + (\#correct_{actions} - \#trimmed_{actions})]$.

Appendices A and B display object and action stimuli, respectively. Stimuli were matched in word frequency using language corpora for Vietnamese (CVT: Pham et al., 2008) and English (CELEX: Baayen, Piepenbrock, & Gulikers, 1995). Consistent with word frequencies reported for CELEX in the International Picture Naming Project (Szekely et al., 2004), the log natural transformation, ln (1 + raw frequency count), was calculated for Vietnamese items to compare across language corpora that differed in total number of words. Pictures were black-and-white line drawings from the International Picture Naming Project (Szekely et al., 2004). I (female voice) digitally audio-recorded each word item in Vietnamese and English in a soundproof booth using natural speech intonation.

Timed picture naming.

In this task, the child wore a microphone headset and sat next to the examiner in front of a laptop computer. The microphone headset was connected to the computer via a response time button box. An “X” appeared on the computer screen to alert the child that a picture would appear. As the picture appeared, the child named the picture as quickly as possible. Once the microphone detected a sound, a blank screen with the word "more?" appeared (or “thêm?” in Vietnamese), and the examiner clicked the mouse to continue to the next trial. Dependent measures were accuracy and RT.

As consistent with the picture word verification task, timed picture naming consisted of a set of 40 objects followed by a set of 40 actions with 8 training items and 3 practice items before each set. Criterion to pass training was 6 of 8 items correctly named and spoken without audible hesitations (e.g., “um”, “uh) or microphone malfunctions. Three practice items were repeated immediately prior to beginning the task to avoid last-minute microphone glitches. E-Prime 2.0 computer software was used to conduct the task and record response times. Stimuli consisted of high frequency objects and actions depicted in black-and-white line drawings from the International Picture Naming Project (Szekely et al., 2004) and equated by word frequency using language corpora in English (Baayen et al., 1995) and in Vietnamese (Pham et al., 2008). Appendices C and D display all object and action items and their corresponding word frequencies. Test items were the same for Vietnamese and English although the order of presentation for these items differed for each language. Importantly, objects and actions did not overlap with items used in the picture word verification task.

During the administration of the timed picture naming task, the examiner recorded accuracy, speech hesitations as well as any microphone malfunctions (e.g., the picture on the computer screen did not disappear with the onset of the child’s spoken word). Accuracy was calculated as the number of objects and actions correctly named. The microphone detected the onset of the child’s spoken word, and the computer recorded RTs defined as the time in milliseconds between the onset of the picture and the onset of the spoken word. Consistent with the picture word verification task, RTs were individually trimmed for each participant, in each language separately for objects and actions. RT trimming consisted of two steps: (1) items in which the microphone malfunctioned and RTs <50 ms were omitted and (2) RTs $\pm$ 2 SDs from the individual child's mean were omitted. Across all time points, an average of 2.2 items in Vietnamese (range 0 - 9) and 1.9 items in English (range 0 - 6) were omitted per participant in each language for objects and actions separately. Composite RTs, one for each language, reflected the average time it took a child to name an object or action and was calculated using the following equation: $RT = (SUM_{objectRTs} + SUM_{actionRTs}) / [(\#correct_{objects} - \#trimmed_{objects}) + (\#correct_{actions} - \#trimmed_{actions})]$.

Sentence repetition.

Twenty sentences in each language were used to measure participants' ability to repeat increasingly difficult grammatical structures within complete sentences. The English task consisted of the first 20 items from the Sentence Recall subtest of the Clinical Evaluation of Language Fundamentals, 4th edition (CELF-4: Semel, Wiig, & Secord, 2003). Vietnamese items were not direct translations but rather created to be consistent with Vietnamese grammar yet also match the English sentences by grammatical complexity (i.e., underlying grammatical structure) and sentence length measured in number of syllables. Appendix E shows the Vietnamese sentence repetition items. Children completed two practice items before beginning the task. During the task, the examiner read each sentence aloud, and the child was instructed to repeat the sentence as close to the adult target as possible. Examiner repetition of sentence trials was not allowed. Consistent with the scoring procedure in the CELF-4 (Semel et al., 2003), sentences with no errors received a score of 3, one error received a score of 2, two to three errors received a score of 1, and four or more errors received a score of 0. The dependent measure was percent correct (out of 60 points).

Story tell.

This task consisted of eliciting a spontaneous narrative of a fictional story with the aid of pictures. Stimuli consisted of two wordless pictures books, one for each language: *One Frog Too Many* (Mayer & Mayer, 1975) for English and *A Boy, a Dog, and a Frog* (Mayer, 1967) for Vietnamese. Stimulus books were of comparable length and complexity and contained an organized story with multiple embedded episodes. Consistent with previous cross-linguistic story tell procedures (Berman & Slobin, 1994), children were told to look through every page of the picture book and then to tell the story to the examiner while turning the pages at their own pace.

Stories were digitally audio-recorded and transcribed by native speakers of English and Vietnamese. Transcribers segmented language samples into communication units (c-units: Loban, 1963) and then coded to exclude incomplete or unintelligible utterances and word or phrase repetitions following CHAT conventions from the *Child Language Data Exchange System* (CHILDES; MacWhinney, 2000). (See previous discussion of cross-linguistic differences in c-unit designations in the section on Linguistic Characteristics of Vietnamese: Discourse).

Language samples were analyzed at grammatal and discourse subsystems. At the grammatical subsystem, the mean length of c-units (MLU) in words for English and MLU in syllables for Vietnamese was calculated as a gross measure of syntactical productivity using the mlt +t*CHI command in CLAN (see section on Linguistic Characteristics of Vietnamese for discussion of Vietnamese words vs. syllables). At the discourse subsystem, story quality was scored using a revised version of the procedure developed by Pham and colleagues (2009). Scoring was based on four narrative features: story elements, sequencing, perspective/affect, and coherence. As shown in Appendix F, each of these features was scored using specific quantifiable criteria on a scale of 0 to 5 for a total of 20 maximum points. This measure was applied to a preliminary sample of Vietnamese-English bilingual children (Pham et al., 2009) and appeared to be highly sensitive to age effects, reliable across multiple raters, and easy to quantify in both languages. The revised version (see Appendix F) increased the level of difficulty that corresponded to allotted points to avoid potential ceiling effects for older children. For example, the original version (Pham et al., 2009) gave a score of 5 for five or more complete story episodes, while the revised version gave a score of 3 for five complete story episodes and a score of 5 for seven or more complete story episodes.

Two independent raters reviewed all language samples for accuracy and correspondence with audio recordings. Point-by-point reliability was conducted for c-units and story quality scores for 20% of the language samples by an independent and trained second rater, one for each language. For Vietnamese language samples, average inter-rater reliability was 93.4% (SD = 6, range of 81- 100) for c-units and 90.6% (SD = 7, range of 68 - 100) for story quality scoring. For English language samples, inter-rater reliability was 95.9% (SD = 4, range of 88 - 100) for c-units and 91.7% (SD = 6, range of 73 - 100) for story quality. The following section describes statistical procedures to analyze longitudinal data.

CHAPTER 7 STATISTICAL ANALYSIS

This study used multilevel modeling (Goldstein, 2003; Singer & Willett, 2003) also known as hierarchical linear modeling (HLM: Raudenbush & Bryk, 2002) to examine L1 and L2 developmental trajectories and relationships within and across languages. Multilevel modeling has many advantages over traditional approaches for longitudinal analysis such as repeated measures ANOVA or MANOVA. First, rather than comparing means of observed values at each time point, HLM examines initial status (i.e., intercept) and rate of change (i.e., slope) to model growth trajectories that have occurred as well as to extrapolate future change (Singer & Willett, 2003). Second, participants with missing data can still be included (Singer & Willett, 2003). Including participants with missing data is a critical advantage as attrition is a common occurrence in longitudinal studies (Flick, 1988). The ability to include all participants with or without missing data minimizes threats of sampling bias. Third, multilevel models partition between-subjects and within-subject variability (Singer & Willett, 2003). Between-subjects variability due to individual differences is estimated by fixed effects for the intercept and the slope. Within-subject variability due to change over time is estimated using random effects for individual-level intercept and slope. Accounting for between-subjects and within-subject variability allows HLM to account for nested data such as two languages nested within individual children. The fourth advantage of multilevel modeling is the ability to include static and dynamic predictors in the model. Static predictors are variables that are thought to be consistent over time (e.g., gender, intelligence) and are included in the model to account for variability across subjects. Dynamic predictors, also called time-varying predictors (Singer &

Willett, 2003), can change in value and are measured repeatedly at the same time as the response variable to account for individual variation over time. Dynamic predictors can be time variables (e.g., year, grade level) or can be a separate variable whose value changes alongside changes in the response variable (Long, in press). For instance, this study examines whether a child's L1 is a dynamic predictor of the L2.

All HLM analyses were conducted in this study using the lmer() function in the lme4 package (Bates, 2005) of the R software program (R Development Core Team, 2009).

Data analysis consisted of building univariate and multivariate HLMs to address research questions related to shape, rate, and nature of change in the L1 and L2. Univariate models were used to designate the shape of change, namely whether growth was linear or nonlinear. Multivariate models were used to examine growth of multiple language subsystems nested within each language and growth of the L1 and L2 nested within individual children. The following is an example of a univariate HLM with linear change and one time variable:

Level 1: $Y_{ij} = \pi_{0i} + \pi_{1i}TIME_{ij} + \varepsilon_{ij}$

Level 2: $\pi_{0i} = \gamma_{00} + \zeta_{0i}$

$\pi_{1i} = \gamma_{10} + \zeta_{1i}$

Level 1 specifies individual-level trajectories in which Y_{ij} is the response for the *ith* subject at the *jth* time point, π_{0i} and π_{1i} are the respective individual-level intercept and slope for the *ith* subject, $TIME_{ij}$ is the time variable for the *ith* subject at *jth* time point, and ε_{ij} is individual-level error. Level 2 specifies group-level trajectories and is comprised of two models for the intercept and slope, respectively. The individual-level intercept, π_{0i}, is the sum of the group-level intercept, γ_{00}, and individual deviation from the group-level intercept, ζ_{0i}. Similarly the individual-level slope, π_{1i}, is the sum of the group-level slope, γ_{10}, and individual deviation from the group-level slope, ζ_{1i}. Levels 1 and 2 can be combined in a composite equation: $Y_{ij} = \gamma_{00} + \gamma_{10}(TIME_{ij}) + (\zeta_{0i} + \zeta_{1i} TIME_{ij} + \varepsilon_{ij})$, in which the fixed effects (γ_{00}, γ_{10}) are separated from the random effects (ζ_{0i}, ζ_{1i}), and error is parsed into three parts: individual variation of the intercept and slope (i.e., random effects) and random error (ε_{ij}). In this study, chronological age was designated as the time variable given that participants began the study at different ages in an accelerated cohort design. Examining change by age (vs. grade level or wave of data collection) was thought to be the most meaningful and provided the opportunity to model individual trajectories for each participant as well as group-level trajectories. Age was centered on the youngest age at Wave 1 so that the intercept (Time = 0) would represent initial language performance for all children at age 5.67.

Predictors are added to the basic model at different levels. Dynamic predictors and time variables are added to Level 1, and static predictors are added to the Level 2. The following is an example of a multilevel model presented in a hierarchical form with one time variable (TIME) and an additional dynamic predictor (DYNAMIC):

Level 1: $Y_{ij} = \pi_{0i} + \pi_{1i}TIME_{ij} + \pi_{2i}DYNAMIC_{ij} + \varepsilon_{ij}$

Level 2: $\pi_{0i} = \gamma_{00} + \zeta_{0i}$

$\pi_{1i} = \gamma_{10}$

$\pi_{2i} = \gamma_{20}$

The above example consists of one random effect, namely a random intercept (ζ_{0i}). This model can consist of up to three random effects to account for individual variation in intercept, time, and the dynamic predictor. However, issues with boundary constraints (e.g., correlations corresponding to the covariances of random effects at the boundary limits, r = -1) or difficulties with model convergence can arise when there are more random effects than are needed in the model (Long, in press; Singer & Willett, 2003). The above model can be written in its composite form, $Y_{ij} = \gamma_{00} + \gamma_{10}\, TIME_{ij} + \gamma_{20} DYNAMIC_{ij} + (\zeta_{0i} + \varepsilon_{ij})$, with fixed effects ($\gamma_{00}, \gamma_{10}, \gamma_{20}$) separate from the random effect (ζ_{0i}).

The multivariate model is the extension of the univariate model (Long, in press; MacCallum, Malarkey, & Kiecolt-Glaser, 1997). Logistically, the data are treated as if one single response variable is measured. Data are stacked so that responses of separate dependent measures are arranged in one single column. In the following hypothetical example, Vietnamese and English responses for one task (e.g., percent correct for timed picture naming) for Participant 1 are stacked in one column and are presented with the time variable, age centered at 5.67. The four estimates to be extracted are the fixed intercept for Vietnamese (V.intercept), fixed intercept for English (E.intercept), fixed slope for Vietnamese (V.slope), and fixed slope for English (E.intercept):

ID	Age - 5.67	Response	V.intercept	E.intercept	V.slope	E.slope
1	0.54	56	1	0	0.54	0
1	1.54	65	1	0	1.54	0
1	2.54	76	1	0	2.54	0
1	0.54	70	0	1	0	0.54
1	1.54	75	0	1	0	1.54
1	2.54	80	0	1	0	2.54

The four estimates are coded as dummy variables in which V.intercept = 1 while E. intercept = 0 for Vietnamese responses and vice versa. Consistent with this example, dummy variables, δ_k, are assigned to each dependent measure (δ_1, δ_2 …) where $\delta_k = 1$ if a given measure is on Y_k and $\delta_k = 0$ otherwise, that is when *k* does not equal the target dependent measure, *k**. The following is an example of a multivariate model for linear change (MacCallum et al., 1997):

Level 1: $Y_{ijk*} = \sum_k \delta_k \left(\pi_{0ik} + \pi_{1ik} Time_{ijk} + \varepsilon_{ijk} \right)$

Level 2: $\pi_{0ik} = \gamma_{00k} + \zeta_{0ik}$

$\pi_{1i} = \gamma_{10k} + \zeta_{1ik}$

In Level 1, Y_{ijk*} is the response of the *ith* subject at the *jth* time for the *k** dependent measure. To the right of the equation is the univariate model for the *k** response as $\delta_{k*} = 1$. In Level 2, the fixed effects for intercept and slope are modeled on the dependent measure *k*. Levels can be combined in the following composite equation (MacCallum et al., 1997):

$$Y_{ijk*} = \sum_k \delta_k \left(\gamma_{00k} + \gamma_{10k} Time_{ijk} + \zeta_{0ik} + \zeta_{1ik} Time_{ijk} + \varepsilon_{ijk} \right)$$
$$= \sum_k \left(\gamma_{00k}\delta_k + \gamma_{10k}\delta_k Time_{ijk} + \delta_k \zeta_{0ik} + \zeta_{1ik}\delta_k Time_{ijk} + \delta_k \varepsilon_{ijk} \right)$$

In the previous example, the four estimates are put into this model with the expected value of Y_{ij} equal to γ_{00k}(V.intercept) + γ_{10k}(V.slope) if the response is Vietnamese percent correct and γ_{00k}(E.intercept) + γ_{10k}(E.slope) if the response is English percent correct (Long, in press). An example of a multivariate model with random intercepts using R code is:

```
lmer( response ~ 0 + V.intercept + E.intercept + V.slope + E.slope + (0 +
V.intercept + E.intercept|ID), data = stackdata, REML = False)
```

Estimation yields four fixed effects (V.intercept, E.intercept, V.slope, E.slope) and two random effects (V.intercept, E.intercept) nested within participant (ID) using the stacked dataset and maximum likelihood estimation (REML = False). Logistically fixed and random intercepts are set to 0 in the R code to prohibit a general intercept (in addition to V.intercept and E.intercept) from being included in the model. The following is a description of the steps taken to build HLMs for this study.

Model Building Step 1: Deciding on the Shape of Change

The shape of change was designated for each dependent measure based on a comparison of models that transformed the time variable. Seven first-order fractional polynomial transformations of the time variable, age centered on 5.67, were included in the taxonomy, namely inverse square (exponent of -2), inverse (-1), inverse square root (-0.5), logarithm (0), square root (0.5), linear (1), and square (2). These transformations are shown in Appendix G. Fractional polynomials are recommended over conventional polynomial transformations (e.g., quadratic, cubic) for samples with relatively few waves of data collection to maximize efficiency and minimize the number of parameters required to model nonlinear change (Long & Ryoo, 2010). As outlined in Long and Ryoo (2010), model comparisons were made using fit indices, both nonpenalized (-2LL, R^2) and penalized (AIC, BIC, and adjusted R^2) to narrow down the number of potentially good-fitting models (see bolded models in Appendix H). Graphical comparisons consisted of scatterplots with superimposed regression lines and smooth LOESS curves to see whether the smoothed curve and regression lines greatly overlapped, an indicator that the linear model may be the best fit for the data. Additionally, designation of the shape of change was based on two explicit biases towards (1) linearity for parsimony if linear and nonlinear models had similar fit, and (2) fitting the same models for both languages for convenience in fitting later multivariate HLMs.

Model Building Step 2: Adding Random Effects

Univariate models with the designated time transformations were combined into multivariate HLMs to model three types of nested data: (a) development of lexical, grammatical, and discourse subsystems nested within each language (e.g., timed picture naming accuracy, sentence repetition, and story quality score in Vietnamese), (b) performance on the same task across languages nested within individual children (e.g., sentence repetition in Vietnamese and English), and (c) performance across languages and across language subsystems (e.g., timed picture naming accuracy in Vietnamese and sentence repetition in English.).

First, random effects were added to the multivariate HLMs in a step-up fashion. The inclusion of random intercepts (e.g., V.intercept and E.intercept) was based on inferential testing of whether the variance was significantly greater than zero (H_0: $Var(\zeta_{0i}) = 0$) using fast bootstrapping (Crainiceaunu & Ruppert, 2004) in the RLRsim package in R (Scheipl, Greven, & Kuchenhoff, 2008). Inferential testing for random slopes included analytical likelihood ratio tests (LRT) and AIC weights of evidence to compare the reduced model (random intercept only) and full model (random intercept and slope) as outlined in Long (in press). Nonsignificant random intercepts were included in the final model if the corresponding random slopes were significant as lower-order effects are needed when high-order effects are significant (Long, in press).

Test of Equality of Slopes and of Intercepts

With significant random effects included in the multivariate model, fixed slopes (e.g., V.slope and E.slope) were tested for equality as outlined in Long (in press). Namely, full models (two fixed intercepts and two fixed slopes) were compared to reduced models (two fixed intercepts and one slope) using LRTs and AIC weights of evidence. Similarly, fixed intercepts were tested for equality by comparing full (two fixed intercepts, two fixed slopes) and reduced models (one intercept, two slopes). Examination of the fixed effects of multivariate HLMs as well as testing for equality of fixed slopes and of fixed intercepts addressed the first set of research questions about L1 and L2 trajectories. Specifically, does L1 or L2 increase, decrease, or stay the same over time? Is the initial state the same in Vietnamese and English? Is the rate of change the same in both languages? Is the rate of change the same across subsystems within each language?

Associations Within and Between Languages

The second set of research questions on L1- L2 interdependence was addressed in two separate analyses. First, partial correlations controlling for chronological age were examined at each wave to investigate the nature and magnitude of cross-sectional associations within each language across language subsystems and between Vietnamese and English. Consistent with a Dynamic Systems framework that posits multiple interactions across subsystems, cross-linguistic relationships were examined between the same language subsystem/measure (e.g., Vietnamese and English timed picture naming accuracy) as well as across language subsystems (e.g., Vietnamese picture naming accuracy and English sentence repetition).

Second, longitudinal associations between Vietnamese and English were examined using univariate random-intercept HLMs that consisted of one language as the response variable and the other language as one of the time-varying or dynamic predictors. For each measure, three models were compared using AIC weights of evidence: (a) age as the only dynamic predictor, (b) age and Vietnamese as two dynamic predictors (i.e., main effects model) and (c) age, Vietnamese and their interaction (i.e., interaction model). Age-only models would indicate no cross-linguistic transfer. Main effects models would demonstrate the presence of cross-linguistic transfer, namely the influence of one language on the other beyond the variation accounted for by chronological age. Interaction models would indicate a change in the nature of the cross-linguistic relationship over time. HLMs were conducted at each language subsystem as well as across subsystems. At the same language subsystem, an English measure was the response variable and the corresponding Vietnamese measure was the dynamic predictor. Across subsystems, a presumably higher subsystem in one language (e.g., grammar) was the response variable and a more basic subsystem in the other language (e.g., lexicon) was the dynamic predictor with age as well as the basic subsystem in the target language as covariates. Cross-sectional and longitudinal correlations addressed the second set of research questions: Is L1 performance related to performance in the L2? Are L1-L2 relationships positive or negative? Does the nature of L1-L2 relationships change over time? Are L1-L2 relationships bidirectional or unidirectional?

Statistical Assumptions

Prior to conducting the main analysis, I evaluated whether statistical assumptions for HLM were satisfactorily met. There are three main assumptions for HLM: linearity of function form, normality, and homoscedasticity (Singer & Willett, 2003). Function form of individual change trajectories was examined visually using individual growth plots for each dependent measure (Appendix I). Although some growth plots fit the assumption of linearity closer than others, none appeared to be grossly nonlinear. Normality was assessed using two normal probability plots (i.e., Q-Q plots) of observed vs. estimated residual error for random intercepts and slopes. Plots suggested a straight diagonal line for each dependent measure indicating that the data approximated a normal distribution. Homoscedasticity was visually evaluated using a scatterplot of level 1 raw residual error vs. the level 1 predictor, age centered on 5.67. Resulting figures suggested consistent variance as reflected in a horizontal envelope that encompassed most data within two standard deviations above and below the mean.

Test of Attrition

As previously reported (see Participants section), the overall attrition rate for this four-year longitudinal study was 62% with 13 of the original 34 participants completing Wave 4 of data collection. A high rate of attrition is common with longitudinal data (Flick, 1988). For example, Kohnert (2002) examined lexical processing of Spanish-English bilingual children and had a 47% attrition rate within one year of the original data collection. Nonetheless, it was important to examine how the attrition rate may have affected the results of this study.

In order to examine whether there were initial differences between the 13 participants who completed Wave 4 and the 21 participants with fewer data points, I conducted two-tailed t-tests for two independent samples on the independent variables (e.g., gender) and the 14 outcome measures (seven in each language) at Wave 1. Based on test results, there were no group differences for independent variables of gender ($p = 0.23$), birthplace ($p = 0.65$), TONI-3 ($p = 0.42$), age at Wave 1 ($p = 0.67$), age of US arrival ($p = 0.63$), and participants who received reduced lunch ($p = 0.61$). There were no group differences on any of the English outcome measures: picture word verification accuracy ($p = 0.11$), picture word verification RT ($p = 0.60$), timed picture naming accuracy ($p = 0.52$), timed picture naming RT ($p = 0.39$), sentence repetition ($p = 0.94$), MLU ($p = 0.90$), and story quality ($p = 0.86$). There were no group differences on 6 of 7 Vietnamese outcome measures: picture word verification accuracy ($p = 0.34$), picture word verification RT ($p = 0.40$), timed picture naming accuracy ($p = 0.29$), timed picture naming RT ($p = 0.32$), sentence repetition ($p = 0.24$), and MLU ($p = 0.06$). There was a group difference for Vietnamese story quality ($p = 0.02$). The 13 participants who completed Wave 4 performed higher (mean = 69%, SD = 20%) than the 21 participants with fewer time points (mean = 52%, SE = 18%). Initial group differences in Vietnamese story quality may affect the results for this measure. Limitations on the interpretation of the results of this measure are addressed in the Results section.

CHAPTER 8 RESULTS

Table 3 displays descriptive statistics by wave of data collection. Overall percent correct measures increased over waves and RT measures decreased, reflecting improved performance. There was a ceiling effect for picture word verification accuracy. At Wave 1, children performed on average at 93% correct in Vietnamese and 91% in English. Although there was greater variation in English at Wave 1 (range 63 - 100%), performance rapidly increased to nearly 100% correct in both languages over time. Therefore, the analysis will focus more on the RT measure of picture word verification than accuracy.

Appendix J displays bivariate and partial correlations of potential predictors and dependent measures at each wave of data collection. Bivariate correlations indicated that chronological age was a strong predictor of most language measures in both Vietnamese and English across waves. In contrast, there were few to no significant correlations between language measures and gender (Female), birthplace (US born), nonverbal intelligence (TONI), reduced lunch status (ReLnch), or age of US arrival (Age to US). These predictors were not consistently related to the language measures across waves and therefore not included in further analysis. Chronological age was the main predictor for univariate and multivariate models in this study.

Shape of Change

Appendix G displays the taxonomy of seven first-order fractional polynomial time transformations that were modeled for each dependent measure to examine whether the rate of change was linear or nonlinear. The number of models was narrowed down from seven to three or four (see bolded models in Appendix H) based on relatively smaller values of fit indices (AIC, BIC, -2LL) and larger effect sizes (R^2 and adjusted R^2). Based on these criteria, the linear model was highlighted as a candidate for all dependent measures along with nonlinear models such as logarithmic and inverse square transformations. Graphic comparisons for each dependent measure with superimposed regression and smoothed curves showed that the nonlinear curve did not appear to greatly differ from the linear curve. Therefore, all dependent measures were modeled using a linear rate of change.

Developmental Trajectories in Vietnamese and English

Table 4 displays estimates of the fixed intercepts and slopes of multivariate models. Comparisons within each language between the rates of change across lexical, grammatical, and discourse subsystems showed absolute growth in the L1 and L2. Figures 2 and 3 display Vietnamese and English development across language subsystems, respectively. For Vietnamese, the direction of change for all language subsystems was positive. Rates of change for lexical and grammatical subsystems were equal (4% increase/year), while the discourse subsystem increased at a rate of 2.5% per year. For English, the direction of change was also positive at all language subsystems, and the rates of change differed across lexical (8% increase/year), grammatical (10% increase/year), and discourse subsystems (6% increase/year).

Comparisons between languages showed four general patterns for relative growth of the L1 and L2 based on participants' initial performance (i.e., fixed intercept) and rates of change (i.e., fixed slopes) in both languages: (a) greater initial performance in Vietnamese but a faster rate of change in English, (b) greater initial performance in English with equal rates of change in both languages, (c) equal initial performance and rates of change in Vietnamese and English, and (d) equal initial performance and a faster rate of change in English. At the lexical subsystem, different patterns appeared for receptive and expressive tasks. Accuracy and RT measures of picture word verification showed relatively balanced performance across languages. As shown in Figures 4 and 5, children initially performed the same in the L1 and L2 in accuracy (~90%) and RT (~1650 ms) with comparable reductions in RT over time (~165 ms decrease in RT/year). In contrast, timed picture naming accuracy showed that participants initially named more objects and actions in Vietnamese (65%) than in English (54%) but improved in picture naming at double the rate in English as in Vietnamese over time (8% vs. 4% increase/year; see Figure 6). As shown in Figure 7, participants' initial performance in RT was already faster in English (1240 ms) than in Vietnamese (1471 ms), and this advantage in English was maintained over time with equal rates of change across languages.

Results for sentence production tasks mirrored those found for picture naming. As shown in Figure 8, participants initially performed higher on sentence repetition in Vietnamese (30%) than in English (23%), but the rate of change was more than twice as fast in English as in Vietnamese (11% vs. 5% increase/year). As shown in Figure 9, MLU was initially greater in English (6.5) than in Vietnamese (6.0), with this English advantage maintained over time as rates of change were comparable in both languages.

In contrast to lexical and grammatical expressive measures, participants demonstrated balanced performance in the L1 and L2 at the discourse subsystem. As shown in Figure 10, children's initial performance (49%) and rate of change (~ 5%/year) were statistically the same for Vietnamese and English story quality measures.

However, as previously reported (see Statistical Analysis section), participants who completed all four waves of data on average showed greater performance on Vietnamese story quality at Wave 1 than participants with fewer data points. Therefore the developmental trajectory for Vietnamese discourse may be biased towards higher performance. It is possible that English story quality may have shown a greater developmental trajectory had all participants completed four waves of data collection.

Overall, findings from multiple measures across language subsystems and languages provided a comprehensive picture of developmental trajectories during the early school-age years. Results clearly showed positive growth in both languages with no absolute regression or loss of L1 skills. Receptive measures, at least for the lexical subsystem (picture word verification RT), showed relatively balanced performance in Vietnamese and English. Expressive measures at lexical and grammatical subsystems showed relatively greater gains in English. At the discourse subsystem, developmental trajectories were comparable for both languages. Balanced performance at the discourse subsystem may show a high degree of transfer of meta-linguistic or academic skills in how to use language for the communicative purpose of telling stories.

Associations Within Each Language and Between Languages: Cross-Sectional Analysis

Associations between tasks within each language as well as between the L1 and L2 were first examined using partial correlations controlling for chronological age (see Appendix J, bottom diagonal). For Vietnamese, there were moderate to strong positive links between lexical, grammatical, and discourse subsystems at each wave. The lexical subsystem was related to the grammatical subsystem (e.g., picture naming accuracy and sentence repetition) with partial correlations ranging from $r = .41$ to $.54$ at each wave;

the grammatical subsystem was related to the discourse subsystem (e.g., MLU and story quality) with partial correlations ranging from r = .44 to .53. For English, there were moderate to strong positive links between lexical and grammatical subsystems at each wave (e.g., picture naming accuracy and sentence repetition, r = .50 to .74). The relationship between grammatical and discourse subsystems (e.g., MLU and story quality) decreased with wave; there were moderate to strong partial correlations at Waves 1 and 2 (r = .47 to .73) but small and nonsignificant associations at Waves 3 and 4 (r = -.14 to .15).

Across languages, there were positive partial correlations between Vietnamese and English on the same language subsystem/measure including picture word verification RT at each wave (r = .50 to .63); timed picture naming RT at Waves 2, 3, and 4 (r = .57 to .82); MLU at Waves 2, 3, and 4 (r = .53 to .72); and story quality at each wave (r = .34 to .57). Moderate to strong positive relationships between languages indicated a high degree of L1 and L2 interdependence even after controlling for age effects.

The direction of cross-linguistic transfer (L1 to L2; L2 to L1) was examined using partial correlations. Specifically, I investigated the potential relationship between performance at a lower subsystem in one language and a presumably higher subsystem in the other language. Although most partial correlations were not statistically significant due to the relatively small sample size at each wave, correlations were interpreted in terms of their magnitude. According to Cohen (1992), correlations of r = .10 to .29 were considered small or weak, r = .30 to .49 were considered medium or moderate, and r = .50 or greater were considered large or strong.

At Waves 1 and 2, lower subsystems of Vietnamese related to higher subsystems of English. Between lexical and grammatical subsystems, the influence of Vietnamese on English appeared both positive and negative. That is, at Wave 1, Vietnamese picture naming accuracy was negatively related to English sentence repetition ($r = -.31$), while at Wave 2, Vietnamese picture naming accuracy was positively related to English MLU ($r = .36$). Between grammatical and discourse subsystems, the influence of Vietnamese on English was positive (e.g., Vietnamese MLU and English story quality at Waves 1 and 2, $r = .33$ to .37). Partial correlations between lower subsystems of English and higher subsystems of Vietnamese were small and inconsistent.

At Waves 3 and 4, partial correlations between lower subsystems of Vietnamese and higher subsystems of English were near zero. Instead, there were small to large positive correlations between lower subsystems of English and higher subsystems of Vietnamese. Specifically, between lexical and grammatical subsystems, English picture naming accuracy was related to Vietnamese MLU at Wave 3 ($r = .21$) and English picture naming accuracy was related to Vietnamese sentence repetition at Wave 4 ($r = .51$). Between grammatical and discourse subsystems, English MLU was strongly related to Vietnamese story quality at Wave 3 ($r = .61$), and English sentence repetition was strongly related to Vietnamese story quality at Wave 4 ($r = .73$). In sum, relationships between lower subsystems in one language and higher subsystems in the other language suggested bidirectional transfer that was initially from Vietnamese to English at Waves 1 and 2 and that changed in direction from English to Vietnamese at Waves 3 and 4.

Associations Within Each Language and Between Languages: Longitudinal Analysis

Cross-linguistic associations were further examined longitudinally using HLMs that included one language as a dynamic predictor of the other. Table 5 displays the fixed effects of HLMs in which Vietnamese is a dynamic predictor of English at the same language subsystem and measure. As shown in Table 5, the main effects model or interaction model were selected as the best fit for five of six measures, demonstrating the presence of cross-linguistic associations at lexical, grammatical, and discourse subsystems. Of the five measures, two were best fit with main effects models (picture word verification RT, MLU), and three with interaction models (picture naming ACC, picture naming RT, story quality). For main effects models, adding Vietnamese as a dynamic predictor accounted for a substantial portion of unique variance (ΔR^2 ranging from 0.16 to 0.23) in addition to the variance accounted for by chronological age. For interaction models, the age * Vietnamese interaction accounted for a small but significant proportion of unique variance ($\Delta R^2 = 0.01$ to 0.05) in addition to the variance accounted for by the main effects of Vietnamese and age.

Interactions underscored potential changes in the nature of cross-linguistic relationships over time. Figures 11, 12, and 13 display the three significant interaction models: timed picture naming accuracy, RT, and story quality, respectively. For the two accuracy measures (timed picture naming accuracy and story quality), the relationship between Vietnamese and English appeared to attenuate with age. As shown in Figures 11 and 13, cross-language associations were stronger for younger ages than for older ages as demonstrated by steeper slopes at younger ages. These interactions suggest stronger influences of one language on the other at younger ages and earlier stages of L2 learning. As the L1 and L2 develop with age, other factors may become more influential in their development than the relationship between the two languages. In contrast to the accuracy measures, Figure 12 shows a relatively level slope at younger ages and steeper slopes at older ages for the RT measure (picture naming RT). At first glance, this interaction appears to show a stronger cross-language relationship with age. However, recall that L1 and L2 developmental trajectories for picture naming RT showed the same rate of change for Vietnamese and English. Also, the interaction model for the accuracy measure on the picture naming task suggested an attenuating relationship between the L1 and L2. Combined findings suggest that age/developmental effects may have driven this interaction. That is, older children may have been faster in both languages primarily due to their advanced developmental stage rather than a strong influence of one language on the other.

Directionality of cross-language relationships was further examined by determining whether a lower subsystem of one language was longitudinally associated with a higher subsystem in the other language after controlling for the effects of both age and performance at the lower subsystem in the other language. Table 6 displays fixed effects of four models of forward transfer, operationally defined as the influence of a lower subsystem of Vietnamese (e.g., lexicon) on a higher subsystem of English (e.g., grammar), and four parallel models of backward transfer, defined as the influence of a lower subsystem of English on a higher subsystem of Vietnamese. For forward transfer, one of the four models showed that a measure at the lexical subsystem in Vietnamese (i.e., naming accuracy) accounted for 3% of unique variance in the grammatical subsystem of English (i.e., MLU) beyond what was accounted for by age and the English lexical subsystem. For backward transfer, a measure of the grammatical subsystem of English (i.e., MLU) accounted for 1% additional variance in the discourse subsystem of Vietnamese (i.e., story quality) after controlling for age and the Vietnamese grammatical subsystem. Models of forward and backward transfer suggest that Vietnamese may influence English at lower subsystems (relationships between lexicon and grammar), while English may influence Vietnamese at higher subsystems (relationships between grammar and discourse). Collective results of cross-sectional and longitudinal analyses suggested the occurrence of bidirectional transfer across time points as well as across language subsystems.

CHAPTER 9 DISCUSSION

The purpose of this study was to investigate first and second language (L1 and L2) development in school-age children learning Vietnamese and English. Multiple outcome measures were collected in Vietnamese (L1) and English (L2) in four waves, timed at one-year intervals. A series of analysis was conducted to investigate direction and rate of change in each language as well as relationships across language subsystems, within and between languages. First, L1 and L2 trajectories were mathematically modeled to account for absolute and relative change over time, nested within individual children. Second, cross-linguistic transfer, or the influence of one language on the other, was examined at "deep" (i.e., nonstructural) levels in order to identify cross-linguistic associations and to determine the nature (i.e., supportive, competitive) and direction (unidirectional vs. bidirectional) of these relationships. The following discussion highlights main findings from this study that inform a broader discussion of dual-language learning.

Developmental Trajectories

This longitudinal study showed positive growth in each of the two languages of school-age bilingual children. All seven outcome measures at lexical, grammatical, and discourse subsystems showed increases in Vietnamese (L1) and English (L2) over time. This basic finding is consistent with results of previous cross-sectional studies with early sequential bilingual school-age children in the U.S. context (e.g., Cobo-Lewis et al., 2002; Kohnert et al., 1999; Kohnert & Bates, 2002; Jia et al., 2006) and extends findings to a new language pair, Vietnamese and English, and the use of longitudinal design. This study found rapid increases in the L2 that led to a shift in relative dominance from the L1 to the L2 during middle childhood. For expressive measures at lexical and grammatical subsystems, English (L2) rapidly increased and in most cases surpassed L1 outcomes with rates of change that were 1.5 to 2 times faster in the L2 than in the L1. These shifts towards relative English dominance were observed earlier using measures of response time versus accuracy. For example, average performance on timed picture naming accuracy was initially higher in Vietnamese, while the corresponding RT measure indicated faster lexical generation in English.

Findings at the lexical subsystem replicated and extended findings from previous studies on receptive and expressive lexical processing among school-age bilingual children (Kohnert et al., 1999; Kohnert & Bates, 2002; Jia et al., 2006). This study used a similar set of timed picture naming and picture word verification tasks as in the blocked condition of studies by Kohnert and colleagues (1999, 2002, 2006) and focused on school-age children who learned the L1 at home from birth and the L2, the language of the larger society, early in childhood. This study extended this line of investigation with a different design (longitudinal vs. cross-sectional), language pair (Vietnamese-English vs. Spanish-English) and geographical area (Florida vs. California). Consistent with previous studies, main findings included uneven performance across expressive and receptive domains and across accuracy and response time measures that demonstrated fluctuations in the “dominant language” as a function of time and task. Consistency across separate samples, places, tasks, and designs provide robust empirical evidence for this shift in relative strength from the L1 and L2 as well as the complexity of defining “language dominance” for minority language children.

Findings emphasize that minority language children can and do develop their home language and the language of the larger community. Study results, using multiple measures and a longitudinal design provide robust evidence that minority L1 learners in the US learn English, the language of the broader community. At the same time, these results underscore the notion that language learning need not be a "zero sum" endeavor. Specifically, there was no evidence that gains in one language come at the expense of skill in the other. This may be in part because current study participants continued to use Vietnamese at home as well as receive 90 minutes of instruction in Vietnamese during the school day. Nonetheless, current findings demonstrate the capacity for bilingualism among school-age learners.

Cross-Linguistic Transfer

The first important finding related to cross-linguistic transfer was the occurrence of multiple associations between the L1 and L2. Correlational analysis revealed moderate to strong, positive cross-language associations at each wave, indicating supportive relationships between the L1 and L2. Longitudinal analysis emphasized the magnitude of cross-linguistic transfer and showed that one language accounted for 16 to 23% of unique variance in the other language, beyond what was accounted for by age alone. Collective findings show a high degree of L1-L2 interdependence, in which development in one language may facilitate development in the other. Within a Dynamic Systems (DS) framework, bilingual children's overall language system arises from these multiple and mutually supportive interactions between the L1 and L2, their language subsystems, and over time.

Traditionally, cross-language transfer has been described at the structural level for languages with overlapping speech-sound, word, or grammatical forms (Odlin, 1989). Given that Vietnamese and English are highly distinctive languages with limited to no structural overlap, the presence of longitudinal L1-L2 associations among individual children begs the question of what exactly is "transferring", that is, *how* is one language influencing the other? If not at the structural level, L1-L2 associations found in this study underscore the role of individual differences such as language-learning aptitude or motivation (Castilla et al., 2009) as well as common underlying cognitive processes such as speed of processing, attention, and perception (Kohnert, 2010), which may indeed be subcomponents in the more global term "language aptitude".

Further investigation is needed to examine cognitive and social factors that mediate cross-language associations and contribute to the language-learning process. For example, cross-sectional studies have found that maintenance of a minority L1 promotes a strong sense of ethnic identity among immigrant youth (Phinney et al, 2001), and a strong ethnic identity has been associated with increased self esteem (Pham & Harris, 2001) and academic achievement (Bankston & Zhou, 1995). Further investigation on potentially reciprocal relationships between ethnic identity and L1 and L2 development can contribute to a broader understanding of social and motivational factors underlying dual-language learning. To illustrate, a working hypothesis could be that if high L1 proficiency increases one's ethnic identity (Phinney et al, 2001), a strong sense of ethnic identity may in turn motivate children and adolescents to continue to develop their minority L1, and greater L1 proficiency may lead to stronger L1-L2 associations and contribute to gains in both languages.

A second important finding was that cross-linguistic transfer was bidirectional. Partial correlations (controlling for age) between a lower subsystem of one language and a higher subsystem of the other language revealed transfer from the L1 to the L2 at the first two waves and a change in direction from the L2 to the L1 at the final two waves. Changes in direction of cross-linguistic transfer may be a function of changes in relative proficiency. Developmental trajectories showed a shift towards relative dominance in English over time (see previous section). Relatively stronger performance in the L2 may have contributed to a greater influence of the L2 on the L1 at later waves. Longitudinal analysis showed bidirectional transfer from the L1 to the L2 at lexical and grammatical subsystems and from the L2 to the L1 at grammatical and discourse subsystems. The occurrence of both forward and backward transfer (L1 to L2 and L2 to L1, respectively) is consistent with findings from adult L2 learners with varying levels of L2 proficiency (Su, 2001) as well as studies with developing bilingual children who use a combination of linguistic cues from both of their languages to interpret meaning (Pham & Kohnert, 2010). Within a DS framework, bidirectional cross-linguistic transfer highlights flexibility in the developing language system that allows for multiple interactions to occur between languages and language subsystems. Additional qualitative analysis may complement these quantitative findings on bidirectional transfer. For example, examining the number, type, and direction of errors in children's narratives in the L1 and L2 at multiple time points can capture meaningful illustrations of transfer between the two languages, namely, how the influence of one language on the other manifests within developing lexical and grammatical subsystems. Qualitative analysis of longitudinal narrative data can also contribute to a clearer definition of cross-linguistic transfer by distinguishing it from developmental errors.

A third important finding is that the nature of L1 and L2 relationships may change over time. For example, Vietnamese MLU was positively associated with linear change in English story quality ($b = 7.76$, $SE = 2.45$, $p < 0.05$). However the interaction between age and Vietnamese MLU was negative ($b = -2.01$, $SE = 0.69$, $p < 0.05$), suggesting that the relationship between Vietnamese and English attenuates with age. Significant interactions suggested a high degree of L1-L2 interdependence in the earlier stages of L2 learning and greater independence of L1 and L2 learning at later stages. Within a DS framework, two components can be "connected growers" (van Geert, 1994) whose development is interdependent. However, as the language system emerges, the two components may separate and be linked to other components later on in development. L1 and L2 learning may become more linked to other modalities of communication such as literacy or may develop as a function of social demands such as opportunities to use the L1 and L2 in meaningful and socially embedded contexts (Kohnert, 2007; Pearson, 2007).

Concluding Remarks

Bilingual development informs a broader understanding of processes in language learning by allowing researchers to investigate the potential for multiple interactions within and between languages (Kohnert, 2010). Developmental trajectories modeled in this study accounted for growth across language subsystems, expressive and receptive domains, and shifts in relative strength from the L1 to the L2. Developing bilingual children not only exhibit fluctuations in language proficiency as a function of modality, measure, and language subsystem, their profiles may change over time. Multiple interactions between subsystems within each language as well as between languages contribute to changes in the magnitude, direction, and nature of L1 and L2 relationships.

This study documented natural changes in L1 and L2 proficiency over a four-year time period. Shorter, experimental studies that manipulate factors such as language input, motivation, and cognitive resources (i.e., task demands) are also needed to examine L1-L2 relationships under experimental conditions to investigate external components that can shift the overall language system. To illustrate, Kan and Kohnert (in press) investigated word learning among preschool-age Hmong-English bilinguals through the use of a longitudinal experimental design and nonsense words to control for language input. Kan and Kohnert (in press) found that when the input for both languages was equal, children performed better in their L1 than in the L2 in language comprehension and the same across languages in language production. In contrast to this study, children did not exhibit shifts in relative strength from the L1 to the L2 or faster gains in the L2 for language production in large part due to the experimental control of language input and shorter time period (eight weeks vs. four years). This study highlighted the capacity for young sequential bilingual children to learn their L1 and L2 to the same degree when provided the same amount of opportunities to listen and practice both languages.

In addition to system-external components such as input, system-internal components may affect L1 and L2 trajectories and relationships. For example, children with language impairment may have less stable language systems or have systems that have stabilized at less mature developmental states (Evans, 2001). Children with language impairment and who speak two languages provide a unique window to examine within-individual change in L1-L2 relationships as a function of language intervention, input, and cognitive processes (Kohnert, 2007; 2010). Investigating developmental trajectories, the nature of cross-linguistic relationships, and components that affect change is critical to the understanding of bilingualism and of language development in general.

Table 1

Participant Characteristics

	% of Children	Average	SD	Range
Previous Educational Experiences				
Attended Daycare	28			
Attended Preschool	40			
Attended school in Vietnam	9			
Family Members Living in the Home				
Both parents	84			
Older sibling(s)	52			
Younger sibling(s)	24			
Grandparent(s)	36			
Language Proficiency				
Vietnamese		3.47	0.6	2.5 - 4.0
English		3.59	0.7	1.5 - 4.0
Age of L2 onset (years)		4.4	1.4	1 - 6
Language Use				
Vietnamese across contexts (%)		48	15	20 - 80
Mainly Vietnamese to parents	100			
Mainly Vietnamese to grandparents	95			
English across contexts (%)		41	18	0 - 75
Mainly English to siblings	40			
Mainly English to friends	65			
Mainly English on TV	71			

Note. Twenty-five of 34 parents completed surveys about their children's home, language, and educational experiences. Surveys were completed either in written format or via telephone by a Vietnamese language teacher at Hillcrest (i.e., familiar adult). Parents rated their children's language proficiency on a scale of 1 to 4 (4 = very well) across speaking, listening, reading, and writing domains. Language use was calculated as the average of the percentages of use in each language with parents, grandparents, siblings, friends, and watching television. The term "mainly" in the table indicates 70% or more of the time.

Table 2

Summary of Language Measures

Subsystem	Modality	Task	Language	Dependent measure
Lexical Semantics	Comprehension	Picture word verification	Vietnamese	% correct, response time (RT)
			English	% correct, RT
	Production	Timed picture naming	Vietnamese	% correct, RT
			English	% correct, RT
Syntax	Production	Sentence repetition	Vietnamese	% correct
			English	% correct
		Story Tell	Vietnamese	MLU-syllables
			English	MLU-words
Discourse	Production	Story Tell (Story quality score)	Vietnamese	% correct
			English	% correct

Table 3

Descriptive Statistics

		Vietnamese			English		
	n	M (SD)	Range	Raw	M (SD)	Range	Raw
Age	34	7.3 (0.9)	5.7 - 9.3				
	28	8.3 (0.8)	6.7- 10.0				
	22	9.1 (0.9)	7.7 - 10.9				
	13	10.4 (0.8)	8.7 - 11.9				
Picture Word	34	93 (0.05)	83 - 100	37	91 (0.07)	63 - 100	37
Verification	28	95 (0.05)	75 - 100	38	94 (0.07)	63 - 100	38
Accuracy	22	96 (0.04)	88 - 100	39	95 (0.05)	80 - 100	38
	13	97 (0.02)	93 - 100	39	97 (0.02)	93 - 100	39
Picture Word	34	1435 (308)	967 - 2211		1390 (362)	856 - 2293	
Verification	28	1192 (235)	781 - 1635		1146 (209)	883 - 1836	
Response Time	22	1060 (219)	811 - 1722		1101 (306)	807 - 2216	
	13	917 (112)	737 - 1178		852 (75)	760 - 953	
Timed Picture	34	71 (12)	31 - 91	57	65 (16)	13 - 89	52
Naming Accuracy	28	76 (10)	58 - 94	61	75 (13)	33 - 94	60
	22	77 (10)	61 - 91	61	82 (12)	45 - 98	66
	13	81 (11)	61 - 94	65	89 (6)	78 - 98	71
Timed Picture	34	1360 (376)	796 - 3125		1118 (215)	746 - 1631	
Naming Response	28	1289 (234)	883 - 1832		1056 (202)	742 - 1559	
Time	22	1196 (203)	855 - 1575		1049 (154)	788 - 1358	
	13	1075 (221)	786 - 1500		852 (132)	653 - 1150	

		Vietnamese			English		
	n	M (SD)	Range	Raw	M (SD)	Range	Raw
Sentence	34	38 (15)	12 - 73	23	40 (21)	5 - 93	24
Repetition	28	45 (15)	17 - 80	27	50 (19)	3 - 85	30
	22	46 (18)	17 - 87	28	59 (20)	13 - 92	35
	13	55 (18)	27 - 87	33	70 (16)	32 - 90	42
MLU-words	34	6.7 (1.1)	5.0 - 9.6		7.2 (1.4)	3.8 - 9.7	
	28	7.1 (1.6)	4.2 - 11.6		7.7 (1.1)	5.4 - 10.0	
	22	7.6 (1.6)	4.5 - 12.4		8.0 (1.3)	5.9 - 10.7	
	13	7.8 (2.2)	3.6 - 12.2		8.3 (1.4)	6.8 - 11.0	
Story Quality	34	59 (20)	5 - 95	12	59 (18)	15 - 80	12
	28	60 (19)	25 - 90	12	66 (17)	15 - 100	13
	22	63 (19)	25 - 95	13	74 (9)	60 - 90	15
	13	72 (20)	20 - 90	14	78 (14)	50 - 95	16

Note. Descriptive statistics are summarized by wave of data collection for convenience here. Statistical models are based on chronological age (vs. wave) as the measure of time. Accuracy measures are reported in percent correct with corresponding raw values.

Table 4

Fixed Effects of Multivariate Hierarchical Linear Models.

Within Languages			
Subsystem	Estimate	SE	Z-score
Vietnamese			
Lexicon.intercept	64.37*	2.40	26.78
Grammar.intercept	31.48*	2.94	10.72
Discourse.intercept	54.09*	4.31	12.56
Lexicon.slope	4.22	0.77	5.46
Grammar.slope	4.12	0.70	5.90
Discourse.slope	2.47*	1.27	1.95
English			
Lexicon.intercept	55.62	3.46	16.08
Grammar.intercept	23.71*	3.20	7.42
Discourse.intercept	54.15	4.56	11.87
Lexicon.slope	7.79*	0.95	8.24
Grammar.slope	10.22*	0.83	12.35
Discourse.slope	5.74*	1.67	3.44
Between Languages			
Measure	Estimate	SE	Z-score
PW Verification ACC			
V.intercept	90.78	1.10	82.19
E.intercept	88.98	1.65	54.01
V.slope	1.55	0.30	5.18
E.slope	2.00	0.42	4.76

Measure	Estimate	SE	Z-score
PW Verification RT			
V.intercept	1669.81	52.68	31.70
E.intercept	1620.27	68.27	23.73
V.slope	-171.45	15.02	-11.41
E.slope	-161.65	16.54	-9.77
Naming ACC			
V.intercept	65.02*	2.24	28.99
E.intercept	54.11*	3.06	17.68
V.slope	4.01*	0.71	5.65
E.slope	8.29*	0.75	10.99
Naming RT			
V.intercept	1471.40*	62.29	23.62
E.intercept	1239.51*	48.95	25.32
V.slope	-71.75	16.93	-4.24
E.slope	-69.51	15.49	-4.49
Sentence Repetition			
V.intercept	30.11*	2.82	10.67
E.intercept	23.34*	4.08	5.72
V.slope	4.61*	0.64	7.20
E.slope	10.70*	1.21	8.86
MLU			
V.intercept	6.02*	0.28	21.48
E.intercept	6.50*	0.24	26.70
V.slope	0.39	0.11	3.68
E.slope	0.44	0.07	6.15

Measure	Estimate	SE	Z-score
Story Quality			
V.intercept	49.31	4.20	11.75
E.intercept	49.07	3.12	15.71
V.slope	4.25	1.27	3.33
E.slope	6.42	1.03	6.23

Note. An asterisk (*) denotes estimates that are significantly different based on comparisons of full and reduced models using analytical likelihood ratio tests and AIC weights of evidence. V = Vietnamese. E = English. Vietnamese and English across subsystems consist of multivariate models of timed picture naming accuracy (lexicon), sentence repetition (grammar), and story quality (discourse).

Table 5

Longitudinal Associations: One Language as a Dynamic Predictor of Another

Measure	Estimate	SE	Z-score	ΔR^2
English Picture Word Verification RT				
Intercept	646.61	177.05	3.65	
Age	-56.50	23.73	-2.38	0.31
Vietnamese PWV RT	0.57	0.10	5.55	0.23
Age * Vietnamese PWV RT	--	--	--	--
English Picture Naming ACC				
Intercept	26.36	8.58	3.07	
Age	17.39	3.08	5.64	0.61
Vietnamese Pic Nam ACC	0.37	0.12	3.02	0.01
Age * Vietnamese	-0.12	0.04	-3.09	0.01
English Picture Naming RT				
Intercept	1292.43	188.11	6.87	
Age	-193.29	65.18	-2.97	0.16
Vietnamese Pic Nam RT	-0.08	0.15	-0.53	0.12
Age * Vietnamese	0.11	0.05	2.09	0.05
English Sentence Repetition				
Intercept	22.52	3.36	6.71	
Age	10.60	0.92	11.49	0.49
Vietnamese Sent Rep	--	--	--	--
Age * Vietnamese	--	--	--	--

Measure	Estimate	SE	Z-score	ΔR^2
English MLU				
Intercept	4.43	0.53	8.40	
Age	0.33	0.08	3.91	0.29
Vietnamese MLU	0.34	0.08	4.20	0.16
Age * Vietnamese	--	--	--	--
English Story Quality				
Intercept	14.66	9.56	1.53	
Age	14.98	3.92	3.83	0.26
Vietnamese Story Quality	0.65	0.16	4.06	0.07
Age * Vietnamese	-0.16	0.06	-2.82	0.05

Note. Vietnamese measures were modeled as time-varying or dynamic predictors of English measures at the same language subsystem to examine longitudinal covariation between Vietnamese and English. Three models were compared using AIC weights of evidence: (a) age as the only time-varying predictor, (b) age and Vietnamese as two time-varying predictors (i.e., main effects model) and (c) age, Vietnamese and their interaction (i.e., interaction model). Best-fitting models are presented here with their corresponding estimates, standard errors, z-scores, and effect sizes (ΔR^2). Change in R^2 (ΔR^2) represented additional unique variance accounted for by the full model (e.g., $R^2_{Model\ B} - R^2_{Model\ A}$).

Table 6

Directionality of Cross-Linguistic Transfer

Forward Transfer (L1 to L2)				
Measure	Estimate	SE	Z-score	ΔR^2
English Sentence Repetition				
Intercept	-17.88	7.64	-2.34	
Age	4.05	1.46	2.77	0.49
English Nam ACC	0.77	0.14	5.63	0.18
English Nam ACC + Vietnamese Nam ACC	--	--	--	--
English MLU				
Intercept	3.11	0.97	3.20	
Age	0.05	0.13	0.34	0.29
English Nam ACC	0.04	0.01	3.21	0.10
English Nam ACC + Vietnamese Nam ACC	0.02	0.01	1.76	0.03
English Story Quality				
Intercept	46.48	3.82	12.16	
Age	4.94	1.54	3.21	0.26
English Sent Rep	0.13	0.09	1.37	0.01
English Sent Rep + Vietnamese Sent Rep	--	--	--	--
English Story Quality				
Intercept	16.87	8.74	1.93	
Age	3.77	1.23	3.06	0.26
English MLU	5.10	1.28	3.99	0.10
English MLU + Vietnamese MLU	--	--	--	--

Backward Transfer (L2 to L1)				
Measure	Estimate	SE	Z-score	
Vietnamese Sentence Repetition				
Intercept	23.15	7.82	2.96	
Age	4.12	0.70	5.91	0.34
Vietnamese Nam ACC	0.11	0.11	0.98	0.07
Vietnamese Nam ACC + English Nam ACC	--	--	--	--
Vietnamese MLU				
Intercept	3.99	1.03	3.88	
Age	0.27	0.11	2.52	0.25
Vietnamese Nam ACC	0.03	0.02	2.05	0.09
Vietnamese Nam ACC + English Nam ACC	--	--	--	--
Vietnamese Story Quality				
Intercept	36.38	5.35	6.80	
Age	1.97	1.37	1.43	0.26
Vietnamese Sent Rep	0.44	0.14	3.19	0.11
Vietnamese Sent Rep + English Sent Rep	--	--	--	--
Vietnamese Story Quality				
Intercept	5.08	10.21	0.50	
Age	1.37	1.25	1.10	0.26
Vietnamese MLU	4.83	1.25	3.87	0.17
Vietnamese MLU + English MLU	2.30	1.44	1.60	0.01

Note. Forward and backward transfer are examined with a lower language subsystem in one language (e.g., Vietnamese lexicon) as a dynamic predictor of a higher subsystem in the other language (e.g., English grammar) controlling for age and the lower subsystem of the other language (e.g., English lexicon).

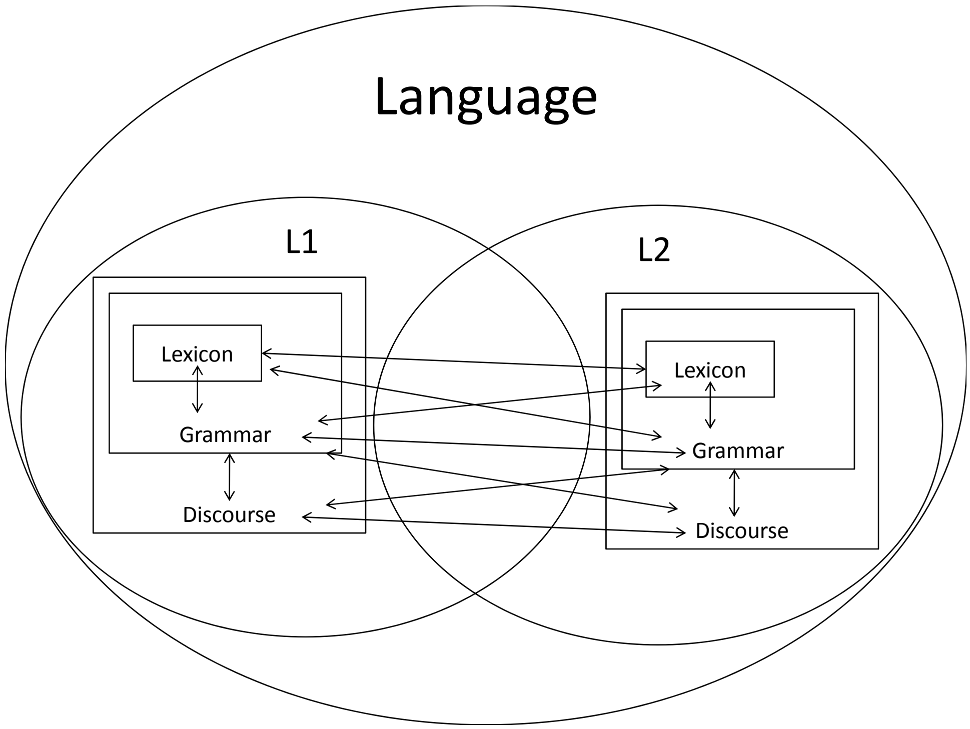

Figure 1. Schematic representation of language as a dynamic system that consists of lexicon, grammar, and discourse subsystems within the first language (L1) and second language (L2). Arrows represent potential relationships between subsystems within each language and between languages and subsystems as consistent within a Dynamic Systems framework that predicts multiple interactions among simpler components.

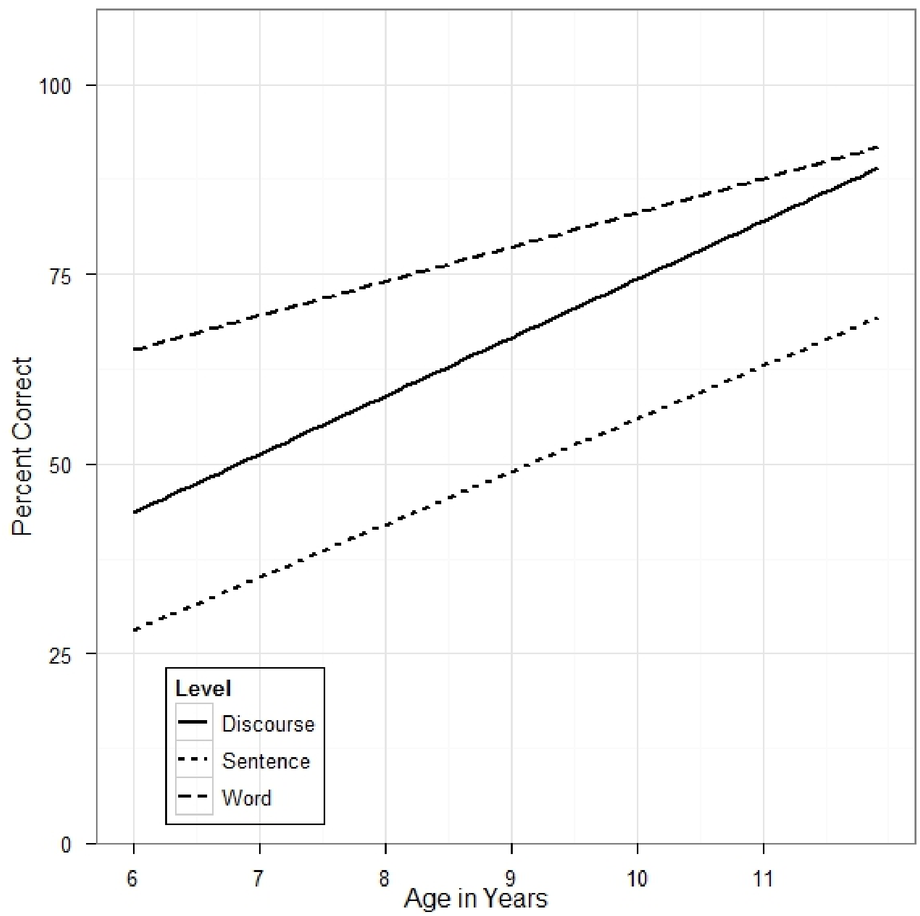

Figure 2. Vietnamese language development across lexical, grammatical, and discourse subsystems based on a multivariate model with the three subsystems as response variables and chronological age as the predictor. Intercepts of lexical, grammatical, and discourse subsystems were unequal. Slopes for lexical and grammatical subsystems were different from the discourse slope. See Table 4 for estimates of intercepts and slopes.

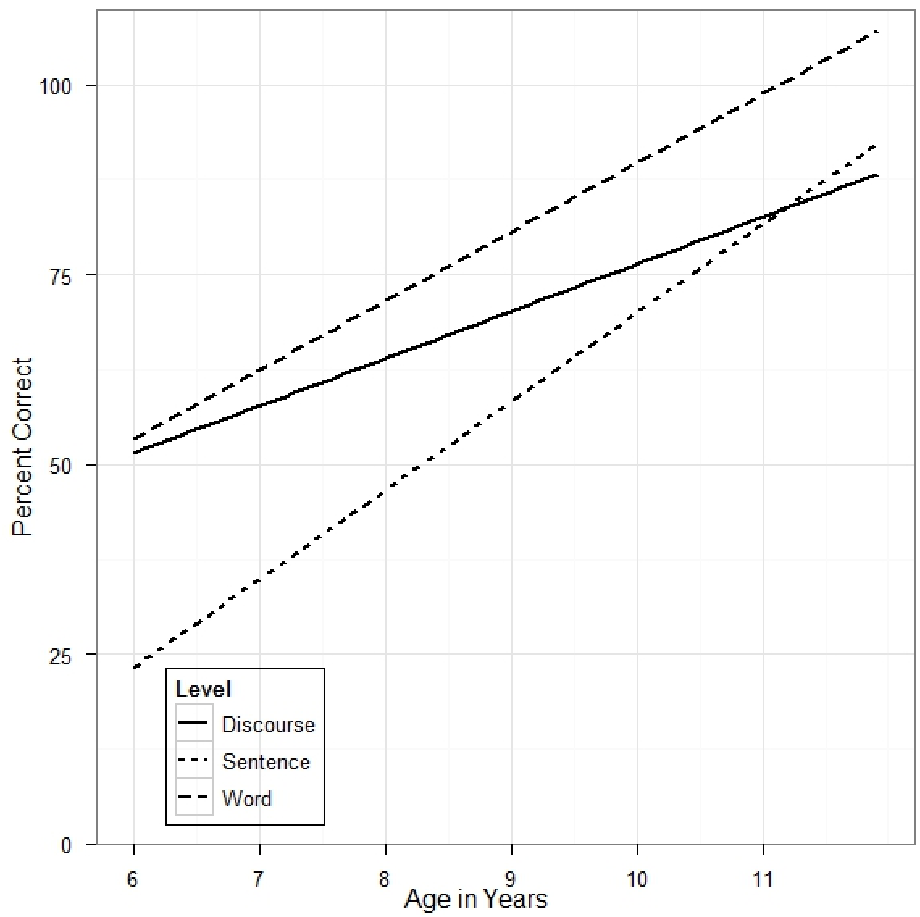

Figure 3. English language development across lexical, grammatical, and discourse subsystems based on a multivariate model with the three subsystems as response variables and chronological age as the predictor. Intercepts of lexical and discourse subsystems were equal. Slopes for lexical, grammatical, and discourse subsystems were unequal. See Table 4 for estimates of intercepts and slopes.

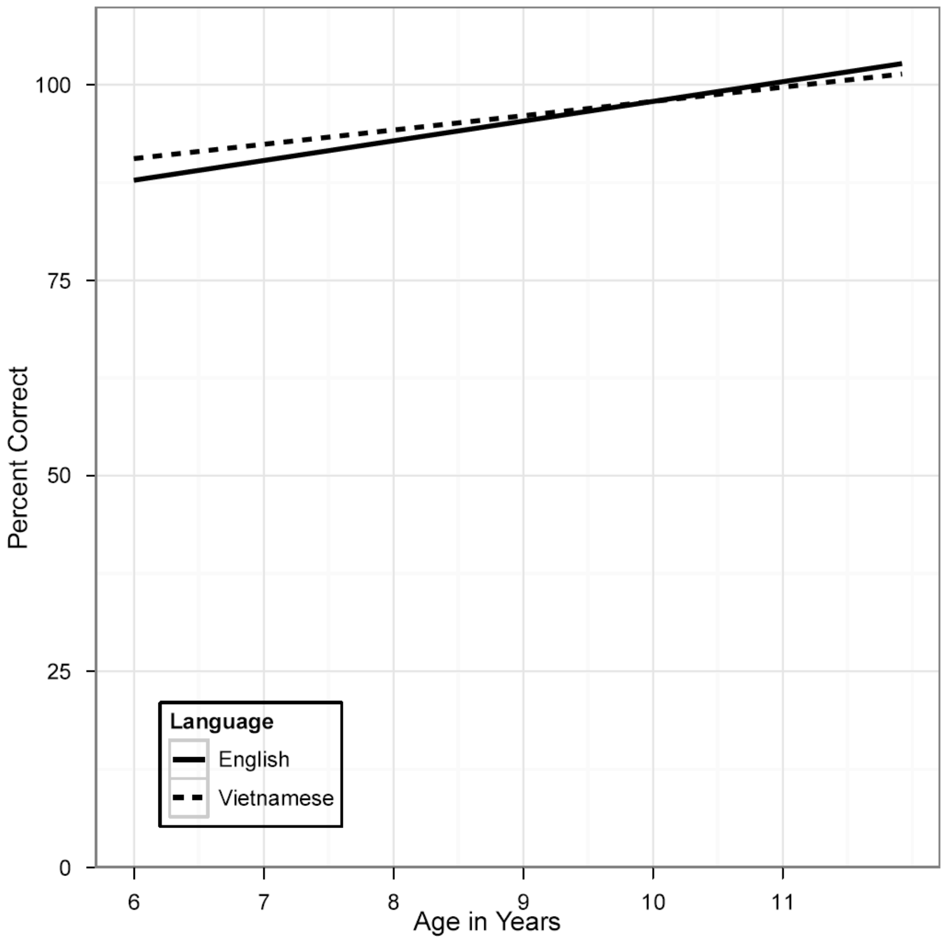

Figure 4. Picture word verification accuracy for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were equal. Vietnamese and English slopes were equal. See Table 4 for estimates of intercepts and slopes.

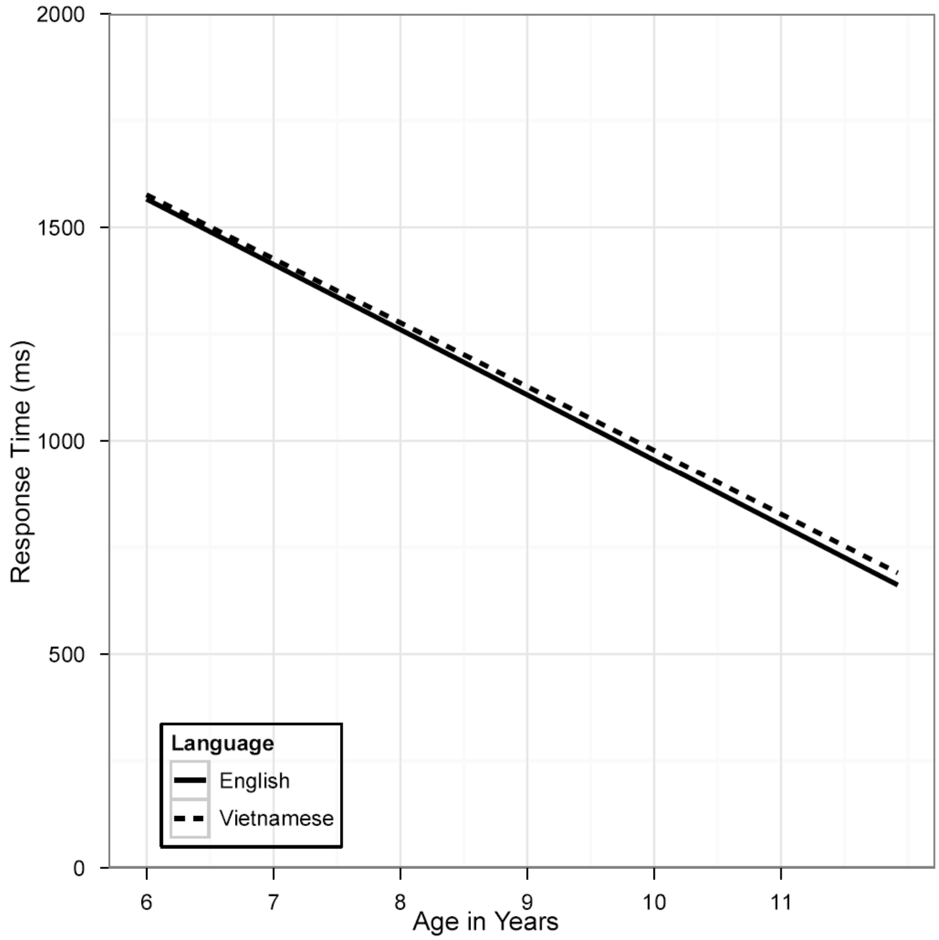

Figure 5. Picture word verification response time for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were equal. Vietnamese and English slopes were equal. See Table 4 for estimates of intercepts and slopes.

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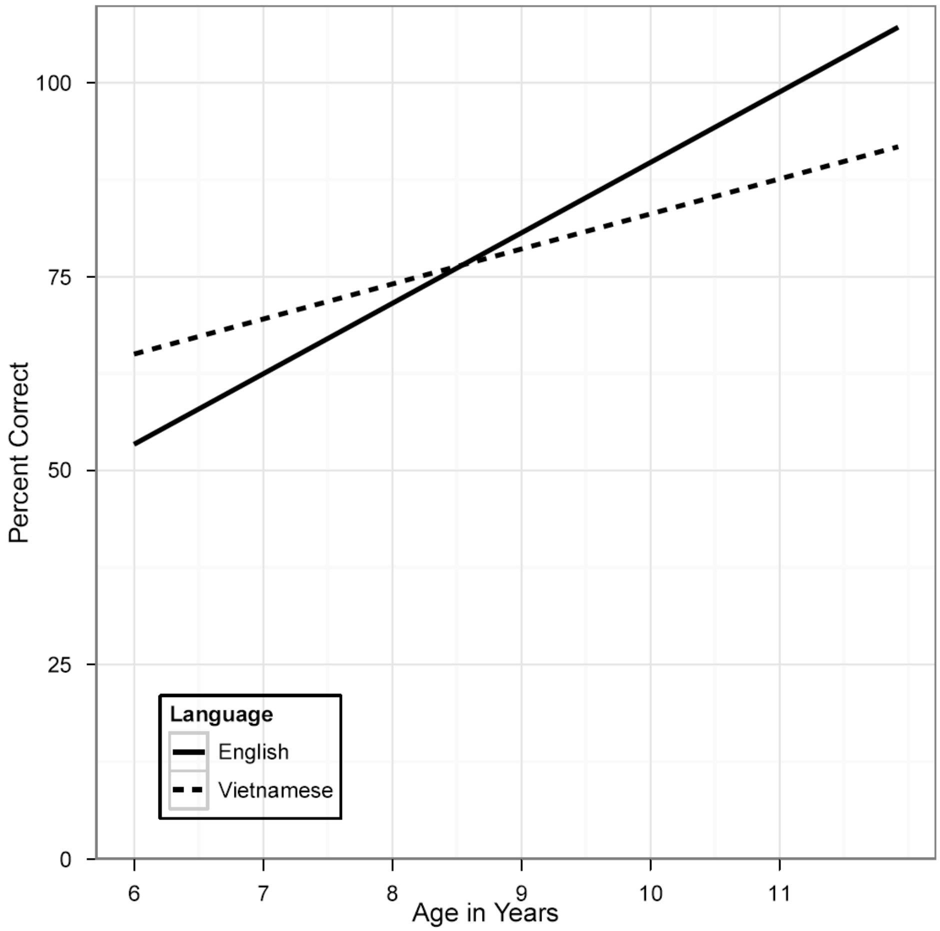

Figure 6. Timed picture naming accuracy for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were unequal. Vietnamese and English slopes were unequal. See Table 4 for estimates of intercepts and slopes.

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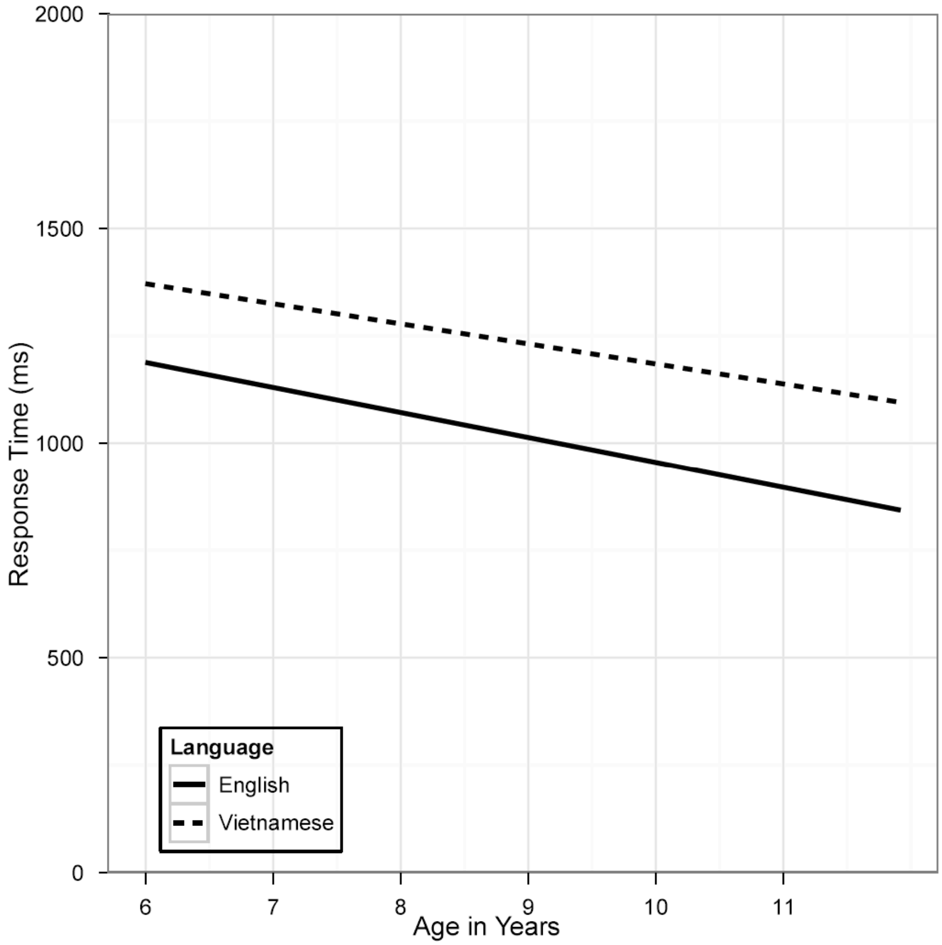

Figure 7. Timed picture naming response time for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were unequal. Vietnamese and English slopes were equal. See Table 4 for estimates of intercepts and slopes.

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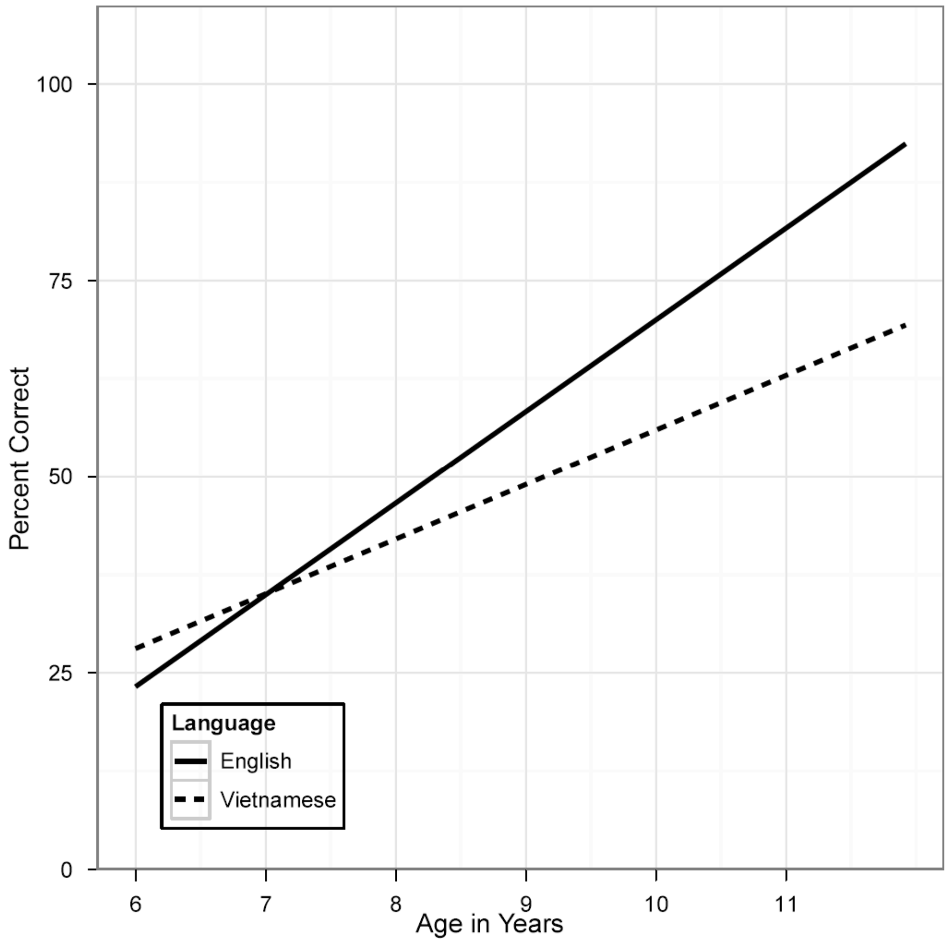

Figure 8. Sentence repetition for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were unequal. Vietnamese and English slopes were unequal. See Table 4 for estimates of intercepts and slopes.

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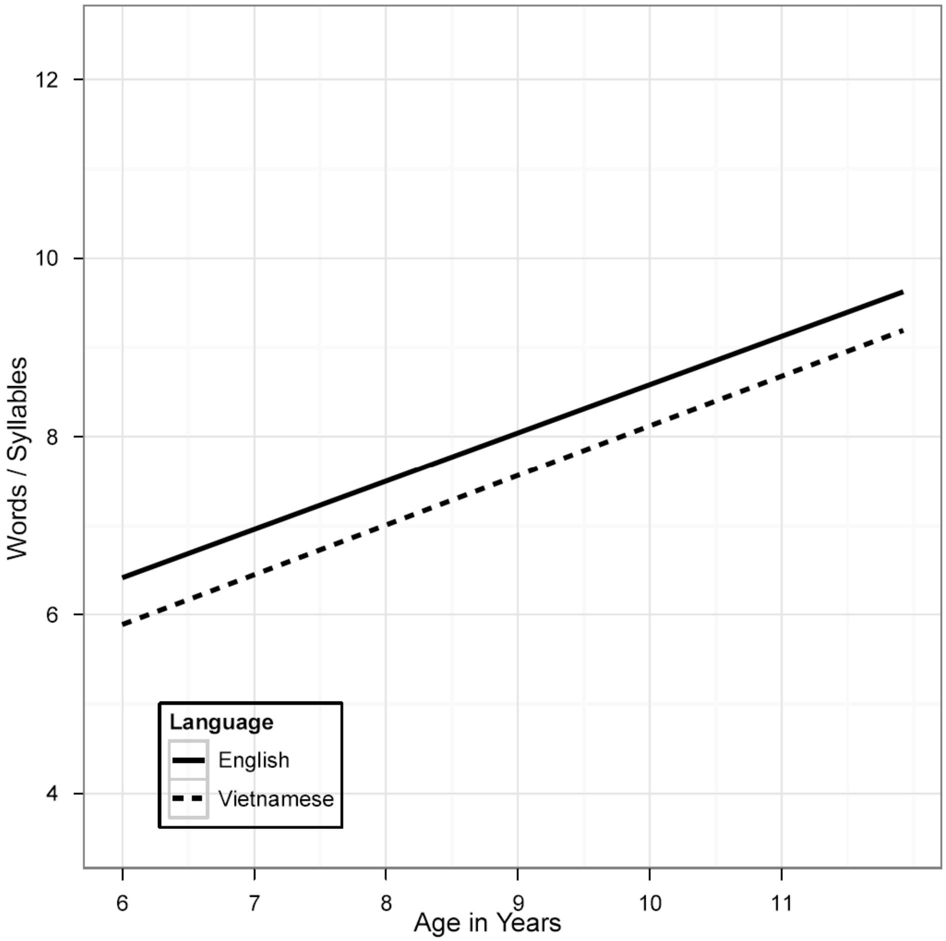

Figure 9. Mean length of utterance (MLU) for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were unequal. Vietnamese and English slopes were equal. See Table 4 for estimates of intercepts and slopes.

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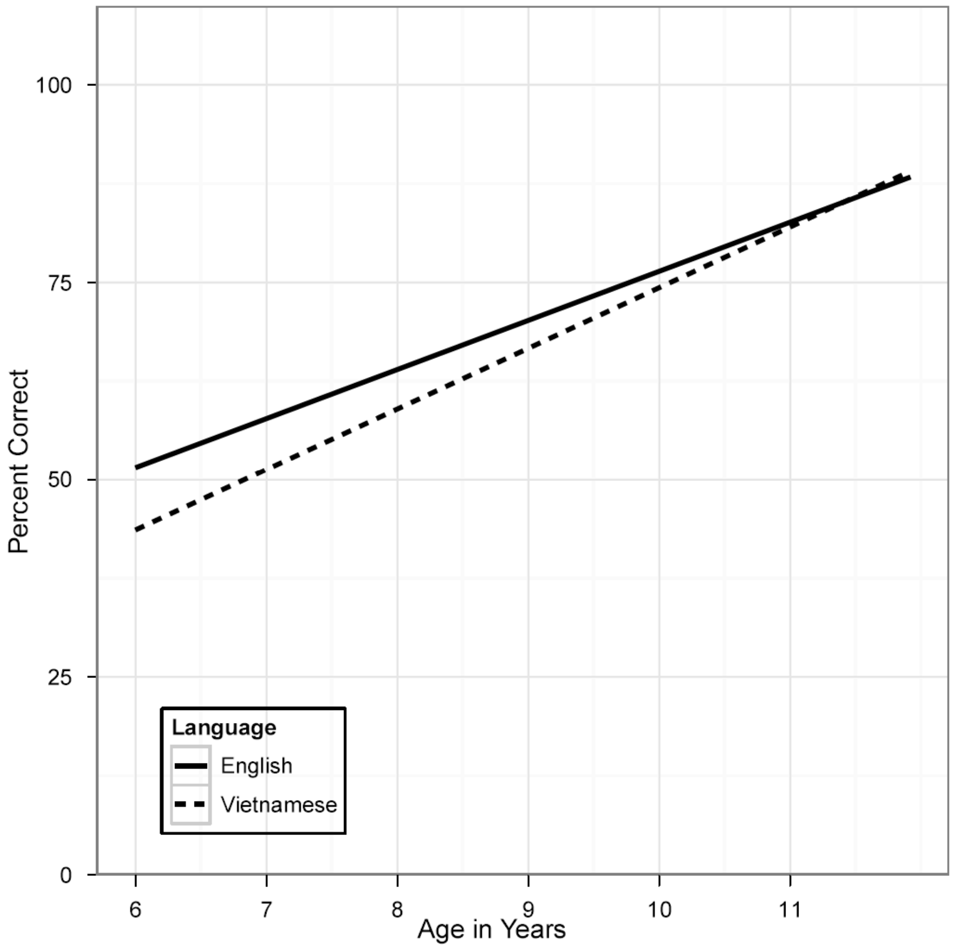

Figure10. Story quality for Vietnamese and English based on a multivariate model with the two languages as response variables and chronological age as the predictor. Vietnamese and English intercepts were equal. Vietnamese and English slopes were equal. See Table 4 for estimates of intercepts and slopes.

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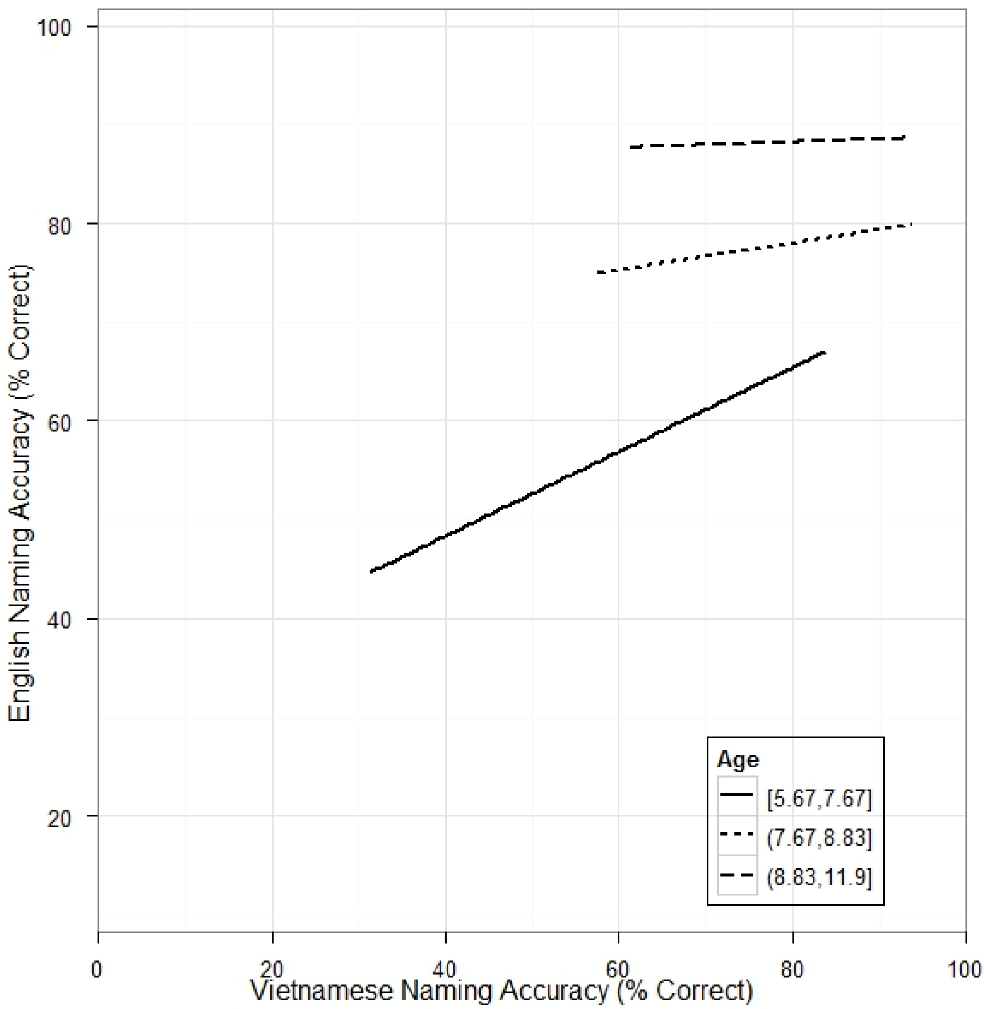

Figure 11. Interaction between Vietnamese timed picture naming accuracy and chronological age when the two variables served as dynamic predictors of English timed picture naming accuracy. Figure shows that the relationship between Vietnamese and English attenuates with age. Age in years is divided into three intervals for graphing purposes only.

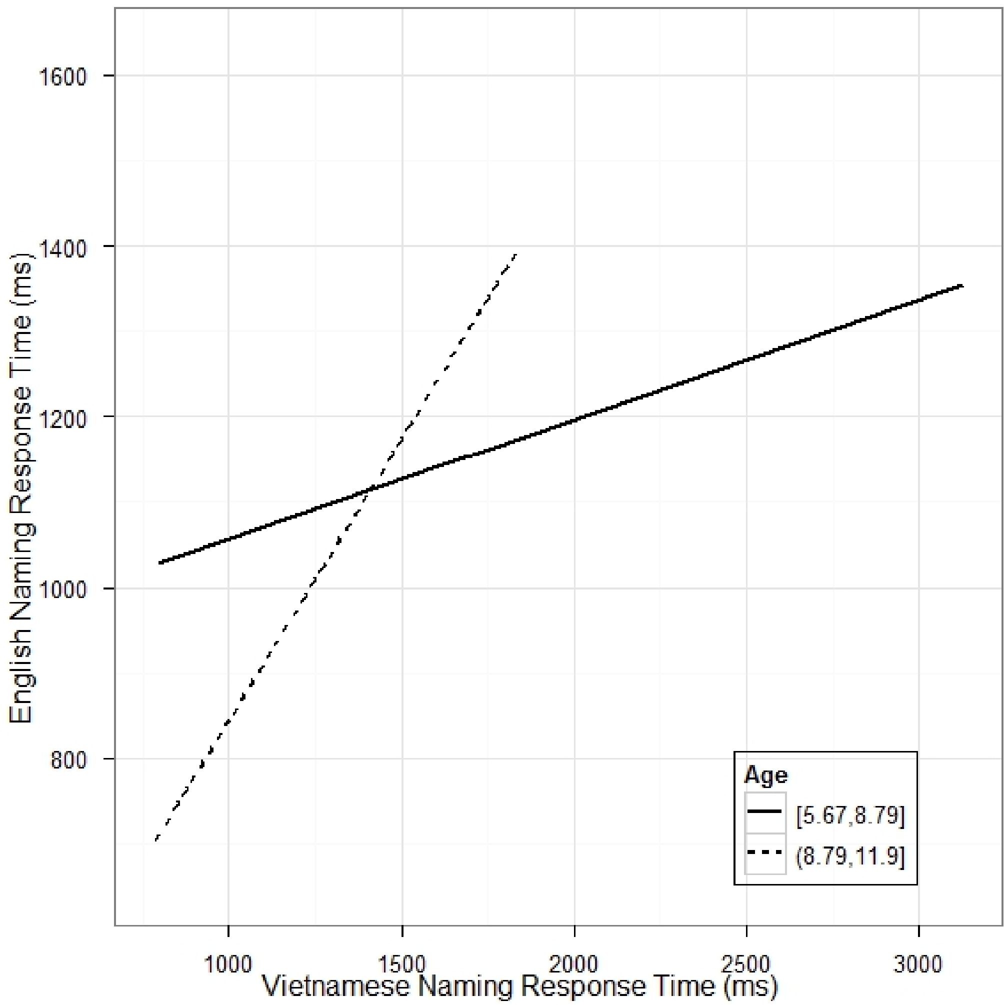

Figure 12. Interaction between Vietnamese timed picture naming response time and chronological age when the two variables served as dynamic predictors of English timed picture naming response time. Figure shows that the relationship between Vietnamese and English is stronger with age. However, developmental effects may be driving this effect (see Results section for discussion). Age in years is divided into two intervals for graphing purposes only.

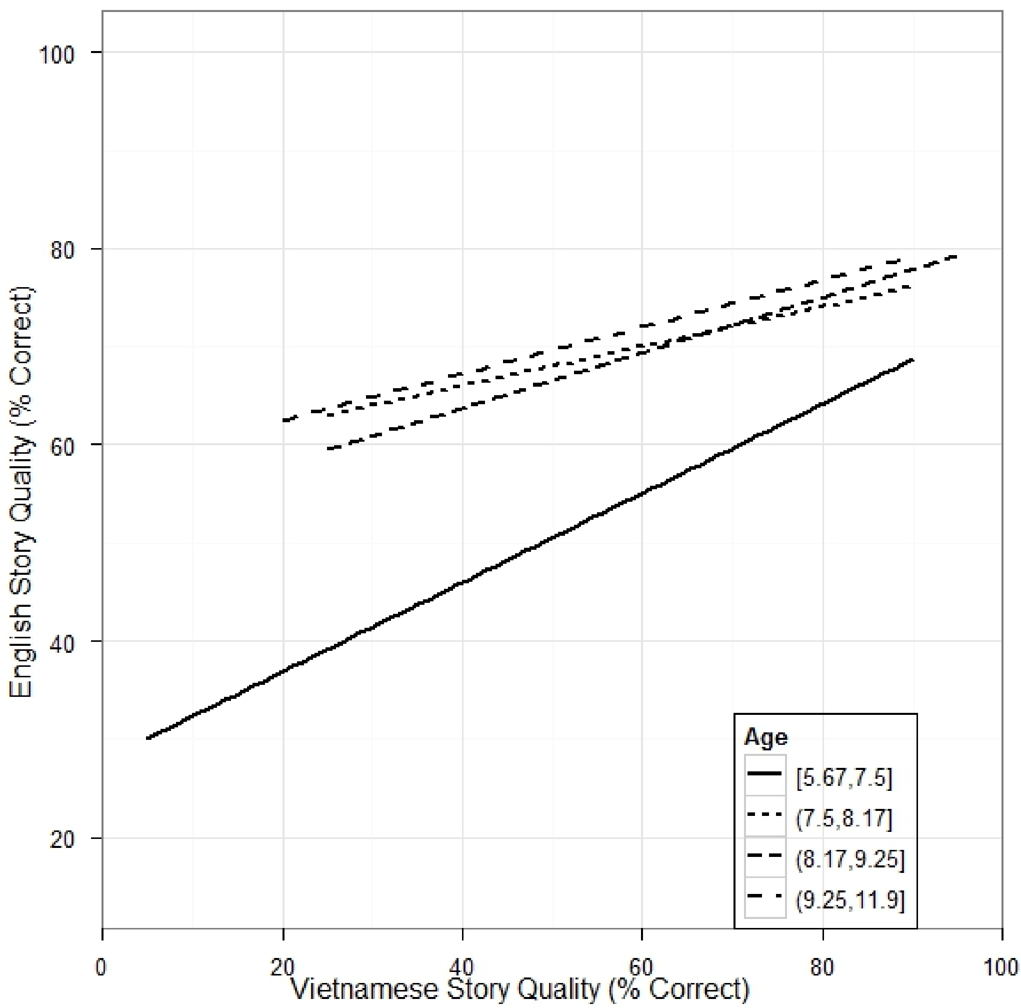

Figure 13. Interaction between Vietnamese story quality and chronological age when the two variables served as dynamic predictors of English story quality. Figure shows that the relationship between Vietnamese and English attenuates with age. Age in years is divided into four intervals for graphing purposes only.

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Appendix A

Picture Word Verification: Object Stimuli

	English		Vietnamese	
	Item	Word frequency	Item	Word frequency
1	Girl	6.08	Con gái	4.93
2	Book	6.08	Quyển sách	4.45
3	Boy	5.86	Con trai	4.58
4	Baby	5.56	Em bé	4.34
5	Road	5.52	Đường	7.04
6	Table	5.46	Bàn	5.17
7	Hair	5.30	Tóc	4.58
8	Doctor	5.22	Bác sĩ	5.29
9	Fish	5.10	Con cá	4.28
10	Bird	4.64	Con chim	4.30
11	Box	4.64	Hộp	4.36
12	King	4.61	Vua	6.31
13	Ear	4.49	Tai	5.04
14	Key	4.47	Chìa khóa	2.56
15	Leaf	4.41	Lá	5.69
16	Bread	4.32	Bánh mì	3.30
17	Rain	4.29	Mưa	5.20
18	Bone	4.25	Xương	4.92
19	Hat	4.23	Nón	4.63
20	Cat	4.22	Con mèo	5.73
21	Shirt	4.13	Áo	5.96
22	Cloud	4.04	Mây	4.33

	English		Vietnamese	
	Item	Word frequency	Item	Word frequency
23	Mirror	3.91	Gương	4.13
24	Pig	3.78	Con heo	2.64
25	Chicken	3.74	Con gà	3.66
26	Bowl	3.53	Tô	3.71
27	Flag	3.30	Lá cờ	3.71
28	Towel	3.14	Khăn	3.93
29	Orange	3.05	Trái cam	5.11
30	Rabbit	3.00	Con thỏ	6.18
31	Pillow	3.00	Gối	3.53
32	Pencil	3.00	Cây viết	2.56
33	Monkey	2.94	Con khỉ	4.86
34	Bear	2.83	Con gấu	6.16
35	Pants	2.83	Quần	5.29
36	Lemon	2.77	Tranh	6.90
37	Spoon	2.77	Muỗng	2.48
38	Tiger	2.57	Con cọp	5.91
39	Crab	2.30	Con cua	2.89
40	Banana	2.20	Chuối	3.58

Note. Items listed from highest to lowest English word frequency. Word frequencies calculated as natural log transformations [ln (1 + raw frequency count)]. Vietnamese word frequencies based on the Corpora of Vietnamese Texts (Pham, Kohnert, & Carney, 2008). English word frequencies based on CELEX Lexical database (Baayen, Piepenbrock, & Gulikers, 1995).

Appendix B

Picture Word Verification: Action Stimuli

	English		Vietnamese	
	Item	Word frequency	Item	Word frequency
1	Write	6.14	Viết	6.09
2	Run	6.09	Chạy	6.53
3	Play	6.00	Chơi	6.54
4	Read	5.92	Đọc	5.67
5	Wait	5.77	Chờ	5.68
6	Carry	5.74	Khiêng	3.14
7	Walk	5.74	Đi bộ	3.74
8	Eat	5.67	Ăn	7.18
9	Pick	5.25	Hái	4.45
10	Pull	5.23	Kéo	5.99
11	Sleep	4.87	Ngủ	5.92
12	Drink	4.87	Uống	5.39
13	Push	4.84	Đẩy	5.53
14	Burn	4.49	Cháy	4.81
15	Pour	4.38	Rót	2.20
16	Sing	4.37	Hát	5.12
17	Jump	4.22	Nhảy	5.80
18	Count	4.16	Đếm	4.20
19	Tie	4.13	Cột	4.26
20	Tear	4.13	Xé	3.58
21	Swing	4.04	Đu	3.30
22	Kick	3.76	Đá	5.71

	English		Vietnamese	
	Item	Word frequency	Item	Word frequency
23	Stir	3.74	Quậy	2.71
24	Fix	3.71	Sửa	4.39
25	Measure	3.61	Đo	4.43
26	Wrap	3.58	Gói	4.42
27	Fish	3.47	Câu	2.94
28	Bite	3.33	Cắn	3.83
29	Chase	3.05	Đuổi	5.32
30	Spill	2.94	Đổ	5.76
31	Rain	2.77	Mưa	5.20
32	Clap	2.57	Vỗ tay	3.43
33	Cough	2.57	Ho	2.40
34	Sew	2.49	May	5.49
35	Hug	2.49	Ôm	5.00
36	Lick	2.49	Liếm	2.56
37	Comb	2.30	Chải	2.83
38	Sting	2.20	Chích	3.37
39	Yawn	2.20	Ngáp	2.48
40	Plug	2.08	Cấm	5.25

Note. Items listed from highest to lowest English word frequency. Word frequencies calculated as natural log transformations [ln (1 + raw frequency count)]. Vietnamese word frequencies based on the Corpora of Vietnamese Texts (Pham, Kohnert, & Carney, 2008). English word frequencies based on CELEX Lexical database (Baayen, Piepenbrock, & Gulikers, 1995).

Appendix C

Timed Picture Naming: Object Stimuli

	English		Vietnamese	
	Item	Word Frequency	Item	Word Frequency
1	Hand	6.59	Tay	6.93
2	House	6.41	Nhà	4.51
3	Paper	5.42	Giấy	5.61
4	Window	5.30	Cửa sổ	3.99
5	Tree	5.26	Cây	6.50
6	Picture	5.17	Hình/ tranh	5.21
7	Bed	5.14	Giường	4.71
8	Heart	5.11	(trái) Tim	4.79
9	Chair	4.92	Ghế	4.88
10	Horse	4.89	(con) Ngựa	5.04
11	Dog	4.75	(con) Chó	5.62
12	Flower	4.54	Hoa/ bông	6.73
13	Mountain	4.44	Núi	5.48
14	Train	4.41	Xe/tàu lửa/ tàu điện	3.18
15	Boat	4.34	Thuyền/ tàu	6.38
16	Bridge	4.21	Cầu	7.03
17	Plate/ dish	4.03	Điã/ dĩa	4.16
18	Knife	3.81	(con) Dao	3.18
19	Wheel	3.81	Bánh (xe)	2.08
20	Clock	3.69	Đồng hồ	4.19
21	Salt	3.64	Muối	2.89
22	Fly	3.61	Ruồi	3.04

	English		Vietnamese	
	Item	Word Frequency	Item	Word Frequency
23	Potato	3.61	Khoai (tây/ lan)	2.56
24	Cake	3.56	Bánh (ngọt)	1.95
25	Glasses	3.50	Mắt kính	3.56
26	Ghost	3.47	Ma	4.76
27	Apple	3.43	(trái) Táo/ bôm	3.85
28	Skirt	3.40	Váy/ cũng	2.64
29	Button	3.30	Nút/ cúc	3.93
30	Beard	3.26	Râu	3.37
31	Corn	3.22	Bắp/ Ngô	4.22
32	Snake	3.18	Con rắn	5.35
33	Mouse/ rat	2.94	Chuột	5.89
34	Sock	2.94	Vớ/ tất	3.18
35	Fan	2.89	Quạt	2.77
36	Candle	2.83	Nến/ đèn cầy	2.48
37	Umbrella	2.71	(cây) Dù/ ô	2.48
38	Ant	2.57	Kiến	6.30
39	Butterfly	2.40	Bướm (bướm)	3.93
40	Spider	2.08	(con) Nhện	3.18

Note. Items and acceptable alternatives listed from highest to lowest English word frequency. Word frequencies calculated as natural log transformations [ln (1 + raw frequency count)]. Vietnamese word frequencies based on the Corpora of Vietnamese Texts (Pham, Kohnert, & Carney, 2008). English word frequencies based on CELEX Lexical database (Baayen, Piepenbrock, & Gulikers, 1995).

Appendix D

Timed Picture Naming: Action Stimuli

	English		Vietnamese	
	Item	Word Frequency	Item	Word Frequency
1	Think	7.60	(suy) Nghĩ	4.74
2	Look/ watch/ see	7.21	Nhòm/ nhìn/ coi	6.66
3	Talk/ call	6.24	Nói (chuyện)/ gọi	4.75
4	Sit	6.22	Ngồi	6.03
5	Stand	6.15	Đứng	6.37
6	Catch	5.74	Chụp/ bắt	3.58
7	Fall	5.69	Té/ ngã/ rớt	3.09
8	Watch	5.53	Coi/ xem	6.68
9	Drive	5.39	Lái/ chạy	4.76
10	Cut	5.25	Cắt	4.39
11	Listen/ hear	5.18	Nghe	6.67
12	Smile	5.09	Cười	5.53
13	Point	4.89	Chỉ	3.04
14	Shake	4.88	Lắc/ rung	3.83
15	Cry	4.80	Khóc	5.43
16	Hide	4.63	Trốn/ núp	4.82
17	Hit	4.62	Đánh	6.65
18	Climb	4.53	Trèo/ leo	3.76
19	Blow	4.44	Thổi	4.51
20	Paint/ draw	4.29	Sơn/ vẽ	4.39
21	Cook	4.29	Nấu/ chiên	4.26
22	Kiss	4.09	Hôn/ thương/ thơm	3.43

	English		Vietnamese	
	Item	Word Frequency	Item	Word Frequency
23	Light	4.01	Đốt/ thắp/ bắt	4.84
24	Sweep	3.95	Quét	3.53
25	Dry	3.89	Sấy	2.08
26	Swim	3.87	Bơi/ lội	4.53
27	Smell/ sniff	3.87	Ngửi/ hửi	2.94
28	Deliver/ give	3.85	Gửi/ đưa thư	5.64
29	Wave	3.83	Vẫy/quắc tay/ chào	2.30
30	Slide	3.58	Tuột/ trượt/ xuống	2.64
31	Weigh	3.43	Cân	4.72
32	Crawl	3.26	Bò	5.14
33	Melt	3.26	Chảy	4.20
34	Brush	3.22	Đánh/chà/ xúc miệng	3.18
35	Kneel	3.18	Qùy	2.08
36	Scare	3.00	Sợ/ hù	6.10
37	Curl	2.77	Uốn/ cuốn	2.64
38	Drown	2.71	Chìm	4.06
39	Bark	2.40	Sủa/ kêu	3.40
40	Water	2.30	Tưới	3.26

Note. Items and acceptable alternatives listed from highest to lowest English word frequency. Word frequencies calculated as natural log transformations [ln (1 + raw frequency count)]. Vietnamese word frequencies based on the Corpora of Vietnamese Texts (Pham, Kohnert, & Carney, 2008). English word frequencies based on CELEX Lexical database (Baayen, Piepenbrock, & Gulikers, 1995).

Appendix E

Vietnamese Sentence Repetition Stimuli

Sentence	Ok	-1	-2 –3	-≥4
1. Hôm nay con được đi chợ với bố mẹ.	3	2	1	0
2. Nhà của cô chú ở đâu vậy?	3	2	1	0
3. Tại sao ngày mai chúng con phải đi học?	3	2	1	0
4. Em vẽ hình và chơi với bạn.	3	2	1	0
5. Cuối tuần chúng con có được đi bơi không vậy?	3	2	1	0
6. Con mèo của chị không bị con chó rượt ở ngoài sân.	3	2	1	0
7. Ngày mai em không phải đi học hả?	3	2	1	0
8. Cuốn sách toán mới của con rơi xuống đất rồi.	3	2	1	0
9. Thầy có cho chúng con bài làm cho tối nay không?	3	2	1	0
10. Mùa hè này chúng ta không thấy những con chim bay trên trời.	3	2	1	0
11. Các hình ảnh này được chụp bởi lớp năm và lớp tám.	3	2	1	0
12. Tại vì chúng con phải đi học sáng mai, nên chúng con phải đi ngủ sớm.	3	2	1	0
13. Ba con gà không được bán cho hai mẹ con bởi bà già ở chợ.	3	2	1	0
14. Qua mùa hè này cây cỏ sẽ không mọc được ở vườn của ông bà.	3	2	1	0
15. Tuy em không đủ tiền, nhưng bà chủ vẫn cho em ăn một tô phở.	3	2	1	0
16. Con thích mặc cái áo màu tím mà bố mẹ mua cho con tuần vừa qua.	3	2	1	0
17. Con tặng cô thiệp sinh nhật rất đẹp mà con vẽ hôm qua.	3	2	1	0
18. Nếu các em thích chơi ở ngoài công viên, các em phải chuẩn bị đồ ăn mang theo.	3	2	1	0

Sentence	Ok	-1	-2 –3	- ≥4
19. Quần áo và giầy dép của con bị ướt nhẹp bởi trận mưa vừa qua.	3	2	1	0
20. Cô giáo vui lắm khi xem bức tranh của những học sinh vẽ hình con thỏ rất đẹp.	3	2	1	0

Note. English sentence repetition task consisted of the first 20 items from the Sentence Recall subtest of the Clinical Evaluation of Language Fundamentals, 4th edition (Semel, Wiig, & Secord, 2003). Vietnamese task was not a translation but created to match English items in sentence length (number of syllables) and underlying grammatical structure.

Appendix F

Story Quality Score Record Form

Story Episodes _______ points (max. 5)

0 = 0 - 1 complete episode
1 = 2 - 3 complete episodes
2 = 4 complete episodes
3 = 5 complete episodes
4 = 6 complete episodes
5 = 7 or more complete episodes

Sequence _______ points (max. 5)

0 = no beginning, end, or action sequence
1 = 1 action sequence *or* beginning *or* end
2 = 2 action sequences; *or* beginning + 1 action sequence; *or* end + 1 action sequence; *or* beginning + end
3 = 3 action sequences; *or* beginning + 2 action sequences; *or* end + 2 action sequences; *or* beginning + end + 1 action sequence
4 = 4 action sequences; *or* beginning + 3 action sequences; *or* end + 3 action sequences; *or* beginning + end + 2 action sequences
5 = 5 action sequences; *or* beginning + 4 action sequences; *or* end + 4 action sequences; *or* beginning + end + 3 action sequences

Perspective/ Affect _______ points (max 5)

0 = Described observable actions in pictures
1 = No dialogue, 1 or more emotion or intention words
2 = Used dialogue
3 = Used dialogue *and* 1 - 2 different intention or emotion words
4 = Used dialogue *and* 3 - 4 different intention or emotion words
5 = Used dialogue *and* 5 or more intention or emotion words

Coherence _______ points (max 5)

0 = Subjects < 25% clear
1 = Subjects 26 - 50% clear
2 = Subjects 51 - 84% clear
3 = Subjects > 85% clear
4 = Subjects include 1 - 2 different pronouns *and* > 85% clear
5 = Subjects include 3 or more different pronouns *and* > 85% clear

TOTAL STORY SCORE ________ points (max 20)

Story Quality Scoring Record Form (cont.)

Definitions

Complete Episode consists of (a) an initiating event/emotion, (b) an action, and (c) a direct consequence (Stein & Glenn, 1979).

Action sequence defined as two separate actions in one utterance (single line). Second action cannot be embedded in first action (i.e., Turtle told the boy that the frog kicked little frog). Emotion or state verbs do not count as an action (i.e., Two examples that are NOT action sequences: He was sad and cried. He liked him and reached for him.)

Beginning includes in English: “one day”, “once upon a time”, “once there was”, and in Vietnamese: “hồi xưa”, “một ngày”

End includes in English: “the end”, “they all became friends” (summative statement that includes at least 3 characters) and in Vietnamese: “hết”, “con trai, con chó, và con ếch làm bạn” “cả ba vui”. Exclude picture description such as “they play together” or only 1-2 character’s emotion “the boy was happy” “the big frog and small frog were friends”.

Dialogue defined by a quote directed at another character to include a 2nd person pronoun such as you/me, or a direct command without a subject “don’t do that!.” In Vietnamese, questions without subjects are allowed “có sao không?” (Exclude quotes solely comprised of a sound effect such as “the boy said ah!” or exclamation not directed at another character “the boy said oh no!”).

Emotion words include: happy, sad, jealous, scared, surprised. Exclude observable behaviors such as “crying” or “screaming”.

Intention words include in English: tried, mean to, wanted, hoped to, think/thought, and in Vietnamese: dự định, chuẩn bị, muốn, mong

Clear Subject: 1 subject per utterance. In English, each utterance must include noun or pronoun as subject. Pronouns must refer to a character previously named in the text (i.e., The boy got a present. He opened it.). In Vietnamese, each utterance does not require a subject; an (omitted) subject is ‘clear’ when it was previously mentioned and not obligatory (i.e., Con trai chạy xuống. Bị té.) %clear = # of utterances with clear subjects/ total # of utterances x 100.

Pronoun include in English: she, he, they, it, him, her, and in Vietnamese: nó, ảnh, anh ấy, cậu, chàng, thằng, em.

Appendix G

Taxonomy of First-Order Polynomial Transformations of Time

Model	Power	Transformation	Composite formula	Description
A	-2	$\frac{1}{Time_{ij}^{2}}$	$Y_{ij} = \gamma_{00} + \gamma_{10}\mathrm{TIME}_{ij}^{-2} + (\zeta_{0i} + \zeta_{1i}\mathrm{TIME}_{ij}^{-2} + \varepsilon_{ij})$	Inverse square
B	-1	$\frac{1}{Time_{ij}}$	$Y_{ij} = \gamma_{00} + \gamma_{10}\mathrm{TIME}_{ij}^{-1} + (\zeta_{0i} + \zeta_{1i}\,\gamma_{10}\mathrm{TIME}_{ij}^{-1} + \varepsilon_{ij})$	Inverse
C	-0.5	$\frac{1}{\sqrt{Time_{ij}}}$	$Y_{ij} = \gamma_{00} + \gamma_{10}(1/(\mathrm{TIME}_{ij}^{0.5})) + (\zeta_{0i} + \zeta_{1i}(1/(\mathrm{TIME}_{ij}^{0.5})) + \varepsilon_{ij})$	Inverse square root
D	0	$\log(Time_{ij})$	$Y_{ij} = \gamma_{00} + \gamma_{10}\log(\mathrm{TIME}_{ij}) + (\zeta_{0i} + \zeta_{1i}\log(\mathrm{TIME}_{ij}) + \varepsilon_{ij})$	Log
E	0.5	$\sqrt{Time_{ij}}$	$Y_{ij} = \gamma_{00} + \gamma_{10}(\mathrm{TIME}_{ij}^{0.5}) + (\zeta_{0i} + \zeta_{1i}(\mathrm{TIME}_{ij}^{0.5}) + \varepsilon_{ij})$	Square root
F	1	None	$Y_{ij} = \gamma_{00} + \gamma_{10}\mathrm{TIME}_{ij} + (\zeta_{0i} + \zeta_{1i}\mathrm{TIME}_{ij} + \varepsilon_{ij})$	Linear
G	2	$Time_{ij}^{2}$	$Y_{ij} = \gamma_{00} + \gamma_{10}(\mathrm{TIME}_{ij}^{2}) + (\zeta_{0i} + \zeta_{1i}(\mathrm{TIME}_{ij}^{2}) + \varepsilon_{ij})$	Square

Note. Taxonomy conducted on each dependent measure using univariate random intercept models.

Appendix H

Comparison of Linear and Nonlinear Models

	Vietnamese							English						
PWV ACC	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	573	572	567	556	**549**	**548**	553	617	612	601	**586**	**587**	**594**	605
BIC	584	583	578	567	**560**	**558**	563	627	623	611	**596**	**597**	**604**	616
-2LL	565	564	559	548	**541**	**540**	545	609	604	593	**578**	**579**	**586**	597
R^2	.004	.03	.10	.21	**.26**	**.26**	.23	.007	.05	.15	**.27**	**.29**	**.26**	.19
Adj R^2	-.09	-.06	.02	.13	**.19**	**.19**	.15	-.09	-.04	.07	**.20**	**.22**	**.18**	.11
PWV RT	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	1385	1377	1356	**1320**	**1307**	**1318**	1344	1398	1395	1384	**1359**	**1345**	**1347**	**1361**
BIC	1396	1387	1366	**1330**	**1317**	**1329**	1354	1408	1406	1394	**1370**	**1355**	**1357**	**1371**
-2LL	1377	1369	1348	**1312**	**1299**	**1310**	1336	1390	1387	1376	**1351**	**1337**	**1339**	**1353**
R^2	.03	.10	.24	**.40**	**.44**	**.41**	.32	<.001	.01	.09	**.23**	**.31**	**.31**	**.26**
Adj R^2	-.07	.008	.17	**.35**	**.39**	**.35**	.25	-.10	-.08	.004	**.16**	**.24**	**.24**	**.19**

	Vietnamese							English						
Nam ACC	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	693	682	**666**	**657**	**666**	**677**	691	793	783	756	**701**	**671**	**688**	**731**
BIC	703	692	**676**	**667**	**677**	**687**	701	803	793	766	**711**	**681**	**699**	**741**
-2LL	685	674	**658**	**649**	**658**	**669**	683	785	775	748	**693**	**663**	**680**	**723**
R^2	.18	.28	**.41**	**.47**	**.44**	**.38**	.30	.05	.13	.33	**.56**	**.64**	**.61**	**.50**
Adj R^2	.10	.21	**.35**	**.42**	**.38**	**.32**	.23	-.05	.05	.27	**.52**	**.60**	**.57**	**.45**
Nam RT	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	1373	1373	1373	**1370**	**1366**	**1364**	**1362**	1306	1303	1297	**1288**	**1283**	**1282**	1285
BIC	1383	1384	1383	**1380**	**1376**	**1374**	**1373**	1316	1313	1307	**1298**	**1294**	**1293**	1295
-2LL	1365	1365	1365	**1362**	**1358**	**1356**	**1354**	1298	1295	1289	**1280**	**1275**	**1274**	1277
R^2	<.001	<.001	.007	**.02**	**.04**	**.04**	**0.05**	.03	.06	.11	**.16**	**.17**	**.16**	.13
Adj R^2	-.10	-.10	-.09	**-.07**	**-.06**	**-.05**	**-.04**	-.06	-.03	.02	**.07**	**.08**	**.08**	.05

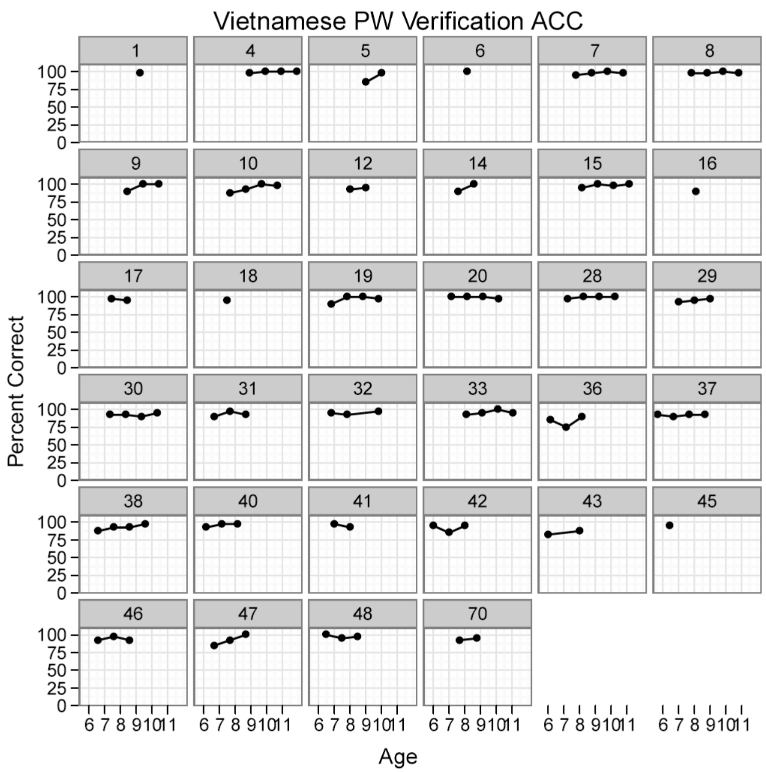
	Vietnamese							English						
Sent Rep	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	752	749	741	**724**	**712**	**709**	**714**	856	853	840	**807**	**779**	**774**	**794**
BIC	763	760	751	**735**	**723**	**719**	**724**	866	863	850	**817**	**790**	**785**	**804**
-2LL	744	741	733	**716**	**704**	**701**	**706**	848	845	832	**799**	**771**	**766**	**787**
R^2	.04	.09	.19	**.29**	**.33**	**.34**	**.32**	.01	..05	.18	**.38**	**.48**	**.49**	**.43**
Adj R^2	-.05	.005	.11	**.22**	**.27**	**.28**	**.26**	-.09	-.04	.10	**.32**	**.43**	**.44**	**.37**
MLU	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	331	331	328	**321**	**317**	**315**	**318**	317	316	309	**295**	**288**	**289**	**297**
BIC	342	341	338	**331**	**327**	**326**	**328**	327	326	319	**306**	**299**	**299**	**307**
-2LL	323	323	320	**313**	**309**	**307**	**310**	309	308	301	**287**	**280**	**281**	**289**
R^2	.02	.06	.13	**.22**	**.25**	**.25**	**.23**	.007	.04	.12	**.24**	**.29**	**.29**	**.24**
Adj R^2	-.07	-.04	.04	**.14**	**.18**	**.18**	**.15**	-.09	-.06	.04	**.17**	**.23**	**.22**	**.17**

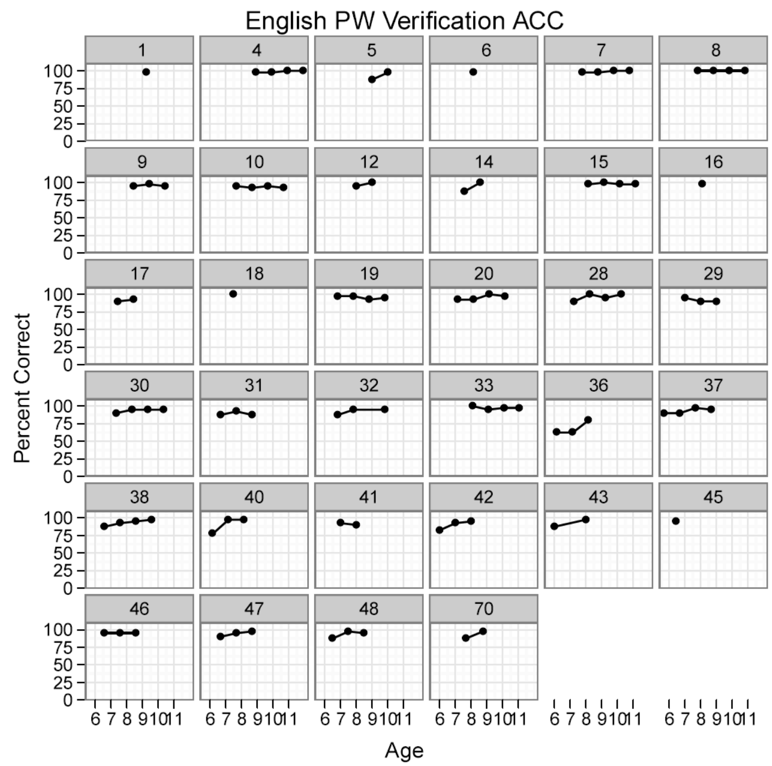
	Vietnamese							English						
Story	-2	-1	-0.5	0	0.5	1	2	-2	-1	-0.5	0	0.5	1	2
AIC	819	818	816	**812**	**811**	**811**	**812**	824	817	**803**	**791**	**794**	**803**	814
BIC	829	828	826	**822**	**821**	**821**	**823**	834	827	**813**	**801**	**804**	**813**	824
-2LL	811	810	808	**804**	**803**	**803**	**804**	816	809	**795**	**783**	**786**	**795**	806
R2	.01	.04	.12	**.22**	**.26**	**.26**	**.24**	.04	.12	**.23**	**.32**	**.31**	**.26**	.17
Adj R2	-.09	-.05	.03	**.14**	**.19**	**.19**	**.16**	-.05	.02	**.16**	**.26**	**.24**	**.19**	.09

Note. Univariate models for all dependent measures in each language were fit to linear and nonlinear transformations: picture word verification accuracy (PWV ACC), picture word verification response time (PWV RT), timed picture naming (Nam ACC), timed picture naming response time (Nam RT), sentence repetition (Sent Rep), mean length of utterance (MLU), and story quality (Story). Models consist of first-order fractional polynomials in order of their power terms: inverse square (-2), inverse (-1), inverse square root (-0.5), log (0), square root (0.5), linear (1) and square (2). See taxonomy of models in Appendix G. Models with potentially good fit are bolded.

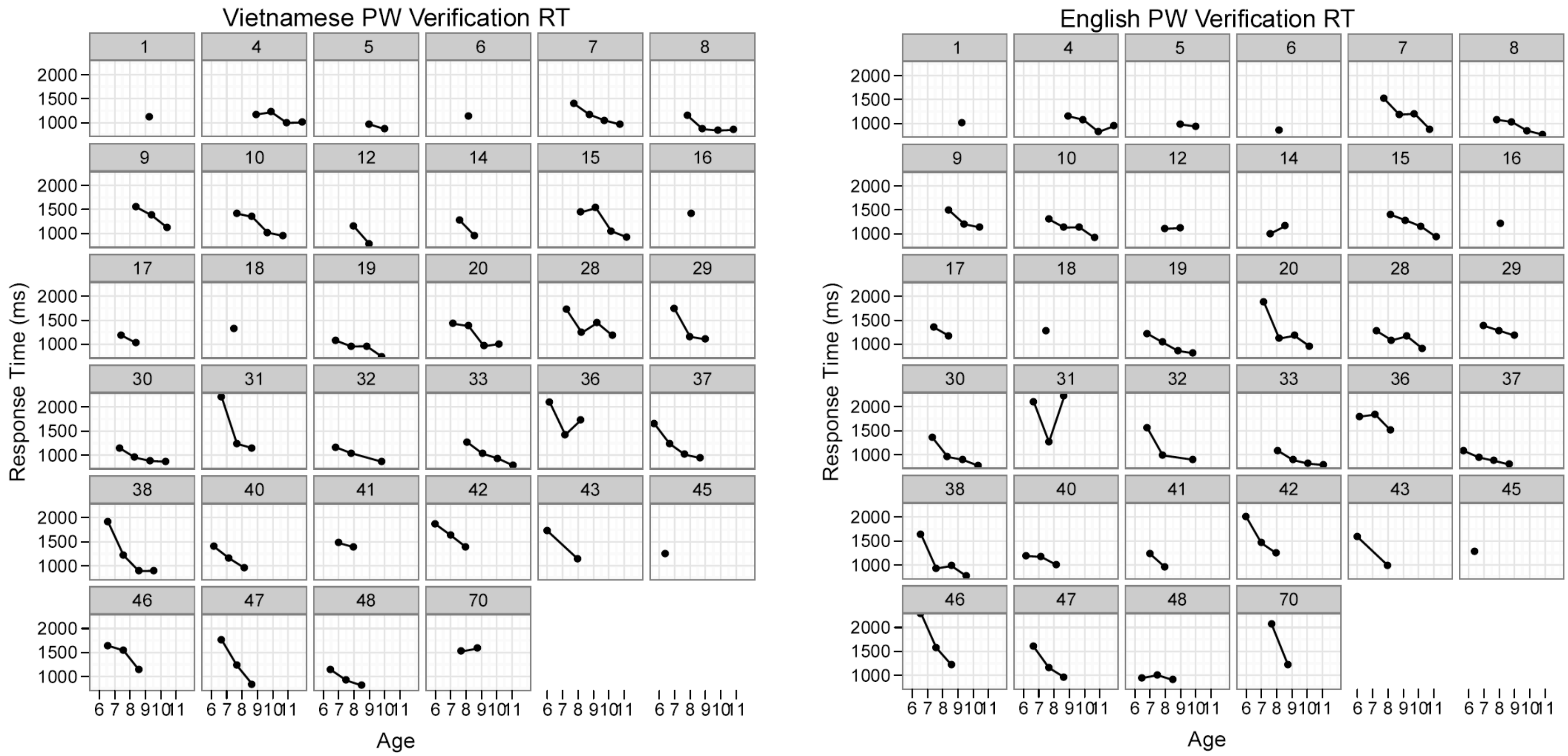
Appendix I

Individual Participant Plots for Each Dependent Measure

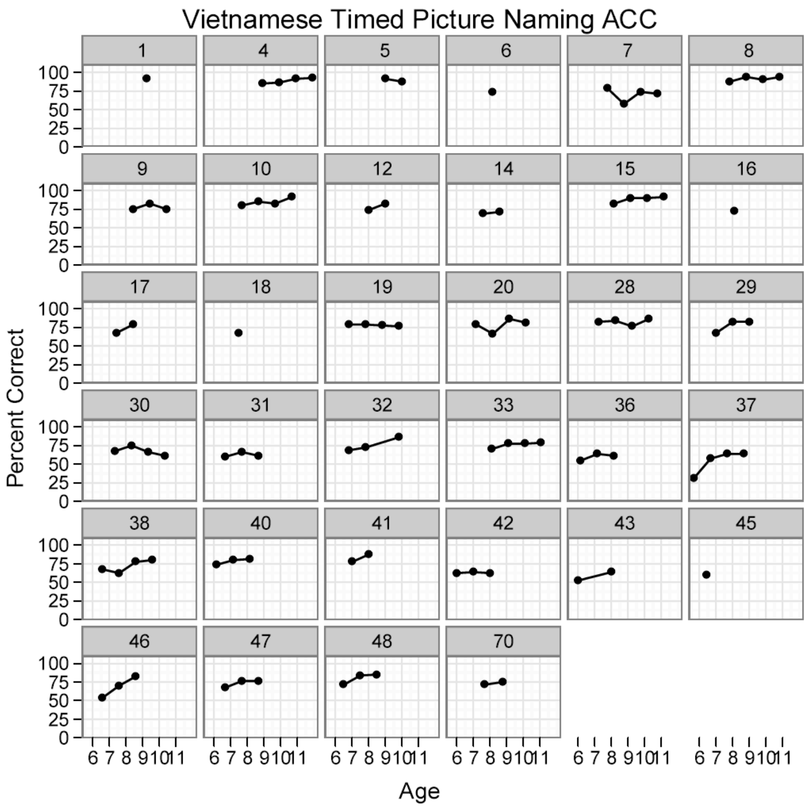


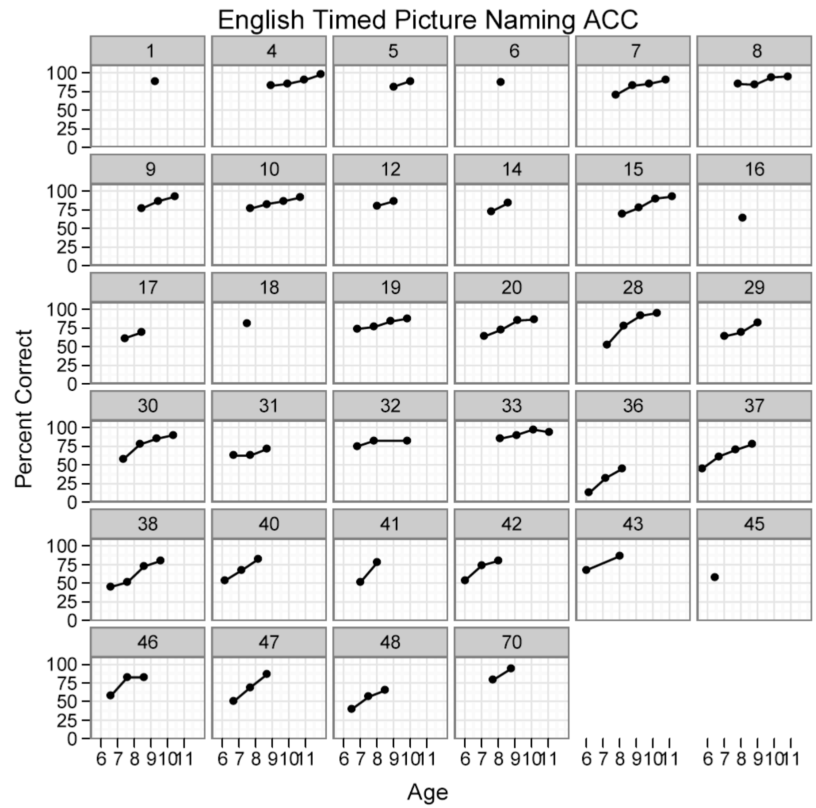


Note. Picture word verification accuracy in Vietnamese and English.

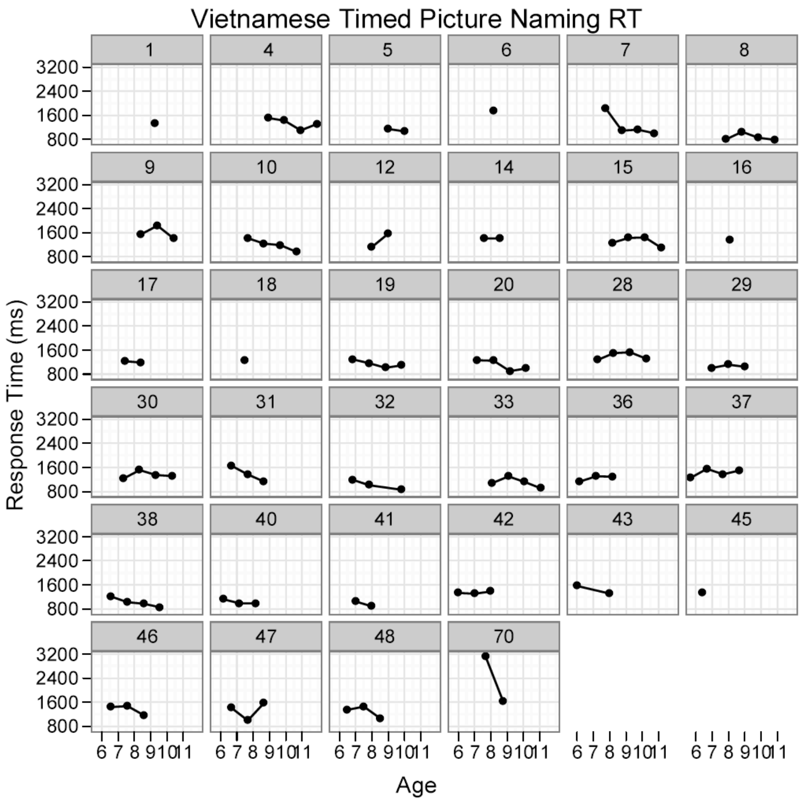


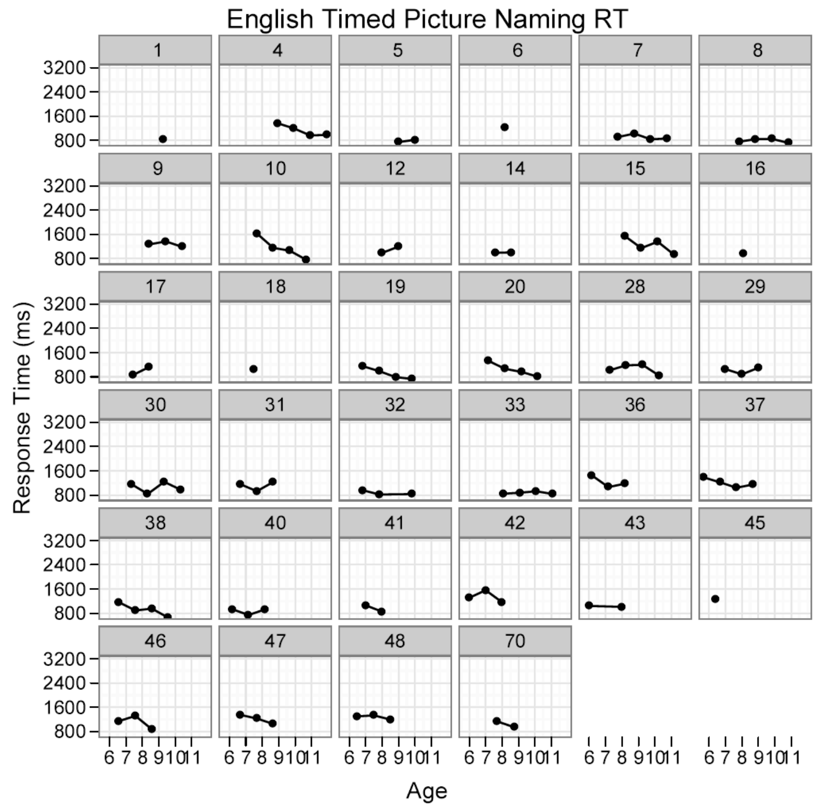
Note. Picture word verification response time in Vietnamese and English.



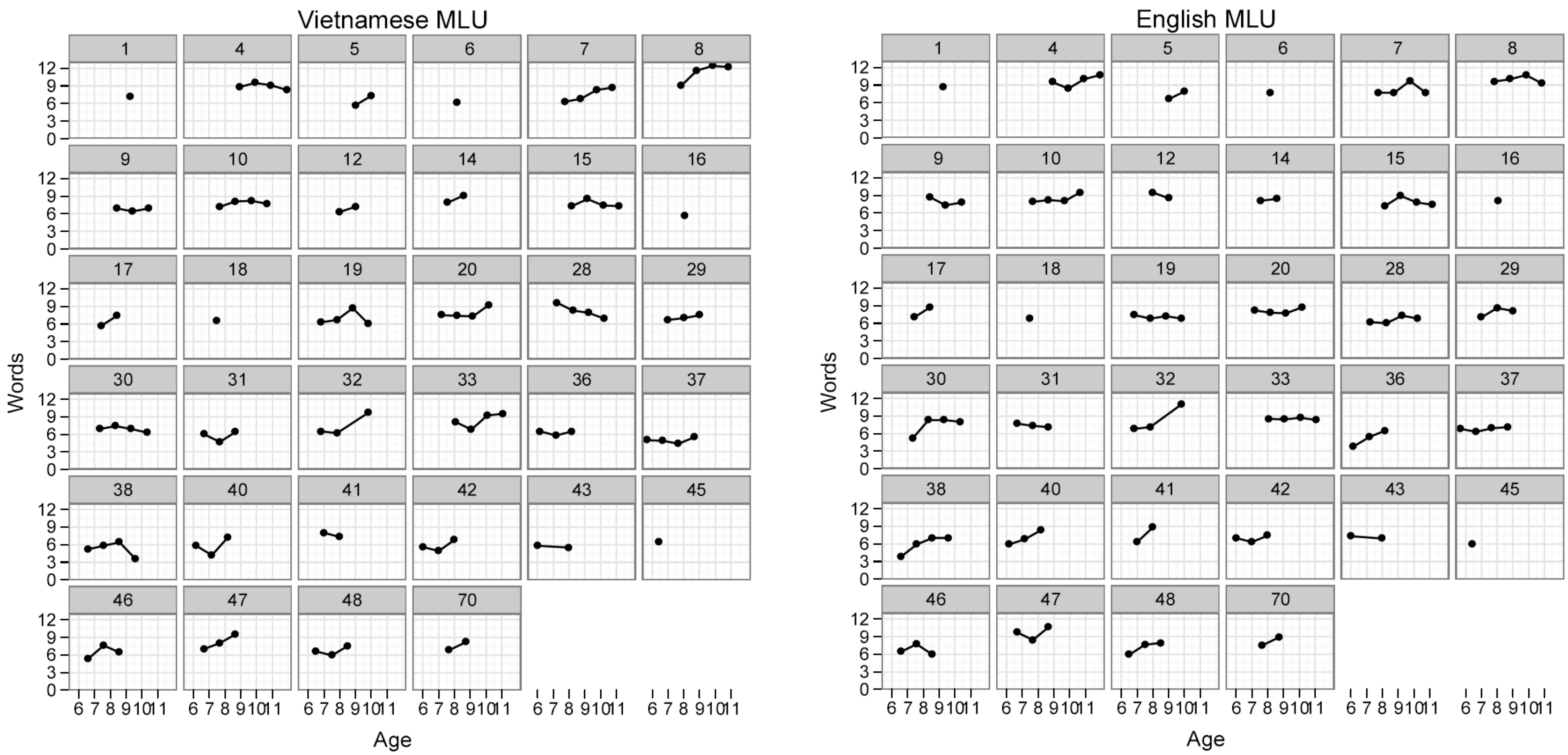


Note. Timed picture naming accuracy in Vietnamese and English.

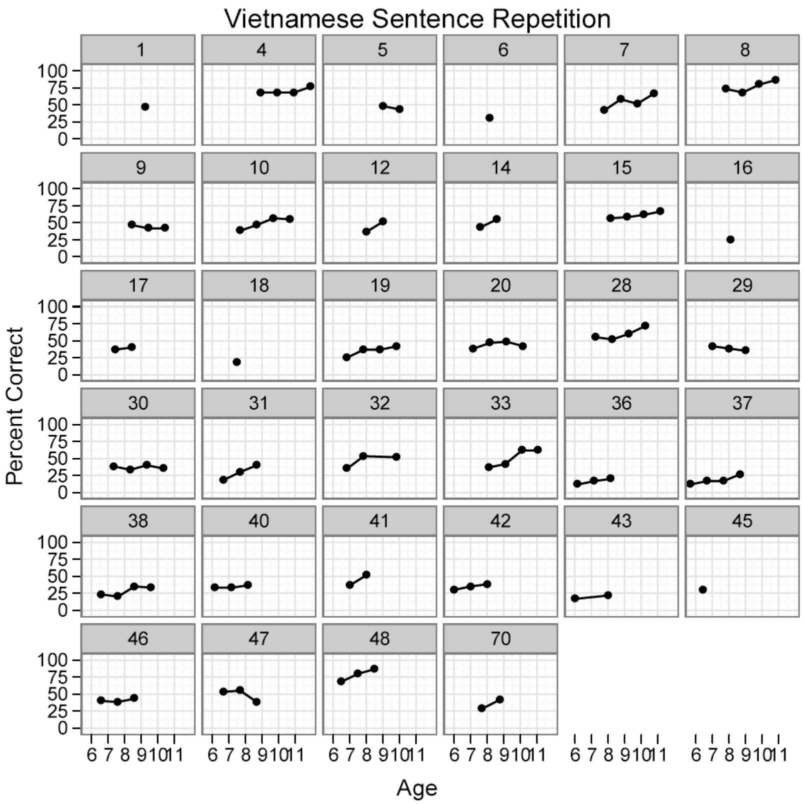


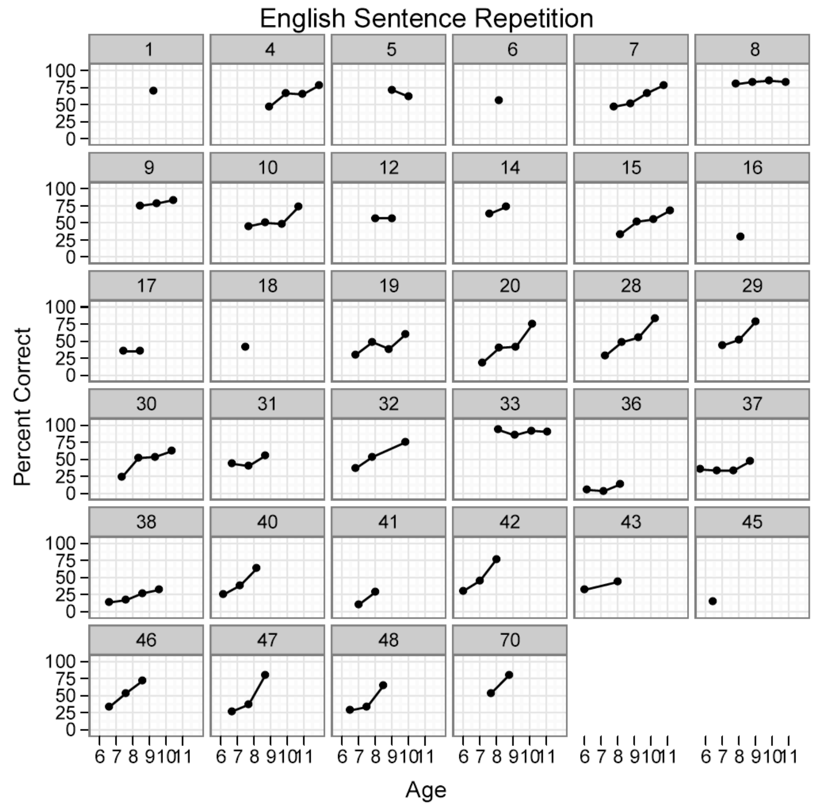


Note. Timed picture naming response time in Vietnamese and English.

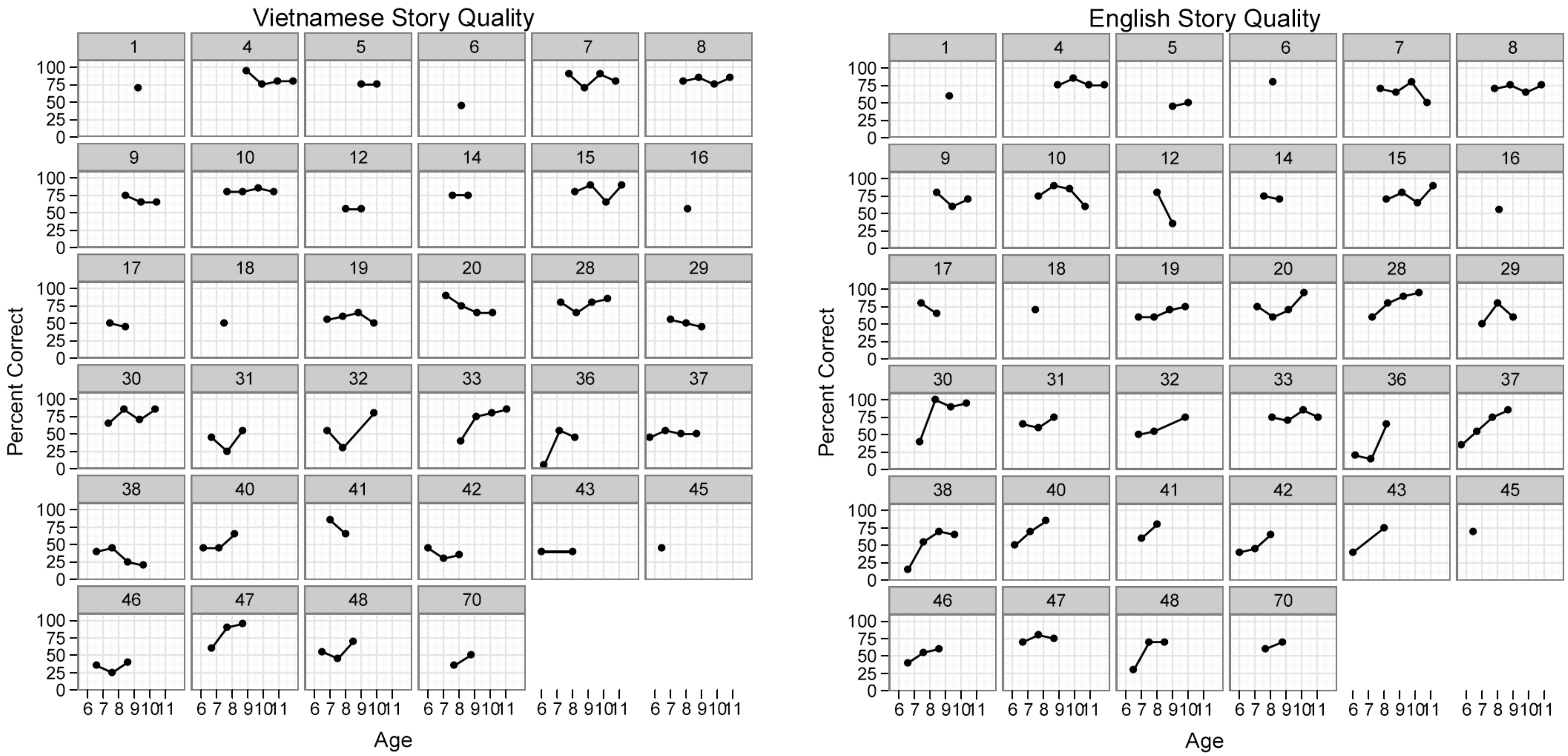


Note. Mean length of utterance in Vietnamese and English.





Note. Sentence repetition in Vietnamese and English.



Note. Story quality in Vietnamese and English.

Appendix J

Intercorrelations of Language Measures at Each Wave

Wave 1 (n = 34)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Age 1	-.11	-.08	.10	.27	.14	.12	**-.56**	**.55**	**-.37**	**.72**	.08	**.70**	-.23	**.50**	**.62**	**.44**	**.49**	**.58**	**.62**
2. Female	---	.26	.28	-.11	**-.37**	.24	.10	.18	.05	-.09	-.12	-.17	.18	.09	-.24	-.14	.01	.11	.02
3. US born	.26	---	-.22	.08	**-.82**	-.28	.26	-.03	.12	-.27	.24	-.01	.04	**-.39**	-.03	-.29	-.01	**-.36**	.00
4. TONI	.29	-.22	---	.10	-.06	**.47**	-.28	.31	-.07	.18	.11	.31	-.13	.18	.02	.11	.23	.32	.14
5. ReLnch	-.09	.10	.08	---	-.03	-.15	-.33	-.01	**-.45**	.30	-.25	.28	**-.46**	.10	.30	.20	.18	.08	.19
6. Age to US	**-.36**	**-.82**	-.08	-.07	---	.14	-.29	-.11	-.25	.25	-.16	-.07	-.13	.34	.02	.20	-.19	.27	-.16
7. V.PWV.ACC	.26	-.27	**.46**	-.19	.12	---	-.35	.34	-.14	.27	-.10	.11	-.09	**.45**	-.02	**.41**	.11	**.41**	.28
8. V.PWV.RT	.05	.26	-.27	-.23	-.26	-.34	---	**-.46**	**.66**	**-.53**	.16	**-.58**	**.38**	**-.45**	**-.40**	-.23	-.30	**-.45**	**-.37**
9. E.PWV.ACC	.29	.02	.31	-.20	-.23	.33	-.22	---	-.28	**.38**	-.03	**.72**	-.18	**.37**	**.46**	.29	**.60**	**.56**	**.59**
10. E.PWV.RT	.01	.10	-.04	**-.39**	-.22	-.10	**.58**	-.10	---	-.34	**.47**	-.24	.29	**-.36**	-.32	-.31	-.17	**-.38**	-.20
11. V.Nam.ACC	-.02	-.31	.16	.16	.22	.27	-.22	-.04	-.12	---	-.08	**.49**	-.23	**.65**	.29	**.57**	.31	**.69**	**.48**
12. V.Nam.RT	-.11	.25	.10	-.28	-.17	-.11	.25	-.09	**.53**	-.20	---	.17	.16	-.15	.08	-.10	.11	-.11	.10
13. E.Nam.ACC	-.12	.07	.34	.13	-.23	.04	-.32	**.57**	.02	-.02	.15	---	**-.38**	.28	**.76**	.29	**.68**	**.45**	**.68**

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
14. E.Nam.RT	.16	.02	-.11	**-.42**	-.10	-.06	.31	-.07	.22	-.09	.18	-.31	---	-.05	**-.42**	-.01	-.09	-.01	-.12
15. V.SentRep	.17	**-.40**	.14	-.05	.32	**.46**	-.24	.12	-.22	**.48**	-.23	-.12	.07	---	.34	**.63**	**.41**	**.65**	.35
16. E.SentRep	-.22	.02	-.06	.18	-.09	-.13	-.08	.18	-.13	-.31	.03	**.58**	**-.37**	.03	---	.28	**.61**	.22	**.52**
17. V.MLU	-.10	-.28	.07	.10	.16	**.40**	.01	.06	-.18	**.40**	-.15	-.02	.10	**.52**	.01	---	**.37**	**.58**	**.50**
18. E.MLU	.08	.03	.21	.05	-.30	.05	-.03	**.46**	.01	-.08	.09	**.54**	.03	.21	**.45**	.20	---	**.47**	**.80**
19. V.story	.22	**-.39**	.32	-.10	.24	**.42**	-.19	**.36**	-.22	**.48**	-.20	.09	.16	**.51**	-.23	**.45**	.26	---	**.57**
20. E.story	.12	.06	.09	.04	-.31	.26	-.04	**.38**	.03	.07	.06	**.45**	.02	.06	.23	.33	**.73**	.34	---

Note. Bivariate correlations on upper diagonal and partial correlations controlling for age on lower diagonal. Correlations with corresponding p-values of $\leq$ 0.05 (two-tailed) are bolded. V = Vietnamese. E = English. Age 1 = chronological age at Wave 1. ReLnch = reduced lunch. TONI = Test of Nonverbal Intelligence, 3rd edition (Brown, Sherbenou, & Johnsen, 1997). PWV = Picture Word Verification. ACC = Accuracy. RT = Response time. Nam = Timed picture naming. SentRep = Sentence repetition. MLU = Mean length of utterance in words. Story = Story quality.

Wave 2 (n = 28)

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Age 2	-.21	-.08	.09	.32	.14	**.52**	-.25	**.45**	-.28	**.57**	.19	**.69**	-.13	**.48**	**.69**	**.62**	**.58**	**.56**	.28
2.	Female	---	.34	.28	-.16	**-.44**	.12	.16	-.02	-.15	-.14	-.37	-.20	-.06	.08	-.31	-.22	.09	-.15	.26
3.	US born	.33	---	-.23	.06	**-.81**	-.07	.15	-.20	.09	-.25	-.07	-.24	-.17	-.32	-.10	-.31	-.19	-.14	-.10
4.	TONI	.31	-.22	---	.11	-.06	.27	-.03	.33	-.30	.09	-.17	.30	-.07	.30	.13	.23	.22	-.15	.17
5.	ReLnch	-.10	.09	.09	---	-.02	.07	**-.53**	-.01	-.04	.27	-.29	.18	-.34	.16	.22	.25	.06	.14	-.08
6.	Age to US	**-.43**	**-.81**	-.08	-.07	---	.10	-.30	.24	-.20	.20	.19	.16	.10	.22	.06	.13	-.03	.15	.12
7.	V.PWV.ACC	.27	-.04	.26	-.13	.03	---	-.26	**.84**	**-.46**	**.40**	.09	**.61**	-.14	**.48**	**.56**	**.39**	**.42**	.24	**.50**
8.	V.PWV.RT	.12	.13	-.01	**-.49**	-.28	-.15	---	-.31	**.56**	-.28	.19	-.11	**.41**	-.27	-.20	-.16	-.23	-.20	-.06
9.	E.PWV.ACC	.08	-.19	.32	-.18	.19	**.80**	-.23	---	**-.57**	**.39**	.12	**.71**	.01	**.55**	**.63**	.34	**.44**	.19	**.50**
10.	E.PWV.RT	-.22	.07	-.28	.06	-.17	**-.38**	**.53**	**-.52**	---	-.29	.19	-.35	**.39**	-.28	-.27	-.14	-.26	-.33	**-.47**
11.	V.Nam.ACC	-.02	-.25	.05	.11	.15	.14	-.18	.19	-.16	---	-.05	**.42**	-.14	**.57**	**.40**	**.55**	**.57**	**.41**	**.45**
12.	V.Nam.RT	-.34	-.06	-.19	**-.38**	.17	-.01	.25	.04	.26	-.20	---	.17	**.53**	-.03	.33	.02	-.07	-.04	-.06
13.	E.Nam.ACC	-.07	-.26	.33	-.06	.09	**.40**	.08	**.62**	-.23	.04	.05	---	-.07	**.44**	**.87**	**.51**	**.59**	.30	**.39**
14.	E.Nam.RT	-.09	-.18	-.06	-.32	.12	-.09	**.39**	.08	.37	-.08	**.57**	.02	---	.14	-.08	-.07	-.21	-.13	-.19

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
15. V.SentRep	.21	-.32	.29	.00	.18	.31	-.18	**.43**	-.17	**.41**	-.15	.18	.23	---	**.42**	**.60**	**.58**	.37	**.42**
16. E.SentRep	-.24	-.06	.09	.00	-.05	.32	-.04	**.50**	-.11	.02	.28	**.74**	.01	.14	---	**.55**	**.58**	.31	.33
17. V.MLU	-.12	-.34	.23	.07	.05	.09	-.01	.09	.05	.31	-.12	.15	.01	**.44**	.21	---	**.70**	**.63**	**.45**
18. E.MLU	.27	-.17	.21	-.16	-.13	.17	-.11	.24	-.12	.36	-.23	.33	-.17	**.43**	.31	**.53**	---	**.47**	**.53**
19. V.story	-.03	-.12	-.24	-.05	.08	-.07	-.08	-.08	-.21	.14	-.18	-.14	-.08	.14	-.12	**.44**	.21	---	**.49**
20. E.story	.34	-.08	.15	-.18	.08	**.43**	.01	**.44**	**-.43**	.37	-.12	.28	-.17	.34	.20	.37	**.47**	**.42**	---

Note. Bivariate correlations on upper diagonal and partial correlations controlling for age on lower diagonal. Correlations with corresponding p-values of $\leq$ 0.05 (two-tailed) are bolded. V = Vietnamese. E = English. Age 2 = chronological age at Wave 2. ReLnch = reduced lunch. TONI = Test of Nonverbal Intelligence, 3rd edition (Brown, Sherbenou, & Johnsen, 1997). PWV = Picture Word Verification. ACC = Accuracy. RT = Response time. Nam = Timed picture naming. SentRep = Sentence repetition. MLU = Mean length of utterance in words. Story = Story quality.

Wave 3 (n = 22)

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Age 3	.08	.02	.13	.21	-.07	**.60**	-.24	.34	-.19	**.58**	-.08	**.63**	.00	**.62**	**.43**	**.57**	**.54**	**.59**	.16
2.	Female	---	.21	.34	-.19	-.29	.25	**-.44**	.26	.06	.40	-.27	-.01	-.14	.17	.10	-.06	.13	.15	-.01
3.	US born	.21	---	-.28	.19	**-.80**	-.06	.01	-.14	.08	-.19	.06	-.10	-.09	**-.44**	-.13	-.17	.05	-.08	-.06
4.	TONI	.34	-.28	---	.20	-.01	.21	-.33	**.52**	-.22	**.43**	**-.54**	.21	**-.54**	.35	.04	.21	.24	.09	.08
5.	ReLnch	-.21	.19	.18	---	-.23	.24	.20	-.05	-.19	.15	-.28	.18	**-.43**	.10	.01	.41	.26	.28	.26
6.	Age to US	-.29	**-.80**	.00	-.22	---	-.07	.07	.01	-.09	-.04	.22	.00	.37	.33	.03	-.05	-.14	.12	.34
7.	V.PWV.ACC	.26	-.09	.17	.15	-.04	---	-.33	**.43**	-.27	**.68**	-.19	**.55**	-.25	**.62**	**.51**	**.68**	**.59**	**.70**	.11
8.	V.PWV.RT	**-.43**	.02	-.31	.26	.05	-.24	---	**-.65**	**.52**	**-.50**	.40	**-.43**	.35	-.38	-.31	-.36	**-.50**	-.35	-.15
9.	E.PWV.ACC	.24	-.16	**.52**	-.13	.04	.30	**-.63**	---	**-.61**	**.49**	-.10	**.72**	-.38	.40	.41	.32	**.51**	.41	.26
10.	E.PWV.RT	.07	.08	-.20	-.15	-.11	-.20	**.50**	**-.59**	---	**-.43**	.08	-.41	.40	-.24	-.17	-.31	-.37	-.25	-.16
11.	V.Nam.ACC	**.44**	-.25	**.44**	.04	.00	**.51**	**-.45**	.38	-.40	---	**-.44**	**.48**	-.28	**.71**	.35	**.58**	**.42**	.37	-.17
12.	V.Nam.RT	-.26	.07	**-.53**	-.27	.22	-.19	.39	-.08	.07	**-.49**	---	.01	**.61**	-.28	.01	-.31	-.13	.11	.20
13.	E.Nam.ACC	-.08	-.15	.17	.06	.06	.28	-.37	**.69**	-.38	.18	.07	---	-.25	.39	**.65**	**.49**	**.48**	**.46**	.28
14.	E.Nam.RT	-.14	-.09	**-.54**	**-.44**	.37	-.32	.36	-.41	.40	-.34	**.61**	-.31	---	-.01	-.09	-.37	-.25	-.10	.03

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
15. V.SentRep	.16	**-.57**	.35	-.03	**.48**	.39	-.30	.26	-.17	**.54**	-.29	.00	-.01	---	**.49**	**.67**	**.51**	**.56**	.09
16. E.SentRep	.08	-.16	-.01	-.09	.07	.35	-.24	.31	-.10	.13	.05	**.53**	-.09	.31	---	**.53**	**.56**	.39	-.02
17. V.MLU	-.12	-.22	.17	.37	-.02	**.51**	-.28	.16	-.26	.37	-.32	.21	**-.44**	**.49**	.38	---	**.81**	**.65**	.05
18. E.MLU	.11	.05	.21	.18	-.12	.40	**-.45**	.42	-.33	.16	-.10	.21	-.30	.26	.43	**.72**	---	**.73**	.21
19. V.story	.13	-.12	.02	.20	.20	**.53**	-.26	.27	-.17	.05	.19	.15	-.11	.31	.19	**.47**	**.61**	---	**.55**
20. E.story	-.02	-.07	.06	.23	.35	.02	-.12	.22	-.14	-.33	.22	.24	.03	-.01	-.10	-.05	.15	**.57**	---

Note. Bivariate correlations on upper diagonal and partial correlations controlling for age on lower diagonal. Correlations with corresponding p-values of ≤ 0.05 (two-tailed) are bolded. V = Vietnamese. E = English. Age 3 = chronological age at Wave 3. ReLnch = reduced lunch. TONI = Test of Nonverbal Intelligence, 3rd edition (Brown, Sherbenou, & Johnsen, 1997). PWV = Picture Word Verification. ACC = Accuracy. RT = Response time. Nam = Timed picture naming. SentRep = Sentence repetition. MLU = Mean length of utterance in words. Story = Story quality.

Wave 4 (n = 13)

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Age 4	.07	-.06	.18	.41	-.04	.53	.09	.49	.40	**.57**	-.18	**.89**	-.08	**.78**	**.66**	.50	.44	**.66**	-.14
2.	Female	---	.50	.25	-.18	**-.60**	-.04	.07	-.05	.37	.11	-.16	-.31	.19	-.14	-.11	-.03	.30	-.15	-.36
3.	US born	.51	---	-.05	.03	**-.74**	-.07	-.37	.04	-.10	-.12	.01	-.28	.19	-.13	-.29	-.27	-.06	-.33	-.37
4.	TONI	.24	-.04	---	.32	-.30	.23	.30	.24	.26	.40	-.05	.07	-.02	.29	.09	.28	**.59**	-.11	-.39
5.	ReLnch	-.23	.05	.27	---	-.13	.32	-.04	.17	.14	.43	-.28	.53	-.31	**.64**	**.66**	.51	.39	.40	-.49
6.	Age to US	**-.60**	**-.75**	-.30	-.13	---	.00	.46	-.01	.02	-.23	.39	.24	.11	-.05	.14	-.13	-.22	.30	**.57**
7.	V.PWV.ACC	-.10	-.05	.16	.13	.03	---	.43	.47	**.66**	**.76**	-.24	.50	-.42	**.60**	.28	.16	.20	.21	-.07
8.	V.PWV.RT	.07	-.36	.29	-.08	.47	.45	---	.41	**.61**	.22	.41	.19	.23	.25	.17	-.08	-.05	.18	.24
9.	E.PWV.ACC	-.10	.07	.18	-.03	.01	.28	.42	---	.16	.32	-.09	.49	-.10	**.66**	.37	.32	-.04	.19	.00
10.	E.PWV.RT	.37	-.08	.21	-.02	.05	.58	**.63**	-.05	---	.50	.10	.31	.11	.34	.41	.22	.35	.39	.11
11.	V.Nam.ACC	.09	-.11	.37	.26	-.25	**.65**	.20	.06	.36	---	-.44	.52	-.43	**.71**	.43	.46	.51	.31	-.12
12.	V.Nam.RT	-.15	.00	-.02	-.23	.39	-.17	.43	.00	.19	-.42	---	-.01	**.82**	-.24	-.19	-.46	-.31	.03	.49
13.	E.Nam.ACC	**-.81**	-.51	-.20	.40	.61	.06	.25	.15	-.12	.03	.34	---	-.07	**.84**	**.76**	.50	.24	**.74**	.05
14.	E.Nam.RT	.19	.19	-.01	-.31	.10	-.45	.24	-.08	.15	-.47	**.82**	.01	---	-.17	-.04	-.14	-.02	.24	.38

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
15. V.SentRep	-.31	-.14	.25	.56	-.03	.35	.29	.52	.04	.52	-.17	.51	-.17	---	**.76**	**.69**	.36	**.68**	-.16
16. E.SentRep	-.20	-.34	-.04	.57	.23	-.11	.15	.07	.21	.09	-.10	.50	.02	.52	---	**.83**	.44	**.85**	.03
17. V.MLU	-.08	-.27	.22	.39	-.13	-.15	-.15	.10	.02	.25	-.43	.13	-.12	.54	**.77**	---	**.63**	**.68**	-.07
18. E.MLU	.30	-.04	**.58**	.26	-.23	-.04	-.10	-.33	.21	.35	-.26	-.36	.02	.05	.23	.53	---	.40	-.19
19. V.story	-.26	-.38	-.30	.19	.44	-.22	.16	-.20	.18	-.11	.20	.45	.40	.34	**.73**	.53	.17	---	.18
20. E.story	-.35	-.38	-.38	-.47	.57	.00	.26	.07	.18	-.05	.47	.39	.37	-.09	.17	.00	-.14	.37	---

Note. Bivariate correlations on upper diagonal and partial correlations controlling for age on lower diagonal. Correlations with corresponding p-values of ≤ 0.05 (two-tailed) are bolded. V = Vietnamese. E = English. Age 4 = chronological age at Wave 4. ReLnch = reduced lunch. TONI = Test of Nonverbal Intelligence, 3rd edition (Brown, Sherbenou, & Johnsen, 1997). PWV = Picture Word Verification. ACC = Accuracy. RT = Response time. Nam = Timed picture naming. SentRep = Sentence repetition. MLU = Mean length of utterance in words. Story = Story quality.