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Factors That Influence Fast Mapping in Children Exposed to Spanish and English

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Abstract

Purpose—The purpose of this study was to determine if children exposed to two languages would benefit from the phonotactic probability cues of a single language in the same way as monolingual peers and to determine if cross-linguistic influence would be present in a fast mapping task.

Method—Two groups of typically-developing children (monolingual English and bilingual Spanish-English) took part in a computer-based fast mapping task which manipulated phonotactic probability. Children were preschool-aged (N = 50) or school-aged (N = 34). Fast mapping was assessed through name identification and naming tasks. Data were analyzed using mixed ANOVAs with post-hoc testing and simple regression.

Results—Bilingual and monolingual preschoolers showed sensitivity to English phonotactic cues in both tasks, but bilingual preschoolers were less accurate than monolingual peers in the naming task. School-aged bilingual children had nearly identical performance to monolingual peers.

Conclusions—Knowing that children exposed to two languages can benefit from the statistical cues of a single language can help inform ideas about instruction and assessment for bilingual learners.

Keywords

bilingual; word learning; phonotactic probability; children

Word learning is an essential skill for academic success; successful vocabulary instruction leads to increased comprehension (e.g. Stahl & Fairbanks, 1986). Unfortunately, academic outcomes for children designated as English Language Learners in the United States are lower than outcomes for monolingual peers (e.g. Genesee, Lindholm-Leary, Saunders, & Christian, 2005). The purpose of this study was to determine if children who are exposed to Spanish and English fast map novel English words differently than children who are exposed primarily to English. More specifically, we sought to determine if certain types of words are easier or more challenging for bilingual children to learn compared to monolingual children.

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Word learning for monolingual children

The first step in word learning is fast mapping, in which a lexical labels is mapped to a semantic referent after only one to three exposures to the referent (Carey, 1978). Fast mapping does not always directly mirror outcomes during slow mapping, in which children have more exposures to a novel word, and are thought to strengthen their representations of the word (e.g. Gray & Brinkley, 2011; Horst & Samuelson, 2008, but see Capone & McGregor, 2005). However, if bilingual children do have different outcomes for word learning, it is essential to know at which point in the process the differences emerge.

Recent word learning research suggests that children are sensitive to the implicit linguistic patterns of their native language. Through statistical learning, children pick up on patterns in their language without even trying (e.g. Saffran, Newport, Aslin, Tunick, & Barrueco, 1997). Sensitivity to the statistical regularities of linguistic patterns influences the speed and accuracy of word learning. Numerous implicit factors influence word learning, but the pattern of interest in this study was phonotactic probability - the probability of the order of occurrence of particular speech sounds within syllables and words (Vitevitch, Luce, Charles-Luce, & Kemmerer, 1997). There is no doubt that phonotactic probability does not act in isolation (e.g. Capone Singleton, in press; Hoover, Storkel, & Hogan, 2010). However, for this study we focused on the main effect of phonotactic probability and not possible interactions. Phonotactic probability is important because there are predictions for how it influences monolingual learners.

There is a limited number of word learning studies that address the main effect of phonotactic probability. However, studies suggest that words with high phonotactic probability provide an advantage over words with low phonotactic probability for monolingual children in word learning tasks (Storkel, 2001; 2003; Storkel & Maekawa, 2005). This advantage has also been found for fast mapping tasks, even when neighborhood density is controlled (Alt, 2011). Neighborhood density is the number of words that differ from a given word by only one phoneme (Storkel & Hoover, 2010). However, seemingly contradictive evidence does exist. For example, Gray and Brinkley (2011) recently found low phonotactic probability advantages for preschoolers in slow mapping tasks, but not in fast mapping tasks. Storkel and Lee (2011) found low probability advantages for a word learning task, but were only able to report on the recognition portion of the task, as their four-year-old participants had floor effects for production tasks. Thus, phonotactic probability effects appear to be task dependent, and may be influenced by the age of the participant. As a measure of implicit learning, a child's sensitivity to phonotactics provides an opportunity to examine bilingual word learning, because children acquiring two languages are exposed to two different patterns of phonotactic probability that may or may not overlap.

Word learning in bilingual children

One might predict that typically-developing bilinguaml children would learn new words in the same way as typically-developing monolingual children because they are all unimpaired learners. However, bilinguals may experience cross-linguistic influence due to their knowledge of two languages. Cross-linguistic influence is the systematic influence of one language on the other language during acquisition which can result in differences in the patterns of language development for children exposed to two languages (Paradis & Genesee, 1996). Although cross-linguistic influence seems to be the exception and not the rule of bilingual language acquisition, the notion of interaction among two developing languages deserves consideration.

Cross-linguistic influences have been well-documented in the literature for expressive phonology (e.g., Fabiano-Smith & Goldstein, 2010; Kehoe, Lleó, & Rakow, 2004; Schnitzer & Krasinski, 1996) and syntax (e.g., Döpke, 2000; Gathercole, 2007; Gawlitzek-Maiwald & Tracy, 1996; Müller & Hulk, 2001; Paradis & Navarro, 2003; Paradis & Genesee, 1996). For example, Fabiano-Smith and Goldstein (2010) found evidence of bilingual Spanish-English children using the English aspirated voiceless stop in Spanish productions of initial voiceless stops and using the Spanish unaspirated voiceless stop in productions of English. Döpke (2000) found English-influenced errors that appeared in bilingual English-German children's German in relation to verb position, the position of negations and modal participles, and the use of finite verb markings. These types of word order errors are reportedly not common in monolingual German speakers.

Given the evidence of cross-linguistic influence in syntax and phonology, combined with evidence of smaller language-specific vocabularies for bilingual children (Bialystok, Luk, Peets, & Yang, 2010), it makes sense to examine if bilingual children might be subject to cross-linguistic influences during novel word learning.

One of the most common models of bilingual language acquisition, Genesee's Dual Systems model (1989), suggests separate systems for each language. Given separate systems, a bilingual child would, theoretically, learn a new word in one language in the same way as a monolingual peer. Theory, however, is cleaner than practice. Although evidence from the literature favors a Dual Systems model of language acquisition, there is ample evidence that adults who are bilingual are influenced by using two languages. This might manifest in terms of the cognitive benefits (e.g. executive control advantages) and linguistic costs (e.g. smaller language –specific vocabulary; increased lexical retrieval times) reported for adult bilinguals (Bialystok & Craik, 2010) compared to adult monolinguals. So, although each language may be primarily separate, these findings suggest that it would be inaccurate to assume they did not have any influence on one another. It is simply a natural side effect of having access to two linguistic systems that likely share neural architecture (De Bleser et al., 2003; Perani & Abutalebi, 2005).

The Competition Model, as explained by Hernandez, Li, and MacWhinney (2005) acknowledges dual activation across languages that can, initially, allow for "intrusion", or influence, of one language upon the other. However, once a child has had adequate exposure that allows her to strengthen language-specific connections, the amount of cross-linguistic influence experienced is minimal. The key question is: what constitutes adequate exposure? Although we know bilingual infants are sensitive to the phonotactic patterns of two languages (e.g. Sebastián-Gallés & Bosch, 2002), and that infants can pick up on non-native implicit information within minutes (e.g. Gerken, Wilson, & Lewis, 2005), we do not have information on how this affects their word learning, or on how older children who may be exposed to their second language later in life will respond to different phonotactic probabilities. Simply put, the literature does not yet provide adequate information on what constitutes sufficient exposure to phonotactics to overcome the possibility of cross-linguistic influence in word learning. We also do not have a specific model for how, precisely, cross-linguistic influence would manifest in word learning. However, the results of Messer, Leseman, Boom and Mayo (2010) would support the idea that cross-linguistic influence might lead to a muted phonotactic probability effect. In their study, bilingual children showed greater advantages for high probability nonwords in their dominant language, and muted effects for high probability nonwords in their nondominant language in a nonword repetition task.

Gollan, Montoya, Fennema-Notestine, and Morris (2005) have suggested that being bilingual is equivalent to "having a lexicon full of lower frequency words, relative to monolinguals" (p. 1220) with the low frequency due to relative lack of practice with each language's words. Although they were discussing vocabulary, the same principle could apply, in theory, to using implicit statistical rules like phonotactic probability. It is possible that in the early stages of bilingual language acquisition there is more cross-linguistic influence, due to lack of adequate exposure, which results in differences in the way monolingual and bilingual children react to language-specific patterns, like phonotactic probability.

The Current Study

This study examines fast mapping - a component of word learning- in a bilingual population. This information will allow us to determine if the unique profiles that exist in bilingual nonword repetition tasks extend to tasks that involve label-referent pairing and word recognition. By examining the effects of phonotactic probability on fast mapping we hope to better understand how statistical learning works when a child is exposed to two sets of phonotactic probabilities. Because the literature on bilingual learners provides evidence of both linguistic separation and cross-linguistic influence, it is unclear how exposure to two languages, and therefore two sets of phonotactic probabilities, may affect the fast mapping component of the word learning process.

It seems clear from the broader literature that bilingual individuals have notable distinctions from monolinguals in terms of both language and cognitive profiles (e.g. Bialystok & Craik, 2010). Therefore, our first hypothesis was that children who were exposed to Spanish and English would show a unique learning profile compared to monolingual learners due to cross-linguistic influences. We were specifically interested in examining the effect of English phonotactic probability on bilingual learners. Our hypothesis was that, compared to monolingual children, children exposed to Spanish and English might show muted phonotactic probability effects, thus showing less of a difference in accuracy between high and low probability words than monolingual peers. Given that exposure is predicted to be the key to overcoming cross-linguistic interaction, we also predicted that greater exposure to English would result in greater fast mapping accuracy of English-like nonwords.

Method

Participants

This study followed all guidelines of the human subjects' protection program required by the University of Arizona's Institutional Review Board. Two groups of children participated in the current study: fifty 4–5-year-old preschool children and thirty-four 7–8-year-old children. Children were classified as either functionally monolingual (exposed primarily to English) or bilingual (exposed to both Spanish and English). Because our research question was concerned with implicit learning of phonotactic probability patterns, children were described as functionally mono- or bilingual based on their language exposure, and not on their language proficiency (details to follow). Children were recruited from Tucson, Arizona, a community in which Spanish is spoken in the homes of 29% percent of the population (American Community Survey, 2006). Children were recruited from Head Start centers, preschools, elementary schools, and after-school programs. All children were matched for age (4–5s: $t = .09$, $p = .92$; 7–8s: $t = -.67$, $p = .50$), gender, and maternal level of education (4–5s: $t = 1.65$, $p = .10$; 7–8s: $t = .86$, $p = .39$). The demographics of the preschool monolingual group were: 15 White, 4 Black/African American, 1 Alaska Native and 5 not reported. Thirteen participants reported their ethnicity as Hispanic, 10 as not Hispanic, and 2 were not reported. The bilingual preschool group's demographics were: 6 White, 1 Alaska Native, 1 multi-racial, and 17 not reported. Twenty-four participants reported their ethnicity as Hispanic, and one did not report ethnicity. The demographics for the school-aged monolingual group were: 11 White, 1 Black/African American, 1 multi-racial, and 4 not reported, with ethnicity breakdowns of 5 Hispanic, 10 not Hispanic and 2 not reported. The demographics for the bilingual school-aged group were: 8 White and 9 not reported, with ethnicity breakdowns of 14 Hispanic and 3 not Hispanic.

Inclusionary Criteria

Parents completed a questionnaire that was modified from one provided by Restrepo (personal communication, 2006). Using a sum of those responses, we derived a language profile score (see Appendix A). Based on this score, children were characterized as monolingual or bilingual. The score included information about parents' native language, child's native language, language at school combined with two language difference scores based on how much Spanish versus English the child hears at home and at school. All five values were summed and the resulting number (ranging from −9 to 9) was the language profile score. Values for the first three items (parents' native language, child' native language, and school language) ranged from −1 to 1, with −1 representing Spanish only, 1 representing English only, and 0 representing both Spanish and English. For example, on parents' native languages, a score of −1 indicated that both parents reported Spanish as their native language. A score of 1 indicated that both parents reported English as their native languages. A score of 0 indicated that one parent's native language was English and one parent's native language was Spanish, or that both parents reported both Spanish and English as their native languages. Values for the last 2 items (language heard at home and language heard at school) ranged from −3 to 3, with −3 representing a child hearing primarily Spanish and 3 representing a child hearing primarily English. These two items were given more value than the other items in order to emphasize language exposure, not just output. Parents reported how much of each language children heard using a 4-point scale (e.g. never, sometimes, most of the time, all the time). If parents reported that their child was exposed to any language other than English and Spanish, the child was excluded from the study (n = 11).

We also wanted to ensure that all children were typically-developing. Therefore, we excluded any children whose parents reported concerns about their child's development (n = 28), who did not pass a hearing screening (n = 10), who had a history of receiving speech or language services (n = 19) or who reported a history of other developmental or acquired disorders (n = 18). In order to ensure that the English-speaking 4-and 5-year-olds had typical language skills, we tested them using the Structured Photographic Expressive Language Test- III (SPELT-III) (Dawson, Stout, & Eyer, 2003). This test has a sensitivity of 90% and a specificity of 100% when a cut-off of 95 is used (Perona, Plante, & Vance, 2005). Any English-speaking children who scored below 95 were excluded from the study (n = 20). Children involved in the study were highly intelligible in their typical conversational speech. One monolingual child was excluded, despite testing as having normal language skills, due to speech skills deemed impaired by the research team.

The SPELT-III is not a valid measure to identify disordered language in children who are not native English-speakers. Thus far, there are no widely-recognized standardized measures which are appropriate for that task (Dollaghan & Horner, 2011). Therefore, in order to ensure our bilingual children had typical language abilities, we used a two-pronged approach. We excluded children based on parental report of language concerns and we used language sample analyses based on a story retell of Mercer Mayer's picture book entitled *Frog Where Are You* (1969). The story was told to participants using the English and Spanish scripts provided in the SALT manual (Miller & Iglesias, 2006) on different days, with dialectical modifications made for the Mexican-Spanish speakers in our population. Children were given the opportunity to retell the story in both English and Spanish, and their highest score was used to gauge their language ability. Transcriptions were broken into modified communication units and analyzed for mean length of utterance in words (MLUW) and percentage of utterances with grammatical errors using the Systematic Analysis of Language Transcription (SALT) software (Miller & Iglesias, 2006). The particular units of analysis were chosen based on findings indicating that they were promising for discriminating Spanish-speaking children with language disorders from those with typical language skills (Simon-Cerejido & Gutiérrez-Clellen, 2007). We used the Texas ELL database from the SALT program as our comparison database for the Spanish story retells and either the Texas ELL or San Diego Narrative Retell database for our analyses of the English story retells. Children were compared to peers within 6 months of their age range whenever possible. Children were excluded when their MLUW was below one standard deviation from the mean and/or the percent errors in their overall sample was not commensurate with the average of the normative sample. There were two exceptions to this rule. Two children were included who had low error rates, but MLUW scores that fell below the 1SD range (−1.44, −1.67) for their Spanish story retells. Given that SALT's Texas ELL database's youngest participants are 5 years, 5 months, and many of our participants were significantly younger than this, we relied on clinical judgment for these cases. By excluding children with low MLUW and high error rates (n = 13), we ensured that the children in our sample had unambiguously typical language skills. (See Table 1 for details on participant characteristics.)

Finally, we also included a descriptive measure of the preschool children's English vocabulary. We used the Peabody Picture Vocabulary Test-IV (Dunn & Dunn, 2007). We did not assess Spanish vocabulary because our research question was focused on how children would learn nonwords that were English-like.

Because the SPELT-III does not have sensitivity/specificity data available for older children, we used language sample analyses to ensure typical language skills for both monolingual and bilingual school-aged children. The monolingual children retold the story in English only and the bilingual children retold the story in both Spanish and English. We used the same exclusionary criteria as we did for the preschool participants (n = 17).

Due to timing differences in the onset of data collection for each age group, we used a different descriptive measure for the vocabulary for the older children. For this age group, we chose to capture their overall, rather than language specific, vocabulary levels. Therefore, we used the Receptive One-Word Picture Vocabulary Test (Brownell, 2000) and the Expressive One-Word Picture Vocabulary Test (Brownell, 2000). We administered the standard edition to the monolingual children and the bilingual edition (Brownell, 2001) to the bilingual children. Administration of the bilingual edition followed the guidelines provided in the manual. (See Table 2 for details on participant characteristics.)

Stimuli Construction

We created 24 nonwords for children to learn. The nonwords were constructed to be English-like, in order to mirror the English-only classroom situations many bilingual children face. Phonemes, syllable shape, syllable structure, and stress were manipulated to make the nonwords as English-like as possible.

Nonwords were constructed to use phonemes that were part of English and not part of Spanish, whenever possible. Many nonwords contained consonant sounds that carry linguistic meaning in English but not in most dialects of Spanish such as /z/(Brice & Brice, 2007). Most of the nonword stimuli used in this task contain vowels that appear in English and not in Spanish such as lax vowels or schwas (Goldstein, 2001). Although there are phonemes that are unique to each language, the languages also share many phonemes. For this reason, we also manipulated syllable structure. Nonwords were built to have consonant clusters and final consonants, both of which are more common in English than in Spanish (Eddington, 2000). Finally, we used English stress patterns for all multi-syllabic words, rather than syllable-timing.

In order to test the hypothesis about phonotactic probability, the 24 nonwords were broken into short (1–2 syllable) and long (3–4-syllable) nonwords which were contrasted for English phonotactic probability. (See Appendix B for a list of the nonwords). Words of differing lengths were used to be more representative of academic vocabulary words. Words were not contrasted for length, because longer words tended to have higher phonotactic probability, thus confounding length and phonotactic probability. Phonotactic probability was calculated using summed biphone probabilities using the Phonotactic Probability Calculator (Vitevitch & Luce, 2004). Given that we had words of different lengths, we used a z-score conversion (Storkel, 2004a) to code the words as common or rare. The probabilities were significantly different from one another (High x = 1.041, SD = .009; Low x = 1.009, SD = .004; t = −.1138, p < .001). The average z-score for both the short and long high probability nonwords was .91, and was −.91 for both the short and long low probability words. To control for neighborhood density, mostly multi-syllabic nonwords (18 of 24) that had no neighbors in English (or Spanish) were used. Of the six single-syllable nonword labels, the three high phonotactic probability nonwords had a combined total of 15 neighbors (x = 5.0, range = 4–7), and the three low phonotactic probability nonwords had a combined total of 16 neighbors (x = 5.33, range = 4–8).

Three nonword foils were constructed for each target nonword for use in the name identification task by modifying the target using three basic manipulations. One foil was generated from an initial consonant change (either an omission, cluster reduction, or cluster creation by a consonant addition), one foil was generated from a final consonant change (substitution or omission), and one foil was generated by modifying (reducing) the syllable structure. For single syllable nonwords, the foil resulting from the syllable reduction was the nonword without the initial consonant cluster (i.e., target: /tɹɪv/, foils: /tɪv/, /tɹɪd/, /ɪv/). All nonword foils remained phonotactically legal in English.

Game Design

Children were asked to help a paleontologist and his forgetful assistant catalog new dinosaurs. The task took place on a computer screen. Children saw an animation of a novel dinosaur walking across a scene and eating something. During the animation, which lasted approximately 10 seconds, children would hear the name of the novel dinosaur two times, allowing them to map the dinosaur to the lexical referent. Immediately following the presentation of each dinosaur, children took part in a name identification task. While viewing a snapshot of the dinosaur, they were asked to indicated whether or not that was the dinosaur's name, and prompted to select either "Yes" or "No" on a button box. Children made a yes/no judgment about four nonwords per dinosaur, using their dominant hand. Three of the nonwords were foils and one of the nonwords was the correct name. The children heard these in random order and did not receive feedback on the accuracy of their responses so as not to influence the following response. They were not made aware of the ratio of correct to incorrect choices. The next choice would be presented only when a child made a decision. If they were unsure, they were asked to make their best guess. The name identification task was followed by the naming task. The paleontologist's assistant finally admitted he just could not remember the name and needed the child to tell him the dinosaur's name. Children were asked to produce the correct name of the dinosaur in order to have a more complete metric of how well they fast mapped each new word. Then the next dinosaur was presented and the entire process was repeated for each of the 24 dinosaurs. If children did not label the dinosaur, even after being prompted to guess, a "no response" was recorded by the examiner, who then advanced the game. Preschool-age children viewed 24 dinosaurs over 2 sessions, while school-age children typically saw all 24 dinosaurs in one session.

Training

In order to make sure children understood the task, they were given a training that modeled the task and provided explicit feedback. After the children were told the story of the paleontologist and his forgetful assistant, they tried the game using a familiar animal (a dog). For each yes/no response on the name identification task, they received feedback about whether they were right or wrong. If they were wrong, they heard the name again, and were given another chance. If they provided an incorrect response or no response when asked to say the name, they were presented with the stimulus again. Then, they progressed to two real dinosaurs, and were given decreasing feedback. If the children got all the components correct (given second chances to take out the influence of memory) on the last training item, then they were allowed to proceed to the experimental portion. Children who did not pass the training were excluded from the study (preschool n = 2; school-aged n = 0).

Accommodating language differences

All research teams included native Spanish-speaking research assistants. Therefore, there was always someone available to communicate with or explain a task to the children who were dominant Spanish-speakers. The training task was in English, because we wanted it to be clear that the nonwords children would learn would be English nonwords. However, the Spanish-speaking research assistants translated the training into Spanish if a child did not respond initially to the prompts in English, to ensure that the children understood the task. No child needed a translation of the prompts beyond the training. The experimental task itself was also in English, but language was limited to the following phrases that were repeated: “Look! It’s a X. I see a X.” “Is it a X?” and “What’s its name?”.

Procedures

After receiving the appropriate permissions, children were tested at their schools, afterschool programs, homes, or the University of Arizona over the course of 2–4 sessions by teams of trained research assistants. The initial session always started with a hearing screening, and was then followed in quasi random order by the language testing, the training and the experimental task. The SPELT-III and the story retells were audio recorded to allow for interrater reliability and transcription, respectively. The experimental task was presented on a laptop computer, using DirectRT software (Jarvis, 2006). Children listened to the stimuli on headphones. Their responses for the name identification task were recorded via the computer when the child pressed a button on a large button box. The responses for the naming task were audio recorded for later transcription by researchers trained in phonetic transcription. Children received stickers and small prizes or certificates for participating in the tasks.

Scoring

For the name identification task, the dependent variable was the child’s accuracy at correctly accepting the dinosaur’s real name and correctly rejecting the foils. Accuracy determinations were made via computer based on the child's button press. Recall that each word had a correct label and three foils. There were 24 nonwords total, so for each level of phonotactic probability, a child was making 48 decisions (12 nonwords x 4 choices).

For the naming task, the dependent variable was percent consonants correct (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). Audio recordings of the child's productions were transcribed by two trained researchers. Interrater reliability averaged 95.05% (range 83.88% – 100%) for the preschoolers and 96.6% (range 88.54% – 100%) for the school-aged children. Any discrepancies were resolved by a third listener. A production was considered correct if it was perceived as an allophone of the target phoneme, and was not identified as another phoneme in English, with the exception of clear developmental errors (e.g. /w/for /r/).

Interrater reliability was calculated for 10% of the standardized tests administered. The average reliability was 98.33% (SPELT-III), 99.25% (ROWPVT), and 100% (PPVT-IV, EOWPVT). All language samples were double-scored at three stages: gross transcription, breaking into C-units (or modified C-Units), and identification of errors. To pass to the next stage, we had to achieve a minimum reliability of 90%, or a triple-scorer was brought in. Average reliability ratings across all three stages were 97%.

Results

4–5 year olds: Name identification task

In order to test differences between the groups on the name identification task, we ran a mixed ANOVA with group (monolingual, bilingual) as the between group variable and phonotactic probability (high, low) as the within group variable. There was no main effect for group, $F(1, 48) = 1.63$, $p = .20$, $\eta_p^2 = .03$, but there was a significant main effect for phonotactic probability, $F(1, 48) = 4.82$, $p = .03$, $\eta_p^2 = .09$. The predicted interaction (group by phonotactic probability) did not reach significance, $F(1, 48) = 2.42$, $p = .12$, $\eta_p^2 = .04$. Children were more accurate on high phonotactic probability words (X = 69.08%, SD = 12.91%) than on low phonotactic probability words (X = 66.76%, SD = 12.56%).

4–5 year olds: Naming task

In order to test differences between the groups on the naming task, we ran a mixed ANOVA with group (monolingual, bilingual) as the between group variable and phonotactic probability (high, low) as the within group variable. There were significant main effects for group, $F(1, 48) = 11.72$, $p < .001$ $\eta_p^2 = .19$, and phonotactic probability, $F(1, 48) = 17.79$, $p < .001$, $\eta_p^2 = .27$. There was no significant interaction between group and phonotactic probability, $F(1, 48) = .567$, $p = .45$, $\eta_p^2 = .01$. The monolingual children (X = 51.88%, SD = 15.60%) were more accurate than the bilingual children (X = 37.29%, SD = 14.44%) overall, and children were more accurate on high (X = 48.74%, SD = 18.45%) versus low phonotactic probability words (X = 40.44%, SD = 17.61%).

7–8 year olds: Name identification task

We repeated the same name identification analyses with the older children. There was no main effect for group, $F(1, 32) = 1.70$ p = .20 $\eta_p^2 = .05$. There was a significant main effect for phonotactic probability, $F(1, 32) = 19.31$, p < .001, $\eta_p^2 = .37$, with results in the expected directions. Children were more accurate on high probability words (X = 88.25%, SD = 6.68%) than on low probability words (X = 83.54%, SD = 6.12%). There were no significant interactions between group and phonotactic probability, $F(1, 32) = .176$, p = .67 $\eta_p^2 = .005$.

7–8 year olds: Naming task

We repeated the naming analyses with the older children. The results were similar to the name identification task results. There was no main effect for group, $F(1, 32) = .039$, p = .84, $\eta_p^2 < .01$. There was a main effect for phonotactic probability, $F(1, 32) = 35.69$, p < .001, $\eta_p^2 = .52$, but no interaction between group and phonotactic probability, $F(1, 32) = 1.40$, p = .24, $\eta_p^2 = .04$. All children were more accurate on high phonotactic probability words (X = 81.67% SD = 9.22%) than on low phonotactic probability words (X = 69.48% SD =11.55%)

Exposure and performance

We predicted that more exposure to English would predict better fast mapping due to more exposure to the patterns of English phonotactics. To test this, we ran a forward stepwise multiple regression to see if the language profile score we used to determine if a child was monolingual or bilingual would predict performance on the overall task. Age was also incorporated as a predictor variable. We ran separate regressions for the monolingual and bilingual participants.

Not surprisingly, given the limited range of language profile scores for the monolingual group, language profile score did not predict outcomes on either of the experimental measures. However, age did [Name identification: Adjusted $R^2 = .901$, $F(1,40) = 377.59$, p < .001; Age $\beta = .95$, $t = 19.43$, $p < .001$; Naming Adjusted $R^2 = .388$, $F(1,40) = 27.08$, p < .001; Age $\beta = .635$, $t = 5.20$, $p < .001$]. Older children were more accurate.

However, both variables were predictive of performance for the name identification task for the bilingual children [Adjusted $R^2 = .852$, $F(2, 39) = 119.20$, p < .001]. Both predictor variables were significant (Age $\beta = .815$, $t = 11.83$, $p < .001$; Language Profile Score $\beta = .194$, $t = 2.82$, $p = ..007$). The findings were the same for the naming task [Adjusted $R^2 = .655$, $F(2, 39) = 40.06$, p < .001]. Again, both predictor variables were significant (Age $\beta = .620$, $t = 5.86$, $p < .001$; Language Profile Score $\beta = .312$, $t = 2.97$, $p = .005$). Older children and children who had more exposure to English had higher scores on the experimental tasks.

In addition to phonotactic processing, motor practice producing English phonemes could facilitate naming of these nonwords. Therefore, we considered whether the proportion of shared English and Spanish phonemes contained in each nonword would affect naming accuracy. We only examined this for the preschoolers, because they were the only group to show differences in naming accuracy. Nonwords were analyzed for shared phonemes, specifically consonants, because only consonants were scored in the naming task. The range of shared consonants for each of the 24 nonwords was 0 – 100%. There was a high proportion of shared consonants for all the high probability nonwords, so only the low probability words were analyzed to avoid a confound with phonotactic probability. Nonwords were broken into three categories of shared consonants: 66–100% shared (n = 3); 40–50% shared (n = 4); and 0–25% shared (n = 5). Using a one-way Analysis of Variance with unequal N post hoc testing ($F(2, 9) = 5.56$, $p = .026$, $\eta_p^2 = .552$), we found that bilingual preschoolers were more accurate at producing words with the highest percentage of shared consonants (M = 48%, SD=6.6%) than those with the lowest percentage of shared consonants (M = 24.45%, SD = 13.67%). Monolinguals did not show an effect of shared Spanish/English consonants ($F(2, 9) = 3.75$, $p = .065$, $\eta_p^2 = .454$), which indicates that these words were not simply easier overall (high: M = 63.42%, SD = 7.89%; low: 41.61%, SD=11.76%), although there was a trend in this direction.

Discussion

Recall that our purpose was to determine if bilingual children would show unique learning profiles in regards to English phonotactics, and whether exposure to English would result in better performance on fast-mapping English-like nonwords. We found that there were between-group differences for preschool children, but not for school-aged children. Bilingual preschoolers were as accurate as monolingual preschoolers on name identification, but they were less accurate than monolingual peers at naming novel words. All children benefitted from high probability nonwords on both tasks. For both age groups, the amount of exposure to English predicted overall performance, with greater accuracy linked to more English exposure.

Therefore, we did not find support for unique learning profiles. The findings of near-identical performance for monolingual and bilingual school-aged children are certainly consistent with the Dual Systems Model (Genesee, 1989) which predicts that each language will develop independently in bilingual children. The bilingual preschooler's scores on the naming task were lower than monolingual peers, but their pattern of performance was identical. Their overall performance on the name identification task was equivalent to peers. This study does not provide evidence for cross-linguistic influence of phonotactic patterns on word learning.

Given the null findings, it is difficult to interpret what this means in terms of the Competition Model, as explained by Hernandez et al. (2005). We did not find evidence of competition, or cross-lingusitic influence. However, the model allows for a lack of cross-linguistic influence in the case that children have had enough exposure to the language to overcome the competition, or the influence of one language one the other. This could be interpreted as our participants having had enough exposure to both languages so as not to experience the influence of one language on the other during a fast mapping task. This would imply that 'enough' exposure happens relatively quickly – certainly by preschool. However, to support this claim, we would need to find a group of either younger children or children who were newly exposed to English and verify the presence of competition, or cross-linguistic influence, in that group. Given that we did not have such a group, we have no evidence to support cross-linguistic influence.

Individual differences are often important in studies of learning and individuals grouped together under the heading ‘bilingual’ tend to be famously heterogeneous. Therefore, we sought to examine a possible predictor of overall performance on our tasks. Our hypothesis was that greater familiarity with the phonotactics of the novel words would lead to better outcomes overall. In other words, greater exposure to English would lead to better fast mapping.

We looked at all participants to see if overall exposure to English predicted outcomes. It did, for both tasks. The more English exposure a child had, as determined by our Language Profile Score, the more likely he or she was to do well on these particular tasks. At first it might be easy to dismiss this as a side-effect of the bilingual preschoolers’ relative lack of practice with the phonemes needed for accuracy in the naming task. However, recall that this analysis included the school-aged children as well, and the results were still significant. Therefore motor practice alone cannot explain why increased exposure to English predicted improved accuracy on the naming task. It certainly cannot explain the outcomes for the name identification task. It seems that more exposure to the language in which one must learn novel words appears to help, at least in the initial fast mapping phase. The amount of exposure may be the difference between implicit knowledge of phonotactic patterns resulting in a facilitative versus a competition effect, particularly in a metalinguistic task like the name identification task. In other words, those children who have had enough language-specific strengthening of cues no longer experience “intrusion” or cross-linguistic influence (Hernandez et al., 2005). Even researchers who have documented cross-linguistic interference suggest that interference will become less pronounced as children gain access to a sufficient amount of information in each language (Gathercole, 2007). Please recall that, although we can explore these findings related to exposure in the context of the Competition Model, we did not find evidence of group-level cross-linguistic influence. Although this study was not designed to determine how much exposure is sufficient to yield a learning profile like that of a monolingual child, it does seem clear that exposure to the language of the words to be learned is a key component in fast mapping success. Given that exposure predicted overall outcome, but not specifically phonotactic difference scores, we know that the exposure to English must influence fast mapping beyond the implicit learning of phonotactic patterns.

The role of phonotactic probability for all children

We found that high phonotactic probability nonwords were more facilitative to fast mapping than low probability nonwords for both age groups and both tasks. However, as noted earlier, the literature is equivocal on the role of phonotactic probability. There have been instances where low phonotactic probability nonwords have been more facilitative for children (Gray & Brinkley, 2011; Storkel & Lee, 2011). A direct comparison of studies is difficult due to methodological differences, but some factors bear examination, including the role of neighborhood density, age, and task demands. First, neighborhood density is unlikely to be the cause of our findings, given that our high and low phonotactic probability words were matched for neighborhood density.

Advantages for high and low probability effects are quite mixed in the literature with regard to the age of the participants. However, the results from this study show facilitative effects for high probability words for both preschool and school-aged children, with effect sizes actually increasing for the older children. If, in children, these effects vary with age, some of the differences in findings might be due to age differences in the samples. For example, our preschool group’s mean age was at least 7 months older (and up to 16-months older) than the participants in Gray and Brinkley’s (2011) and Storkel and Lee’s (2011) studies. It is not unreasonable to think that there might be a developmental continuum for how children process novel words. This idea is bolstered by the finding that age had a significant, if small, predictive role in determining the phonotactic difference scores for the name identification task.

One must also consider task effects. The literature is mixed in terms of which types of tasks elicit phonotactic probability effects. While many studies have found effects for production tasks, fewer have found effects for word recognition tasks, and the direction of that effect differs by study (Storkel & Lee, 2011- low advantage; Storkel & Maekawa, 2005- high advantage). To clarify, our high probability advantage was found for both production and identification tasks, with stronger effects for the production task. Our task was a fast mapping task. Some of the findings for low probability advantage have only been found in slow mapping, not fast mapping tasks (Gray & Brinkley, 2011). Storkel and Lee’s tasks provided children with at least 8 exposures to the novel words, as compared to our 3 exposures. It is quite possible that the effects of phonotactic probability change across the word learning process with fast mapping performances benefitting more from high probability words and slow mapping performance being enhanced by low probability words.

Limitations

The current study was cross-sectional, but much could be learned by addressing our research questions within a longitudinal design. It may be the case that the changes we saw between our preschoolers and school-aged children were not representative of changes that typically occur with age, but are somehow reflective of our particular sample. We would like to make comparisons to the literature on this point, but given that this is the first study we know of to directly measure how children in these age groups respond to fast mapping of language-specific patterns in a word learning task, we cannot do so.

We did not have a measure of the precise phonotactic frequency of these nonwords in Spanish. We did try to make them as English-like as possible, and the fact that the English-speaking children responded to them as predicted supports that they served their function. Certainly, there is great potential to examine learning using language-specific stimuli that reflect the patterns of other languages, such as Spanish. Also, our sample consisted of children with typical language skills. In terms of overall accuracy, our school-aged children were equivalent, and our bilingual preschoolers were only less accurate than monolingual peers on the naming task. Although our group is representative of our community in terms of education, race, and ethnicity, we deliberately chose children with unambiguously typical language skills. Other bilingual children with a more heterogeneous language ability profile may show more of an effect of the cognitive demands of working with the statistical patterns of two languages.

Future Directions

Future directions based on this work might include testing whether teaching strategies based on findings from monolingual speakers also benefit bilingual children. Additionally, given the overall similarity in performance between groups, responsivity to English phonotactic patterns might have diagnostic potential. For example, if a bilingual child, particularly one who has had a fair amount of exposure to English, shows unusual word learning patterns, this may be an indication of a language disorder, rather than a language difference. Clearly, there are questions about how much exposure to each language would be sufficient and whether or not there is too much individual variability for this to be a useful measure.

Summary

There is much to learn about how children exposed to two languages react when learning novel words in their second language. As one of the first studies examining bilingual fast mapping, these results shed light on the process and show that bilingual school-aged children may treat the task very much like monolingual children, with no evidence of cross-linguistic influence. The clinical implications are that, for children who match our participants in terms of age, grade, and language exposure, clinicians do not need to worry about the effects of English phonotactic probability on the word learning of bilingual children.

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References

Alt M. Phonological working memory impairments in children with specific language impairment: Where does the problem lie? Journal of Communication Disorders. 2011; 44:173–185. [PubMed: 20943232]

American Community Survey. 2006. Retrieved January 24, 2008, from http://factfinder.census.gov/servlet/STTable?_bm=y&-geo_id=16000US0477000&-qr_name=ACS_2006_EST_G00_S1603&-ds_name=ACS_2006_EST_G00_

Bialystok E, Craik FIM. Cognitive and linguistic processing in the bilingual mind. Current Directions in Psychological Science. 2010; 19:19–23.

Bialystok E, Luk G, Peets KF, Yang S. Receptive vocabulary difference in monolingual and bilingual children. Bilingualism: Language and Cognition. 2010; 13:525–531.

Brice, AE.; Brice, RG. The ASHA Leader. 2007. A Tale of Two Languages.

Brownell, R. Expressive one-word picture vocabulary test. Novato, CA: Academic Therapy Publications; 2000.

Brownell, R. Receptive one-word picture vocabulary test. Novato, CA: Academic Therapy Publications; 2000.

Brownell, R. Expressive one-word picture vocabulary test: Spanish-Bilingual Edition. Novato, CA: Academic Therapy Publications; 2001.

Brownell, R. Receptive one-word picture vocabulary test: Spanish-Bilingual Edition. Novato, CA: Academic Therapy Publications; 2001.

Capone NC, McGregor KK. The effect of semantic representation on toddlers' word retrieval. Journal of Speech, Language, and Hearing Research. 2005; 48:1468–1480.

Capone Singleton N. Can semantic enrichment lead to naming in a word extension task? American Journal of Speech Language Pathology. (in press). 10.1044/1058-0360(2012/11-0019)

Carey, S. The child as word learner. In: Halle, M.; Bresnan, J.; Miller, G., editors. Linguistic theory and psychological reality. Cambridge, MA: MIT Press; 1978. p. 264-293.

Dawson, JI.; Stout, CE.; Eyer, JA. Structured Photographic Expressive Language Test. 3. DeKalb, IL: Janelle Publications; 2003.

De Bleser R, Dupont P, Bormans G, Speelman D, Mortelmans L, Debrock M. The organization of the bilingual lexicon: A PET study. Journal of Neurolinguistics. 2003; 16:439–456.

Dollaghan CA, Horner EA. Bilingual language assessment: A meta-analysis of diagnostic accuracy. Journal of Speech, Language, and Hearing Research. 2011; 54:1077–1088.

Döpke S. Generation of and retraction from cross-linguistically motivated structures in bilingual first language acquisition. Bilingualism: Language and Cognition. 2000; 3:209–226.

Dunn, LM.; Dunn, DM. Peabody Picture Vocabulary Test. 4. Minneapolis: Pearson Assessments; 2007.

Fabiano-Smith L, Goldstein BA. Phonological acquisition in bilingual Spanish- English speaking children. Journal of Speech, Language, and Hearing Research. 2010; 53:160–178.

Gathercole VCM. Miami and North Wales so far and yet so near: A constructivist account of morphosyntactic development in bilingual children. The International Journal of Bilingual Education and Bilingualism. 2007; 10:224–247.

Gawlitzek-Maiwald I, Tracy R. Bilingual bootstrapping. Linguistics. 1996; 34:901–926.

Genesee F. Early bilingual development: One language or two? Journal of Child Language. 1989; 16:161–180. [PubMed: 2647777]

Genesee F, Lindholm-Leary K, Saunders W, Christian D. English language learners in US schools: An overview of research findings. Journal of Education for Students Placed at Risk. 2005; 10:363–386.

Gerken L, Wilson R, Lewis W. Infants can use distributional cues to form syntactic categories. Journal of Child Language. 2005; 32:249–268. [PubMed: 16045250]

Goldstein B. Transcription of Spanish and Spanish-influenced English. Communication Disorders Quarterly. 2001; 23:54–60.

Gollan TH, Montoya RI, Fennema-Notestine C, Morris SK. Bilingualism affects picture naming but not picture classification. Memory and Cognition. 2005; 33:1220–1234. [PubMed: 16532855]

Gómez R. Variability and detection of invariant structure. Psychological Science. 2002; 13:431–435. [PubMed: 12219809]

Gray S, Brinkley S. Fast mapping and word learning by preschoolers with specific language impairment in a supported learning context: Effect of encoding cues, phonotactic probability, and object familiarity. Journal of Speech, Language, and Hearing Research. 2011; 54:870–884.

Hernandez, A.; Li, P.; MacWhinney, B. Department of Psychology, Paper 210. 2005. The emergence of competing modules in bilingualism.

Hoover JR, Storkel HL, Hogan T. A cross-sectional comparison of the effects of phonotactic probability and neighborhood density on word learning by preschool children. Journal of Memory and Language. 2010; 63:100–116. [PubMed: 20563243]

Horst JS, Samuelson LK. Fast mapping but poor retention by 24-month-old infants. Infancy. 2008; 13:128–157.

Jarvis, BG. Direct RT Precision Timing Software [computer software]. New York: Empirisoft; 2006.

Kehoe M, Lleó C, Rakow M. Voice onset time in bilingual German-Spanish children. Bilingualism: Language and Cognition. 2004; 7:71–88.

Mayer, M. Frog, Where are You?. New York: Dial Books; 1969.

Messer MH, Leseman PPM, Boom J, Mayo AY. Phonotactic probability effect in nonword recall and its relationship with vocabulary in monolingual and bilingual preschoolers. Journal of Experimental Child Psychology. 2010; 105:306–323. [PubMed: 20116805]

Miller, J.; Iglesias, A. Language Analysis Lab. University of Wisconsin-Madison; 2006. Systematic Analysis of Language Transcripts (SALT), English & Spanish (Version 9) [Computer Software].

Müller N, Hulk A. Cross-linguistic influence in bilingual language acquisition: Italian and French as recipient languages. Bilingualism: Language and Cognition. 2001; 4:1–21.

Paradis J, Genesee F. Syntactic acquisition in bilingual children: Autonomous or interdependent? Studies in Second Language Acquisition. 1996; 18:1–25.

Paradis J, Navarro S. Subject realization and cross-linguistic interference in the bilingual acquisition of Spanish and English: What is the role of the input? Journal of Child Language. 2003; 30:371–393. [PubMed: 12846302]

Perani D, Abutalebi J. The neural basis of first and second language processing. Current Opinion in Neurobiology. 2005; 15:202–206. [PubMed: 15831403]

Perona K, Plante E, Vance R. Diagnostic accuracy of the structured photographic expressive language test: third edition (SPELT-3). Language, Speech, and Hearing Services in Schools. 2005; 36:103–115.

Saffran JR, Newport EL, Aslin RN, Tunick RA, Barrueco S. Incidental language learning: Listening (and learning) out of the corner of your ear. Psychological Science. 1997; 8:101–105.

Schnitzer M, Krasinski E. The development of segmental phonological production in a bilingual child: A contrasting second case. Journal of Child Language. 1996; 23:547–571.

Sebastián-Gallés N, Bosch L. Building phonotactic knowledge in bilinguals: Role of early exposure. Journal of Experimental Psychology: Human Perception and Performance. 2002; 28:974–989. [PubMed: 12190262]

Shriberg LD, Austin D, Lewis BA, McSweeny JL, Wilson DL. The percentage of consonants correct (PCC) metric: extensions and reliability data. Journal of Speech, Language, and Hearing Research. 1997; 40:708–722.

Simon-Cerejido G, Gutiérrez-Clellen VF. Spontaneous language markers of Spanish language impairment. Applied Psycholinguistics. 2007; 28:317–339.

Stahl SA, Fairbanks MM. The effects of vocabulary instruction: A model-based meta-analysis. Review of Educational Research. 1986; 56:72–110.

Storkel HL. Learning new words: Phonotactic probability in language development. Journal of Speech, Language, and Hearing Research. 2001; 44:1321–37.

Storkel HL. Learning new words II: Phonotactic probability in verb learning. Journal of Speech, Language, and Hearing Research. 2003; 46:1312–23.

Storkel HL. Methods for minimizing the confounding effects of word length in the analysis of phonotactic probability and neighborhood density. Journal of Speech, Language, and Hearing Research. 2004a; 47:1454–1468.

Storkel HL, Hoover JR. Word learning by children with phonological delays: Differentiating effects of phonotactic probability and neighborhood density. Journal of Communication Disorders. 2010; 43:105–119. [PubMed: 20004908]

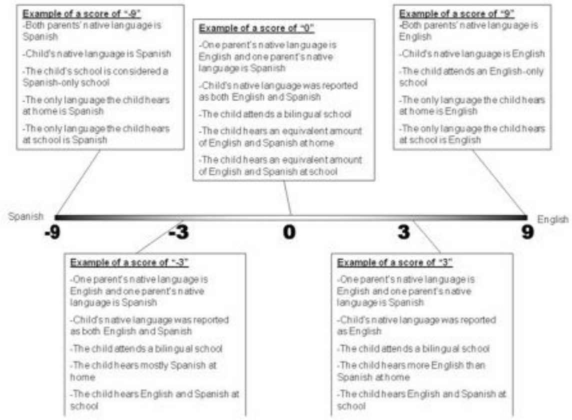
Storkel HL, Lee S. The independent effects of phonotactic probability and neighborhood density on lexical acquisition by preschool children. Language and Cognitive Processes. 2011; 26:191–211. [PubMed: 21643455]

Storkel HL, Maekawa J. A comparison of homonym and novel word learning: The role of phonotactic probability and word frequency. Journal of Child Language. 2005; 32:827–853. [PubMed: 16429713]

Vitevitch MS, Luce PA. A web-based interface to calculate phonotactic probability for words and nonwords in English. Behavior Research Methods, Instruments & Computers. 2004; 36:481–487.

Vitevitch MS, Luce PA, Charles-Luce J, Kemmerer D. Phonotactics and syllable stress: Implications for the processing of spoken nonsense words. Language and Speech. 1997; 40:47–62. [PubMed: 9230698]

Appendix A



Appendix B

Task 1 Stimuli

High Probability	Low Probability
/ˈtɹɪv/	/ˈdɹud/
/ˈpɹɪt/	/ˈglæv/
/ˈpɹɪn/	/ˈplɪd/
/ˈnestəg/	/ˈfaɵzəf/
/ˈdestəg/	/ˈzaɵʃəv/
/ˈgestəl/	/ˈsaɵʃəv/
/ˈmætəvən/	/ˈtɛvəzəd/
/ˈpætənəd/	/ˈʃoivəhəz/
/ˈsɛdətən/	/ˈhavəɵəd/
/ˈpinələnən/	/ˈʃlvəzlhəz/
/ˈsinələnən/	/ˈhlvəʃlhəv/
/ˈminəpənən/	/ˈzlvəɵlhəv/

Table 1

Participants' demographic features and means and standard deviations on descriptive and inclusionary measures: Preschoolers

	Monolingual			Bilingual		
	Mean	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**
Age in months	61.72	4.86	54 – 70	61.60	3.85	54 – 70
Maternal Level of Education	14.37	1.58	12 – 18	13.30	2.73	9 – 18
*[a] PPVT-IV	103.80	9.02	88 – 125	86.05	17.55	68 – 120
[b] SPELT-III	102.88	5.96	95 –116	107.33	8.50	99 – 116
MLUW	n/a	n/a		6.43	1.32	4.33 – 9.67
% C-Units w/Errors	n/a	n/a		10.49	9.66	0 – 23
Language Profile Score	8.52	.71	7 – 9	−2.60	3.07	−9 – 6

*significantly different at $p<.001$

[a]Data on the PPVT-IV were not available for 5 of the bilingual participants.

[b]Three of the bilingual participants demonstrated their language skills via performance on the SPELT-III as opposed to the Frog Story.

Note: PPVT-IV= Peabody Picture Vocabulary Test- 4th edition; SPELT-III=Structured Photographic Expressive Language Test- III; MLUW=Mean Length of Utterance in Words, %C-Units w/Errors= Percentage of utterances in language sample with morphosyntactic errors; Language Profile Scores ranged from 9 to −9, with positive numbers representing more English exposure, and negative numbers representing more Spanish exposure.

Note: Bilingual speakers' MLUW and % C-Units with Errors were taken from either their English or Spanish narratives, depending on which scores were higher.

Table 2

Participants' demographic features and means and standard deviations on descriptive and inclusionary measures: School-aged children

	Monolingual			Bilingual		
	Mean	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**
Age in months	93.70	6.09	84 – 105	95.23	7.15	84 – 104
Maternal Level of Education	14.50	1.93	12 – 16	13.75	2.86	8 – 18
EOWPVT	105.55	13.68	81 – 139	115.46	16.21	78 –145
ROWPVT	118.55	13.12	100 – 124	118.38	12.18	94 –141
MLUW	8.11	0.33	6.61 – 9.41	8.13	0.59	6.62 – 9.86
% C-units w/Errors	7.40	4.42	0 – 14.28	6.43	4.50	0 – 16.66
Language Profile Score	8.82	.39	8 – 9	1.73	2.93	−3 – 6

Note: EOWPVT= Expressive One-Word Picture Vocabulary Test; ROWPVT=Receptive One-Word Picture Vocabulary Test (the standard edition was administered to the monolingual children and the bilingual edition was administered to the bilingual children); MLUW=Mean Length of Utterance in Words, %C-units w/Errors= Percentage of utterances in language sample with morphosyntactic errors; Language Profile Scores ranged from 9 to −9, with positive numbers representing more English exposure, and negative numbers representing more Spanish exposure.

Note: Bilingual speakers' MLUW and % C-units with Errors were taken from either their English or Spanish narratives, depending on which scores were higher.