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Interaction in Bilingual Phonological Acquisition: Evidence from Phonetic Inventories

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Introduction

Knowledge of typical phonological development in bilingual children is limited. Bilingual children are often compared to their monolingual peers to determine typical from disordered development; however, it is not known if this comparison is an appropriate one. Although there have been some studies examining accuracy of production in bilinguals (Gildersleeve-Neumann, Kester, Davis, & Peña, 2008; Goldstein & Washington, 2001; Goldstein, Fabiano, & Washington, 2005; Fabiano-Smith & Goldstein, in press), no studies have examined complexity of phonetic inventories across a bilingual child's two languages, or compared them to those their monolingual peers. For speech-language pathologists to perform best-practice methods of diagnosis and intervention in bilingual populations, knowledge of typical phonetic inventory development in bilinguals is necessary. The goal of the current study is to determine what constitutes typical development of speech sound inventories in bilingual children to better inform methods of best practice with bilingual populations.

Phonological Acquisition in Bilingual Children

It is widely accepted in the literature that bilingual children have differentiated linguistic systems by age 2;0 (Keshavarz & Ingram, 2002; Meisel, 1989), and it is generally accepted that these two systems interact, though the extent to which they interact is as of yet unclear (Paradis & Genesee, 1996). To account for interaction between languages, Paradis and Genesee (1996) proposed a series of hypotheses about how bilingual children acquire their two language systems: *deceleration*, *acceleration*, and *transfer*. The hypothesis of *deceleration* (referred to as *delay* in Paradis & Genesee, 1996) predicts that bilingual children will, at times, demonstrate a slower rate of acquisition of a particular linguistic feature when compared to their monolingual peers. This is attributed to the phonotactics against that feature in one of the target languages impeding acquisition of that feature in the other language. Evidence of deceleration has been documented in the literature in the area of syntactic acquisition in bilinguals (Kester & Gorman, 1996; Vihman, 1982; Swain, 1972), and more recently, for phonological acquisition (e.g., Fabiano-Smith & Goldstein, in press; Gildersleeve, Davis, & Stubbe, 1996). For instance, Gildersleeve-Neumann, Kester, Davis, and Peña (2008) found evidence for slower acquisition of English phonology by typically developing, Spanish-English bilingual 3-year-olds. Specifically, the bilingual children demonstrated an overall lower intelligibility rating, made more overall consonant and vowel errors, and produced more uncommon error patterns than monolingual English-speaking children; however, only the bilingual children's English skills were examined. Thus, it is not known how these bilingual children performed in Spanish with respect to monolingual Spanish-speaking children, nor is it known whether these bilingual children would have shown such deceleration in acquisition of Spanish. Goldstein and Washington (2001) compared the phonological skills of 4-year-old Spanish-

English bilinguals to their monolingual peers in both of their languages and also observed some evidence of deceleration. They found that the bilingual children were much less accurate than monolingual speakers on some sound classes in Spanish (spirants, flap, and trill in Spanish); nevertheless, overall sound accuracy between monolinguals and bilinguals was similar. Taken together, these findings provide some evidence that the rate of acquisition for some phonological skills in bilinguals may slower than those of monolingual counterparts at certain points in time, which would support the hypothesis of deceleration in bilingual phonological development.

Paradis and Genesee's (1996) second hypothesis, *acceleration*, refers to the notion that bilingual children will, at times, demonstrate a faster rate of acquisition when compared to their monolingual peers. Kehoe, Trujillo, and Lleó (2001) and Lleó, Kuchenbrandt, Kehoe, and Trujillo (2003) examined the production of coda consonants in Spanish-German bilingual children and found a higher rate of coda production in the Spanish productions of bilinguals than in those of Spanish monolinguals. In this particular case, it is assumed that the fewer restrictions against the occurrence of coda consonants in German as compared to Spanish had a facilitative effect on the bilingual children's acquisition of coda consonants in Spanish. These findings indicate that at certain times during speech development bilingual children are demonstrating a more rapid rate of acquisition then their monolingual peers. In comparison to evidence for deceleration, however, evidence for acceleration is sparse.

Past studies examining interaction in bilingual acquisition (with the exception of Paradis & Genesee, 1996) have not examined the co-occurrence of deceleration and acceleration in bilingual development. More recently, there has been a shift in focus to how acceleration and deceleration might occur *simultaneously*. For instance, Fabiano-Smith and Goldstein (in press) examined 8 bilingual Spanish-English speaking children, ages 3;0-4;0, on overall consonant accuracy and accuracy by manner class. These bilingual children were compared to their monolingual peers to determine if the rate of phonological acquisition in bilinguals was occurring at a faster or slower rate than monolingual phonological acquisition. They found that bilingual children did show evidence of a slower rate of acquisition on overall consonant accuracy in Spanish when compared to Spanish monolinguals (i.e., deceleration), but this was not so for English. When examined by manner class, bilingual children demonstrated a slower rate of acquisition in Spanish on only a few manner classes (trill, fricatives, and glides), but demonstrated comparable accuracy with monolinguals on all other sound classes. Thus, it was concluded that bilingual children might actually be using one language to aid in acquisition of the other, allowing for commensurate accuracy on most manner classes (in two languages) in the same amount of time as monolinguals acquiring only one language. Therefore, interaction could be causing a slower rate of development on the production of some phonological skills (i.e., accuracy) and simultaneously causing a variation of acceleration, or *bootstrapping* (Tracy, 1995; Gawlitzek-Maiwald & Tracy, 1996), of other phonological skills (i.e., phonetic inventories).

The deceleration and acceleration hypotheses refer to the *rate* of acquisition between bilingual and monolingual children while the third hypothesis, *transfer*, describes a somewhat different perspective on interaction. Transfer has been found in a number of studies examining syntactic and phonological acquisition in bilingual children (Barlow, 2003; Fabiano & Goldstein, 2005; Keshavarz & Ingram, 2002; Schnitzer & Krasinski, 1996; Paradis & Genesee, 1996), and refers to the occurrence of sounds or sound patterns specific to one language in the other language context (when occurring in a bi-directional manner, such transfer is referred to as a *cross-linguistic effect*), and is evidence of interaction between the two languages of bilinguals.

It is important to point out that recent studies examining the phenomena of deceleration, acceleration, and transfer have mainly appealed to relational analyses (e.g., analyses of

accuracy, or systematic correspondences between the target language and child's productions) in their methodologies and have not utilized independent analyses (e.g., characteristics of the child's sound system as a system in its own right). With respect to phonology, transfer can be examined through independent analyses such as phonetic inventory analysis. The purpose of the current study is to evaluate interaction in bilingual phonological acquisition, by focusing specifically on the similarities and differences between the phonetic inventories of bilingual children in order to evaluate the potential interaction between their two language systems in the form of transfer. In particular, we aim to examine bilingual children's phonetic inventories according to implicational hierarchies of phonetic distinctions as established for monolingual children.

Hierarchical Organization of Phonetic Inventories

Implicational relationships have been noted to exist within a child's sound system, and this is attributed to the universal nature of phonological organization. Sounds across the world's languages are characterized by their relative featural complexity, or *markedness*. Some sounds may be less complex relative to others, and thus are often earlier developing. These sounds are referred to as *unmarked* sounds. Other sounds may be more complex, thus may develop later on in acquisition. These sounds are referred to as *marked* sounds. Implicational relationships exist in language, such that the occurrence of relatively marked structure implies the occurrence of relatively unmarked structure (Greenberg, 1966, 1978).

Such implicational relationships have been shown to have clinical application as well. Specifically, the markedness values of the sounds targeted for treatment of children with phonological disorders have been found to affect the extent of generalization in the acquisition of phonological structures (e.g., Gierut, Elbert, & Dinnsen, 1987; Dinnsen & Elbert, 1984), such that targeting marked structures (e.g., fricatives) in treatment yields generalization to unmarked phonological structures (e.g., stops). That is, if children learn to produce more complex sounds, the less complex sounds are automatically acquired in the process.

In order to further define implicational relationships such as this, Dinnsen, Chin, Elbert, and Powell (1990) developed an implicational hierarchy of phonetic distinctions for English based on the typological properties of children's developing inventories, organizing the children's phonetic inventories according to sound *classes* rather than individual sounds. Dinnsen et al. (1990) examined the speech sound productions of 40 children with phonological disorders, ages 3;3 - 6;6. The children's speech samples were examined for two or more productions of each consonant to construct the phonetic inventories (Stoel-Gammon, 1987). Sounds were then organized hierarchically according to manner, place, and voicing features. Generally, the more distinctive features and sound classes a child had in his or her inventory, the more complex the inventory. The results of this study yielded five distinct types of phonetic inventories, labeled as Levels A through E (i.e., Level A = least complex and Level E = most complex) (Figure 1).

As illustrated in Figure 1, a Level A inventory included stops, nasals, and glides; Level B added a voice distinction among stops; Level C added fricatives and/or affricates; Level D added at least one liquid, and Level E added a stridency distinction among fricatives and/or laterality contrast among liquids. Thus, the inventory levels increase in complexity from Level A to Level E with the addition of featural distinctions and/or the addition of sounds with those distinctions. Since inventory levels have been established and validated for English, the question arises if these implicational relationships generalize to other languages.

Typologies for Languages Other than English

Several studies have illustrated how Dinnsen et al.'s typology is able to account for the phonological acquisition of other languages, including Portuguese (Keske Soares, 1998),

Cantonese (Stokes, 2002; Stokes & To, 2002), Jordanian Arabic (Amayreh, 2003; Amayreh & Dyson, 2000), and Spanish (Cataño, Barlow, & Moyna, under review), though with some language-specific modifications. Most relevantly, for Spanish, Cataño et al. revised Dinnsen et al.'s original hierarchy in order to incorporate language specific differences in inventory organization. They examined the phonetic inventories of 16 predominantly Spanish-speaking children, ages 1;6 – 4;5. Spanish phonetic inventories were determined following the criteria of Dinnsen et al. (1990) as well as Stoel-Gammon (1987) and Dyson (1988). The researchers determined a sound to be present in an inventory if it occurred at least twice in the speech sample, regardless of accuracy or target-appropriateness. They found that children's phonetic inventories followed a similar hierarchy as the English-speaking children in Dinnsen et al. (1990); however there were some differences for Spanish (Figure 2). First, the liquid [l] was present for all children at Level A, the lowest level of complexity. Second, since the Spanish sound inventory includes 3 liquids, Level D includes the addition of one liquid, either [ɾ] or [ɾ] (since [l] is already present). Finally, for a child to be functioning at Level E, the most complex level in the hierarchy, he must produce all 3 liquids. It is also interesting to note that the Spanish-speaking children sometimes exhibited the stridency contrast at Level D, just as with English Level E, even though there is no stridency distinction in the dialectal varieties of Spanish that the children were acquiring. That is, even though a stridency distinction was not present in the children's language model, it was sometimes present in their phonetic inventories. Overall, the levels of complexity for Spanish were similar, but not identical, to the hierarchy established for English (Figure 3).

Although Cataño et al. (under review) provided important findings on the application of Dinnsen et al.'s (1990) hierarchy to Spanish-speaking children, there were some weaknesses in their study. Some of the children included in the study were exposed to some English in their environments and the amount of language exposure was not controlled for. The amount of input and output in each language was not controlled for, thus the data included were heterogeneous in nature. The heterogeneity of these data limits their ability to be generalized to other populations. In addition, because data from bilingual and monolingual children were aggregated, it is unknown if bilingual and monolingual children exhibit the same implicational relationships among sounds. The current study aims to determine if similarities and differences exist between the way that bilingual and monolingual children establish hierarchical organization of their phonetic inventories by examining the two speaker groups (i.e., bilingual and monolingual children) separately.

Typologies for Bilingual Children

It is unknown if children who speak *both* Spanish and English will follow the same hierarchical organization as monolingual speakers of either language. Comparing the complexity of phonetic inventories of bilingual children to that of monolingual children could help us determine (1) if levels of complexity for monolingual children hold for bilingual children and (2) if phonetic inventories hold evidence of interaction, more specifically transfer, between the two languages of bilinguals (Paradis & Genesee, 1996). Determining how bilingual children acquire their phonetic inventories as compared to monolingual speakers of either language will help inform clinical methods of assessment of bilingual children with speech sound disorders by providing speech-language pathologists with knowledge of what to expect in the speech of bilingual children as compared to what they observe in monolingual children at a given point in development. Knowledge of typical acquisition in bilinguals ultimately will allow the differentiation of speech *difference* from speech *disorder* in the assessment process. If evidence of interaction (i.e., transfer) is present in the phonetic inventories of bilingual children, we will gain insight into how bilingual children acquire the speech sound systems of their two languages in the same amount of time that monolingual children acquire only one.

The purpose of the current study was to examine how interaction contributes to phonological acquisition in bilingual children in order to determine what constitutes typical development of speech sound inventories in bilingual children. We attempted to evaluate interaction in bilingual phonological development through the examination of typological variation, focusing on phonetic inventories. Specifically, we asked the following:

1. Will phonetic inventories be identical for the bilingual children's two languages?
2. Will the phonetic inventories of bilingual children provide evidence for interaction between their two phonologies?
3. Will bilingual children have sparser phonetic inventories than their monolingual peers because they are learning two languages?

We predicted that bilingual children would not exhibit identical phonetic inventories. More specifically, we predicted that the separation between the bilingual child's two languages would allow for differences in acquisition between the two languages (Keshavarz & Ingram, 2001; Meisel, 1989). We also predicted that a low level of interaction would occur between the two languages of bilingual children, as evidenced by transfer (Paradis & Genesee, 1996). If transfer occurred (i.e., sounds specific to Spanish found in the children's English inventories and English-specific sounds found in their Spanish inventories), it would provide evidence of interaction. If transfer did not occur, there would be no evidence of interaction between the two languages of bilinguals (Paradis & Genesee, 1996). Finally, we predicted that bilingual children would have phonetic inventories that are commensurate with their monolingual peers due to interaction between their two phonological systems (Paradis & Genesee, 1996). We predicted that if transfer did occur, and bilingual children exhibited phonetic inventories that were just as complex as their monolingual peers, that it could be possible bilingual children are utilizing interaction between their two phonological systems for the acquisition of two languages in the same amount of time that monolinguals acquire only one. In addition, evidence of transfer would demonstrate that bilingual children can exhibit deceleration and transfer simultaneously in acquisition. The influence of one language on the other could perhaps bootstrap some phonological skills in bilinguals, even if other phonological skills are being acquired at a slower rate, allowing them to stay on par with their monolingual, age-matched peers (Fabiano-Smith & Goldstein, in press; Tracy, 1995; Gawlitzek-Maiwald & Tracy, 1996).

Evidence of interaction within the bilingual phonological system could shed light on development, assessment, and treatment of bilingual children with phonological disorders. Bilingual children are often compared to their monolingual peers to determine typical from disordered development; however, it is not known if this comparison is an appropriate one. Characterizing children's inventories in terms of sound classes, rather than individual sounds, may be more realistic way for speech-language pathologists to evaluate the phonological skills of bilingual children, given individual differences across children in this population. In addition, evidence of interaction between the two languages of bilinguals will aid in the design of assessment and treatment approaches for bilingual children with phonological disorders.

Method

Participants

Twenty-four typically-developing children, ages 3;0 to 4;0, were included in the study. These children were part of a larger study examining phonological accuracy in bilingual children (aspects of these children's sound systems can be found in Fabiano-Smith and Goldstein (in press)). The children were categorized into three major groups: (1) eight bilingual Spanish-English speaking children (mean age=3;6; range 3;0 – 4;0); (2) eight monolingual Spanish

speakers (mean age=3;4; range 3;2-4;0), and (3) eight monolingual English speakers (mean age=3;3; range 3;0-3;11). A Kruskal-Wallis nonparametric test indicated no significant difference between the groups with respect to age ($\chi^2 = 3.55$, $p = .169$, $df = 2$).

Parent report was used to determine each child's language status (i.e., monolingual or bilingual), bilingual status (i.e., to determine if the child was a simultaneous or sequential bilingual), and phonological status (i.e., to ensure that all children were typically developing, with no speech, language, cognitive, or neurological deficits).

Bilingual participants—Demographic characteristics of all participants can be found in Table 1. Parent report was used to determine the length and amount of exposure to each language. The first author asked parents to describe his or her child's schedule on a typical day. Since both peer and adult interactions influence input and proficiency (Rojas, Bunta, Iglesias, & Goldstein, 2007) the parent interview was conducted in such a way that all linguistic interactions were accounted for. When the parents reported the child's activities, the individual involved, and the language typically used during that activity was recorded. The number of hours that the child was exposed to daily in each language, Monday through Friday, was determined (i.e., input). The same method was used to derive the number of hours the child used each language during the work week (i.e., output). Similar questions were asked regarding the child's weekend schedule. Overall percentages were calculated separately by multiplying the number of hours of exposure (input) or use (output) by 100, then dividing that number by the total number of hours in the week. This outcome served as percent input and output values.

All bilingual children were matched on input and output in Spanish and English. That is, all children received at least 20% input and output in both languages, according to parent report. Previous work has shown that bilingual children need at least 20% exposure in order to use the target language (Pearson, Fernandez, Lewedeg & Oller, 1997). Each child also was matched on a proficiency rating scale on the parent report, whereby the parents rate their child's proficiency, in both English and Spanish, on a scale from 0 to 4 (0 represents that the child cannot speak the indicated language at all and 4 represents that the child has native-like proficiency in the language) (Peña, Bedore, & Rapazzo, 2003; Peña, Bedore, & Zlatic, 2002). All children included in the study were rated as either 3 or 4 by their parents on the scale in both languages, indicating (near) native-like competence. All bilingual participants had at least 8 months of exposure to English: They had at least some English exposure prior to entering school at age 3;0 (after which English exposure began at preschool) or had exposure to both languages in the home from birth. Both bilingual types were aggregated in the current study since all participants were matched on input, output, and proficiency, regardless of whether they were sequential or simultaneous bilinguals. The bilingual children were speakers of Puerto Rican and Dominican Spanish and the northern Philadelphia dialect of English.

Monolingual participants—Data from the 8 monolingual Spanish speakers were collected in Querétaro, Mexico, and data from the 8 monolingual English speakers were collected in Philadelphia, Pennsylvania. Monolingual children were included in this study in order to compare phonetic inventories across monolingual and bilingual speakers. The children in each monolingual group had no input or output in any language but their native language, and their proficiency rating in that language was either 3 or 4.

Data Collection

Single word samples were collected from each child, using the phonology subtest of the *Bilingual English Spanish Assessment* (BESA; Peña, Gutierrez-Clellen, Iglesias, Goldstein, & Bedore, in development), a phonological assessment designed to evaluate children's speech sound productions in both English and Spanish, which has been used for other published

research with bilingual children (e.g., Goldstein & Washington, 2001). The assessment contains 31 separate target items for English and 28 separate target items for Spanish. Each target item was elicited via a spontaneous label made in reference to a photograph (e.g., *¿Qué es eso?* or "What is that?"). If a child did not label the photograph spontaneously, the function of the item was provided to the child. If the child still did not label the item, delayed imitation was used (Goldstein, Fabiano, & Iglesias, 2004).

Each sample was recorded using *The Presenter* wireless lapel microphone, transmitter (model T1-CL), and receiver (model T3-CL) (Shure, Inc., 2004) with input into a Dell Latitude 100L (Dell, Inc., 2004) using a Sound Blaster Audigy 2-Z5, 24-bit sound card (Creative Labs, 2004). Data from the single word samples were phonetically transcribed using narrow transcription and the following diacritics: (1) nasalization; (2) aspiration on stops; (3) absence of aspiration on stops; (4) absence of release on stops; (5) vowel lengthening; (6) partial voicing, and (7) partial devoicing

Analyses

Reliability of single word samples—Reliability of transcription was performed on the single word samples between two primary transcribers (English-Spanish bilingual graduate students of speech-language pathology at Temple University) and the first author of this study, who is a bilingual English-Spanish speaker. All three transcribers were trained in IPA narrow transcription of English and Spanish. The two bilingual graduate students phonetically transcribed all of the single word samples. The first author then performed interjudge reliability on those phonetic transcriptions, and the original transcribers performed intra-judge reliability on their own transcriptions. Since three judges were involved in the reliability process, when a disagreement occurred between two of the judges, the third judge was called in to make a decision. The decision made by the third judge was accepted as the final transcription. Intra- and inter-judge reliability of narrow transcription was calculated on 100% of the Spanish and English target words on the single word assessment, on 100% of the children.

For the Spanish monolingual group, intra-judge reliability reached 99.16% and inter-judge reliability reached 98.74% for narrow phonetic transcription. For the English monolingual group, intra-judge reliability reached 98.7% accuracy and inter-judge reliability reached 96.94% accuracy. For the Spanish samples of the bilingual children, intra-judge reliability reached 99.14% accuracy and inter-judge reliability reached 97.48% accuracy. For the English samples of the bilingual children, intra-judge reliability reached 98.61% accuracy and inter-judge reliability reached 95.67% accuracy.

Phonetic inventory—Phonetic inventories were derived from the children's productions in order to determine what sounds each child had produced. If a child produced a particular sound more than once, regardless of whether it occurred as a correct production in a word or as a substitute for another sound, that sound was included in his or her inventory (Dinnsen et al., 1990). If the sound did not occur more than once, that sound was not included in the phonetic inventory.

After Dinnsen et al. (1990) for English and Cataño et al. (under review) for Spanish, the bilingual and monolingual children's phonetic inventories were assigned to one of the five levels of complexity (A through E, for English and Spanish, respectively) based on the sound classes present in their inventories. These levels were then compared for similarities and differences within bilingual speakers (i.e., inventory content and inventory level) and between monolingual and bilingual speakers.

In order to determine if interaction existed between the two language systems of the bilingual child, the phonetic inventories of the bilingual children were examined for instances of transfer

(e.g., Spanish-specific sounds found in English inventories and English-specific sounds found in Spanish inventories).

Results

The results of the analysis performed to construct the phonetic inventories of the bilingual children can be found in Table 2. Phonetic inventories for the monolingual Spanish and English-speaking children can be found in Tables 3 and 4. Interestingly, the bilingual children did *not* demonstrate sparser phonetic inventories than their monolingual peers. There was no evidence in the phonetic inventories of these bilingual children for Paradis and Genesee's (1996) hypothesis of *deceleration*, in which bilingual children demonstrate a slower rate of acquisition in comparison to their monolingual peers. Rather, it seems that bilingual children are able to acquire two phonetic inventories in the same amount of time as monolinguals acquire only one, and with the same level of complexity.

Typology

Monolingual-bilingual comparison—Typological analysis was used to organize the children's phonetic inventories in a hierarchical manner. The monolingual English- and Spanish-speaking children also demonstrated high levels of typological complexity. All monolingual English-speaking children exhibited inventories at Level E and all monolingual Spanish-speaking children exhibited inventories at either Levels D or E (recall that Level E requires presence of all three liquids, [l], tap [ɾ], and trill [r], the latter being among the last acquired sounds of Spanish). The phonetic inventories of the bilingual children followed the categorizations designed by Dinnsen et al. (1990) for English and Cataño et al. (under review) for Spanish. Seven out of the 8 bilingual children exhibited phonetic inventories at the highest levels of complexity, Levels D or E, in both languages (one child exhibited a Spanish inventory at Level C). Overall, then, bilingual children demonstrated phonetic inventories that were just as complex as their monolingual peers.

Cross-linguistic comparison—Within-group examination of the bilingual children's phonetic inventories indicated that inventories across languages were similar, but not identical. For example, all bilingual children had the sounds [p, b, m, f, t] in their inventories, 7 out of 8 of the children had [s] in both English and Spanish, Child B02 had the Spanish [β] in both of his inventories, and Child B01 did not have [ʧ] in either of his inventories. There were, however, differences across languages as well. For some of the bilingual children, their Spanish inventory was at Level D, but their English inventory was at Level E. Child B08 had [ʧ] in his English inventory, but not in his Spanish inventory. Child B08 had [d] in his English inventory, but not in his Spanish inventory. Child B01 had [ð] in his Spanish inventory but not in his English inventory. Child B04 had [j] in his Spanish inventory, but not in his English inventory. Therefore, the two phonetic inventories of the bilingual children's two languages were similar, but not identical, indicating separation between their two phonological systems (e.g., Keshavarz & Ingram, 2002).

Transfer

In order to determine if interaction exists between the two language systems of the bilingual child, the phonetic inventories of the bilingual children were examined for instances of transfer (e.g., Spanish-specific sounds found in English inventories and English-specific sounds found in Spanish inventories). Evidence of transfer was bi-directional, occurring from English to Spanish and from Spanish to English: Specifically, Child B08 had the English fricative [ʒ] in his Spanish inventory; the Spanish [ɾ] was found in 5 out of the 8 bilingual children's English inventories, and Child B02 had the Spanish sound [β] in his English inventory. Evidence of transfer was found in the bilingual children's phonetic inventories, indicating a low level of

interaction between the two phonological systems of bilinguals. This evidence supports Paradis and Genesee's (1996) hypothesis of *transfer*, indicating that interaction does occur between the two languages of bilingual children.

Discussion

Little is known about typical phonological development in bilingual children. For speech-language pathologists to perform best-practice methods of diagnosis and intervention in bilingual populations, knowledge of typical phonetic inventory complexity is necessary. In addition, how the two language systems of bilingual children are organized will shed light on clinical methods of assessment, diagnosis, and intervention in the bilingual population.

To account for the interaction that occurs between the two languages of bilinguals, Paradis and Genesee (1996) posed the hypotheses of deceleration, acceleration, and transfer. The purpose of the current study was to examine how interaction contributes to phonological acquisition in bilingual children. We attempted to evaluate interaction in bilingual phonological development through the examination of bilingual children's phonetic inventories, examining both level of typological complexity and transfer. These analyses were performed both within bilingual speakers and by comparing bilinguals to their monolingual peers.

First, the phonetic inventories of the bilingual children were commensurate with their monolingual peers in both languages. This finding is contrary to previous studies that have found that bilingual children acquire phonological skills at a slower rate than their monolingual peers (Fabiano-Smith & Goldstein, in press; Yavas & Goldstein, 1998; Gildersleeve, Davis, & Stubbe, 1996). Fabiano-Smith and Goldstein (in press), in a phonological analysis of accuracy of the children in the current study, observed that *these same bilingual children* demonstrated lower accuracy of production on certain manner classes. Even though the accuracy levels of bilingual children were still considered to be within the normal range for monolingual children of the same age, this finding supported Paradis and Genesee's (1996) hypothesis of *deceleration*. The findings from the current study that demonstrated the same bilingual children possess phonetic inventories that are similar to monolingual speakers of either language is evidence that a slower rate of development of one phonological skill does not indicate a slower rate of development for *all* phonological skills in bilingual children. More specifically, the same children that showed slower acquisition on the accuracy of fricatives and glides in English and stops in Spanish, at the same point in development, demonstrated phonetic inventories that were just as complex as their monolingual peers. Therefore, two types of interaction, *deceleration* and *transfer*, were found to be occurring simultaneously in the phonological development of these bilingual children.

These findings are extremely useful to speech-language pathologists attempting to differentiate language *difference* from language *disorder* in bilingual preschoolers. Since very little developmental data exists on bilingual children, the evidence found here from phonetic inventories could aid in clinical decision making to aid in avoiding underdiagnosis of speech sound disorders. That is, it may be that if a 3-year-old bilingual child demonstrates a sparse phonetic inventory in both languages, he or she may present with a speech disorder. Conversely, if a bilingual 3-year-old demonstrates phonological accuracy levels slightly lower than his or her monolingual peers, he or she may not require intervention services. While additional research with larger numbers of children is necessary to further evaluate these claims, the findings nevertheless illustrate the importance of obtaining more than one measure during phonological evaluation. If one only obtains a phonetic inventory or only an accuracy measure, important diagnostic information might be missed.

The results from the analysis of inventory typology indicated that bilingual children organize their two speech sound systems in the same hierarchical fashion as monolingual speakers of English and Spanish. This finding further supports Dinnsen et al.'s (1990) and Cataño et al.'s (under review) typological organization of children's phonetic inventories and demonstrates that the typologies are able to account for the inventories of bilingual children who speak both languages.

Evidence of separation between the two languages of bilinguals was found through the examination of the levels of complexity in both English and Spanish. Most bilingual children were at Level D in Spanish but Level E in English, demonstrating separation between their two phonological systems. Although these levels of complexity are similar, they are not identical; thus, bilingual children seem to recognize which phonological elements belong to Spanish and which belong to English, and organize them in a systematic, but mostly separate manner.

Evidence of separation is clinically important in assessment and intervention because assessment and treatment of one phonological structure does not necessarily indicate assessment and treatment of that structure in the bilingual child's other language. During assessment, if a child possesses a sound his or her English phonetic inventory, it does not indicate that that same child possesses that sound in his or her other language. Consequently, speech-language pathologists cannot assume that generalization of treatment will occur from one language to the other. Evidence of separation between a bilingual child's two language systems calls for assessment and intervention *in both languages* as a method of best practice.

Paradis and Genesee (1996) posed the hypothesis of *transfer* to account for interaction between the two language systems of bilingual children. In the current study, evidence of transfer was found between English and Spanish in the phonetic inventories of bilingual children, indicating interaction between the two languages of bilinguals. Specifically, Spanish sounds were sometimes observed in the children's English inventories (e.g., Child B02: [β]) and English sounds were sometimes found in their Spanish inventories (e.g., Child B08: [ʒ]). These findings indicate that although bilingual children maintain separation for the majority of their phonological structures, there is a very low level of interaction between their two languages (see also Fabiano & Goldstein, 2005).

Since the number of participants included in the current study was quite small, future research should focus on a larger cohort of bilingual children to better identify patterns in children's phonetic inventories. In addition, a larger sample would allow us to see if patterns of transfer exist; that is, do bilingual children prefer to use some sounds interchangeably between their two languages while maintaining firm separation for others? Finally, examining phonetic inventories of bilingual children from different language backgrounds (other than English and Spanish) might shed light on universal tendencies in regards to typological organization.

References

Amayreh M. Completion of consonant inventory of Arabic. Journal of Speech, Language, and Hearing Research 2003;46:517–529.

Amayreh M, Dyson AT. The acquisition of Arabic consonants. Journal of Speech, Language, and Hearing Research 2000;41:642–653.

Barlow J. The stop-spirant alternation in Spanish: Converging evidence for a fortition account. Southwest Journal of Linguistics 2003;22(1):51–86.

Bauman-Waengler, J. Articulatory and phonological impairments: A clinical focus. Needham Heights, MA: Allyn & Bacon; 2000.

Cataño L, Barlow JA, Moyna IM. Phonetic inventory complexity in the phonological acquisition of Spanish: A retrospective, typological study. Clinical Linguistics & Phonetics. under review.

Dinnsen D, Chin S, Elbert M, Powell T. Some constraints on functionally disordered phonologies. Journal of Speech, Language, and Hearing Research 1990;33:28–37.

Dinnsen D, Elbert M. On the relationship between phonology and learning. ASHA Monogram 1984;22:59–68.

Dyson AT. Phonetic inventories of 2- and 3-year-old children. Journal of Speech, Language, and Hearing Research 1988;53:89–93.

Fabiano L, Goldstein B. Phonological cross-linguistic effects in bilingual Spanish-English speaking children. Journal of Multilingual Communication Disorders 2005;3(1):56–63.

Fabiano-Smith L, Goldstein B. Phonological acquisition in bilingual Spanish-English speaking children. Journal of Speech, Language, and Hearing Research. in press.

Gawlitzek-Maiwald I, Tracy R. Bilingual bootstrapping. Linguistics 1996;34(5):901–926.

Gildersleeve, C.; Davis, B.; Stubbe, E. When monolingual rules don't apply: Speech development in a bilingual environment. Paper presented at the annual convention of the American Speech-Language-Hearing Association; Seattle, WA. 1996 Nov.

Gildersleeve-Neumann C, Kester E, Davis B, Peña E. English speech sound development in preschool-aged children from bilingual Spanish-English environments. Language, Speech and Hearing Services in Schools 2008;39:314–328.

Gierut J, Elbert M, Dinnsen D. A functional analysis of phonological knowledge and generalization learning in the misarticulating child. Journal of Speech, Language, and Hearing Research 1987;30:462–479.

Gierut J. Treatment efficacy: Functional phonological disorders in children. Journal of Speech, Language, and Hearing Research 1998;41:85–100.

Goldstein, B.; Fabiano, L.; Iglesias, A. Phonological representation in bilingual Spanish-English speaking children. Poster presented at The 4th International Symposium on Bilingualism (ISB4); Tempe, AZ. 2003 Apr.

Goldstein B, Fabiano L, Washington P. Phonological skills in predominantly English, predominantly Spanish, and Spanish-English bilingual children. Language, Speech, and Hearing Services in Schools 2005;36:201–218.

Goldstein B, Washington P. An initial investigation of phonological patterns in 4-year-old typically developing Spanish-English bilingual children. Language, Speech, & Hearing Services in the Schools 2001;32:153–164.

Greenberg, JH. Language universals, with special reference to feature hierarchies. The Hague: Mouton; 1966.

Greenberg, JH., editor. Universals of human language, Vol 2: Phonology. Stanford, CA: Stanford University Press; 1978.

Kehoe, M.; Trujillo, C.; Lleó, C. Bilingual phonological acquisition: An analysis of syllable structure and VOT. In: Cantone, KF.; Hinzelin, MO., editors. Proceedings of the colloquium on structure, acquisition and change of grammars: Phonological and syntactic aspects. Universität Hamburg: Arbeiten zur Mehrsprachigkeit; 2001. p. 38-54.

Keshavarz M, Ingram D. The early phonological development of a Farsi English bilingual child. International Journal of Bilingualism 2002;6:255–269.

Keske Soares M. Um modelo de terapia com base fonológica para crianças com desvios fonológicos evolutivos [A phonologically based therapy model for children with developmental phonological deficits]. Letras de Hoje 1998;33:107–114.

Kester, E.; Gorman, BK. Spanish-influenced English: Typical semantic and syntactic patterns of the English language learner. 1996. www.Bilinguistics.com

Lleó, C.; Kuchenbrandt, I.; Kehoe, M.; Trujillo, C. Syllable final consonants in Spanish and German monolingual and bilingual acquisition. In: Müller, N., editor. (In)vulnerable Domains in Multilingualism. Amsterdam, Philadelphia: John Benjamins; 2003. p. 191-220.

Meisel, J. Early differentiation of languages in bilingual children. In: Hyltenstam, K.; Obler, L., editors. Bilingualism Across the Lifespan: Aspects of Acquisition, Maturity, and Loss. Cambridge: Cambridge University Press; 1989. p. 13-40.

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

Pearson B, Fernandez S, Lewedeg V, Oller DK. The relation of input factors to lexical learning by bilingual infants. Applied Psycholinguistics 1997;18:41–58.

Peña E, Bedore L, Rappazzo C. Comparison of Spanish, English, and bilingual children's performance across semantic tasks. Language, Speech, & Hearing Services in the Schools 2003;34:5–16.

Peña ED, Bedore LM, Zlatic-Giunta R. Category-generation performance of bilingual children: The influence of condition, category, and language. Journal of Speech, Language, and Hearing Research 2002;45:938–947.

Peña E, Gutiérrez-Clellen V, Iglesias A, Goldstein B, Bedore L. The Bilingual English-Spanish Assessment. in development.

Rojas, R.; Bunta, F.; Iglesias, F.; Goldstein, B. Interlocutor Differential Effects on ELL Children's Language Output Measures; Seminar presented at the convention of the American Speech-Language-Hearing Association; Boston, MA. 2007 Nov.

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.

Stoel-Gammon C. Phonological skills of 2-year-olds. Language, Speech, and Hearing Services in Schools 1987;18:323–329.

Stokes S. Levels of complexity on phonological disorders: Evidence from Cantonese. Clinical Linguistics and Phonetics 2002;16:35–57. [PubMed: 11913031]

Stokes S, To C. Feature development in Cantonese. Clinical Linguistics and Phonetics 2002;16:443–459. [PubMed: 12469450]

Swain, M. Unpublished Ph.D. dissertation. University of California; Irvine: 1972. Bilingualism as a first language.

Tracy, R. Child languages in contact: the simultaneous acquisition of two languages (English/German) in early childhood. Universität Tübingen; 1995. Unpublished Habilitationsschrift

Vihman MM. The acquisition of morphology by a bilingual child, a whole-word approach. Applied Psycholinguistics 1982;3:141–60.

Yavas M, Goldstein B. Phonological assessment and treatment of bilingual speakers. American Journal of Speech-Language Pathology 1998;7:49–60.

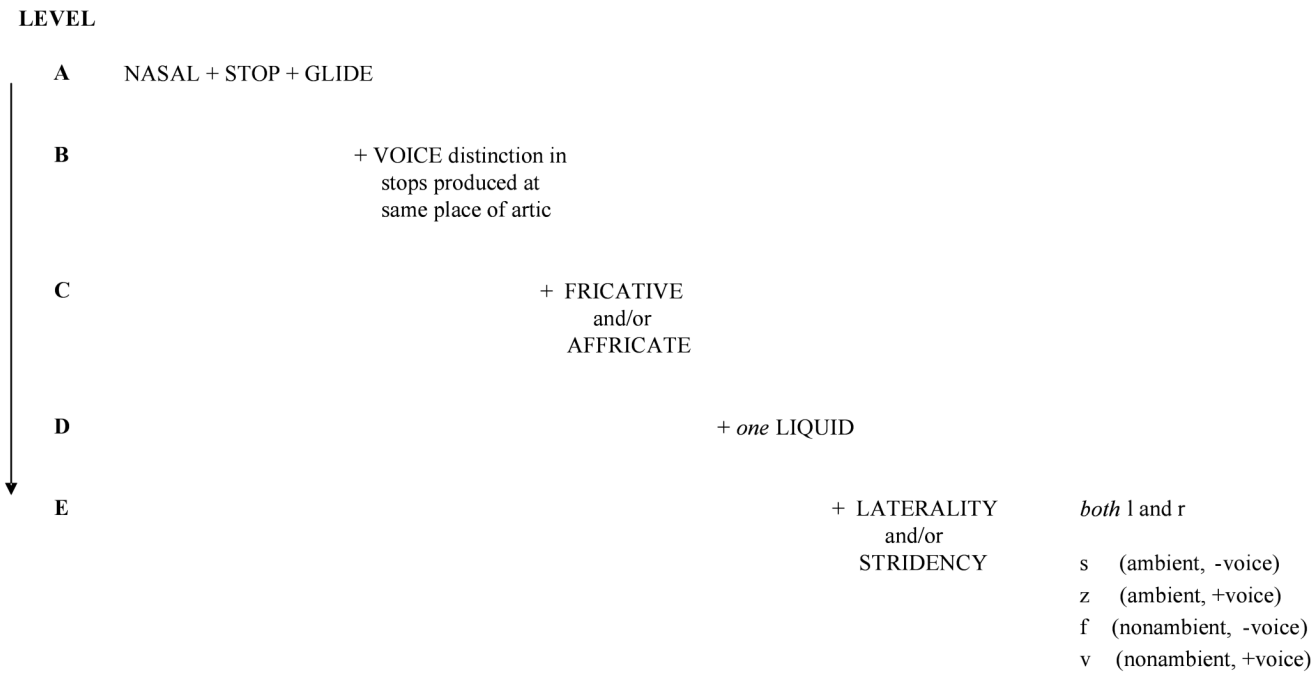

Figure 1.
Implicational hierarchy of phonetic distinctions for English (Dinnsen et al., 1990)

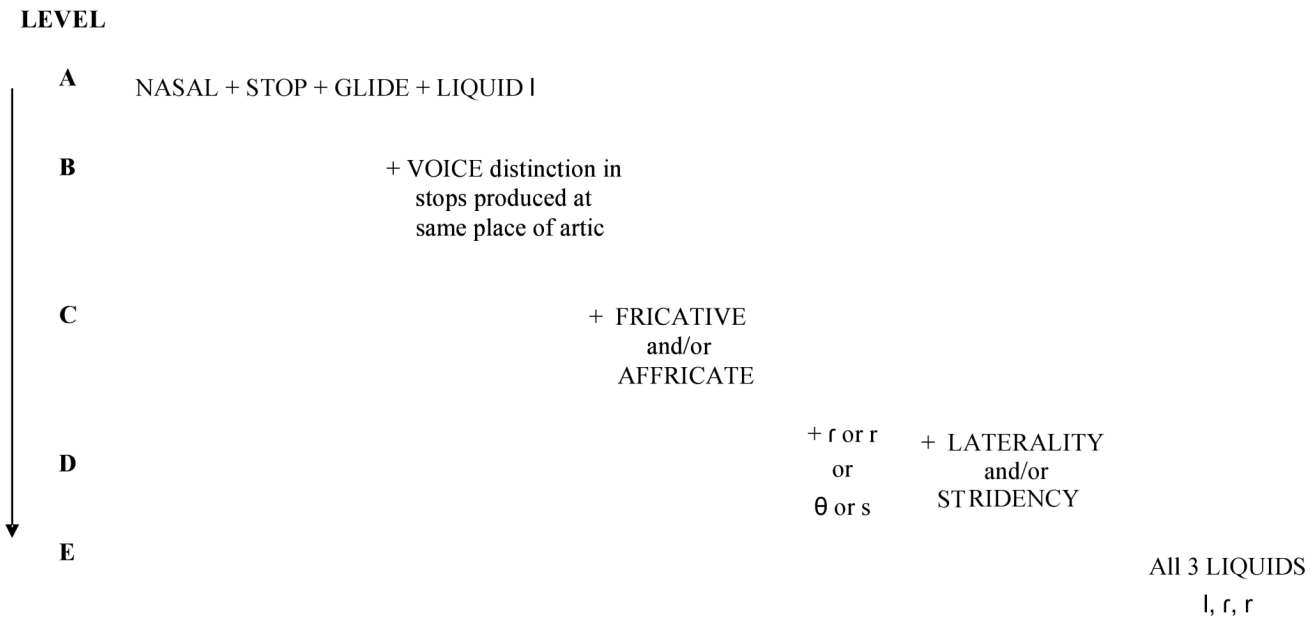

Figure 2.
Implicational hierarchy of phonetic distinctions for Spanish (Cataño et al., under review)

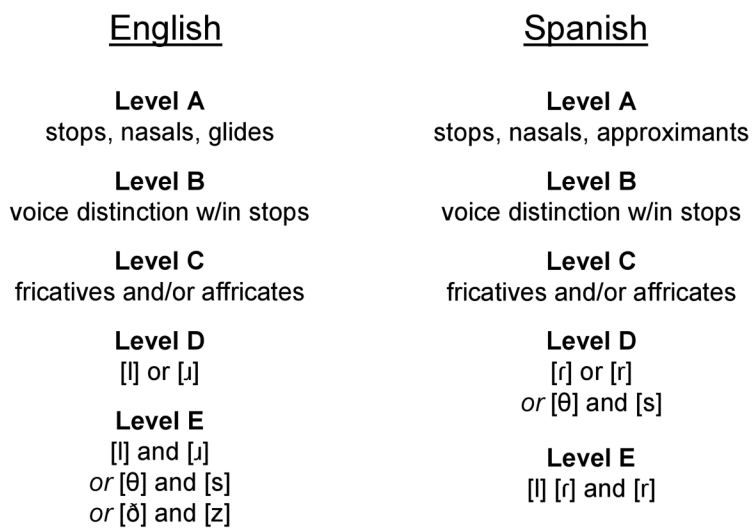

Figure 3.
English and Spanish typological levels compared

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Table 1

Participant characteristics (CA refers to chronological age in years; months).

Child ID	CA	Gender	Language Status	Language spoken	Mother's Level of Education	Percent Input		Percent Output		Proficiency	
						Spanish	English	Spanish	English	Spanish	English
B01	3;8	male	sequential	Spanish/English	high school	63	37	63	37	4	3
B02	3;5	male	simultaneous	Spanish/English	high school	75	25	75	25	4	3
B03	3;8	male	sequential	Spanish/English	some university	58	42	30	70	3	3
B04	3;5	male	simultaneous	Spanish/English	Bachelors degree	50	50	20	80	3	4
B05	3;8	female	simultaneous	Spanish/English	high school	40	60	20	80	3	4
B06	3;4	male	simultaneous	Spanish/English	some university	70	30	20	80	3	4
B07	3;11	male	sequential	Spanish/English	high school	40	60	20	80	3	4
B08	3;5	male	simultaneous	Spanish/English	some university	80	20	50	50	3	3
S01	4;0	male	monolingual	Spanish	some high school	100	0	100	0	4	0
S02	3;3	male	monolingual	Spanish	Masters degree	100	0	100	0	4	0
S03	3;3	male	monolingual	Spanish	high school	100	0	100	0	4	0
S04	3;10	male	monolingual	Spanish	some high school	100	0	100	0	4	0
S05	3;2	female	monolingual	Spanish	Bachelors degree	100	0	100	0	4	0
S06	3;6	female	monolingual	Spanish	Masters degree	100	0	100	0	4	0
S07	3;4	female	monolingual	Spanish	some high school	100	0	100	0	4	0
S08	3;4	male	monolingual	Spanish	some high school	100	0	100	0	4	0
E01	3;3	female	monolingual	English	Masters degree	0	100	0	100	0	4
E02	3;1	female	monolingual	English	Medical degree	0	100	0	100	0	4
E03	3;11	female	monolingual	English	Masters Degree	0	100	0	100	0	4
E04	3;8	male	monolingual	English	high school	0	100	0	100	0	4
E05	3;0	male	monolingual	English	Bachelors degree	0	100	0	100	0	4
E06	3;0	male	monolingual	English	Bachelors degree	0	100	0	100	0	4
E07	3;1	male	monolingual	English	Bachelors degree	0	100	0	100	0	4
E08	3;7	male	monolingual	English	Masters Degree	0	100	0	100	0	4

Table 2

Bilingual children's phonetic inventories for Spanish and English

Child ID	Spanish	Level	English	Level
B01	p b t k g s f x β ð ɣ m n ɾ l j	D	p b t d k g f θ s ʤ m n l ɹ ɾ* w h	E
B02	p b t k g j m n f s β ɣ l r	D	p b t d k g f s ʃ ʧ m n ŋ l ɹ ɾ* β* w h	E
B03	p b t d k g s f m n l ɾ j	D	p b t d k g f s z ʧ m n l ɹ w	D
B04	p b t d k g f s x m n l ɾ j	D	p b t d k g f s m n l ɹ w h	D
B05	p b t d k g f s x ɣ m n l ɾ j	D	p b t d k g f s z m n l ɹ ɾ* w h	E
B06	p b t d k g f s β ɣ m n l ɾ j	D	p b t d k g f θ s z ʧ m n ɾ* l ɹ w h	E
B07	p b t d k g f s x β ɣ m n l j w	C	p b t d k g f s z n l ɹ w h	E
B08	p b t k g f s x ʒ* β ð ɣ m n l ɾ j	D	p b t d k g f ʒ ʧ m n l ɹ ɾ* w h	E

* Instances of transfer

Table 3

Monolingual English-speaking children's phonetic inventories

Child ID	Phonetic Inventory	Level
E01	p b t d k g f v s z ʧ m n l ɹ w h	E
E02	p b t d k g f θ z ʧ m n l ɹ h	E
E03	p b t d k g f s z θ ʧ m n l ɹ w h	E
E04	p b t d k g f s z h ʧ m n l ɹ w	E
E05	p b t d k g f v s z ʧ m n ɾ l ɹ w h	E
E06	p b t d k g f s z θ ð ʃ ʧ m n l ɾ w h	E
E07	p b t d k g f v s z θ h ʧ m n l ɹ w	E
E08	p b t d k g f v s θ ʧ m n ɾ l w h	E

Table 4

Monolingual Spanish-speaking children's phonetic inventories

Child ID	Phonetic Inventory	Level
S01	p b t k g s x ɣ n l ɾ r	E
S02	p b t k g f s x β m n l ɾ r j	E
S03	b t s h m n l ɾ r j w	E
S04	p b t d k g f s x β ɣ ʧ m n l ɾ r j	E
S05	p b t k g f s x β ð ɣ m n l r j	D
S06	p b t d k g f s β ð ɣ m n l ɾ r	E
S07	p b t d k f s x β ɣ m n l ɾ j w	D
S08	p b t k f s x β ð ɣ m n l ɾ r	E