

## **English and Korean stop productions of monolingual versus bilingual children\***

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### **1. Introduction**

A long-standing issue in the theory and description of bilingualism is whether bilingual children develop one or two linguistic systems in the learning of their two languages. The one-system hypothesis (Swain, 1972; Volterra & Taeschner, 1978) suggests that children initially posit linguistic rules common to both languages; then they differentiate the two as they master higher linguistic knowledge. The two system hypothesis (Padilla & Liebmann, 1975; Genesee, 1989), conversely, holds that bilingual children differentiate both systems at an early age, and that children are capable of keeping the two linguistic systems separate as these develop. Although researchers have made attempts to answer this question in several linguistic domains, including phonology, semantics, and syntax, there continues to be a marked lack of research on whether bilingual children develop one or two distinct phonetic systems.

The results reported in this paper are part of an ongoing project investigating phonetic category formation in Korean-English bilingual children. We have investigated the underlying phonetic systems in bilingual children (Lee & Iverson, 2011) by examining whether they can manifest language specific phonetic (acoustic) values for two languages when two phones fall into the same phonological category. For example, although Voice Onset Time (VOT) values of /p/ in English and /p<sup>h</sup>/ in Korean are similar, the vowel-onset fundamental frequency ( $f_0$ ) value of Korean aspirated stops is higher than that of their English counterparts. If a Korean-English bilingual child produces both

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phonemes with similar VOT and vowel onset  $f_0$  values in both languages, this would suggest that the child has a unified linguistic system. On the other hand, production of the two phonemes with different acoustic values would indicate that the child possesses separate linguistic systems for each language.

In our previous study examining the stop productions of 5 and 10 year-old Korean-English bilingual children (Lee & Iverson, 2011), we found that 5 year-olds evidenced a merged stop system whereas 10 year-olds fully distinguished Korean from English stops. In particular, the 5 year-olds produced English voiced and Korean fortis stops with similar values for both VOT and vowel-onset  $f_0$ , but the 10 year-olds produced Korean fortis stops with higher values for vowel-onset  $f_0$  than in English voiced stops. The present study further examines stops produced by 7 year-old Korean-English bilingual children in order to establish the point at which detailed phonetic stop categories come to be distinguished for the two languages. Coupled with our previous findings relating to 5 and 10 year-old Korean-English bilingual children, the results reported here for 7 year-olds provide a more comprehensive understanding of the developmental patterns of stop production among bilingual children and suggest a number of related theoretical and clinical implications.

## 2. Methods

### (1) Participants

Fifteen 7 year-old Korean-English bilingual children without a history of speech, hearing, cognitive, and/or social impairments, based on parent reports, participated in this study. The children were born in the US and learned Korean first, but were exposed to English at around 3 years of age. All children were exposed to both languages at least for 4 years. The children mainly used English with English-speaking peers and siblings, but used Korean at home with their parents and/or grandparents. In order to maintain Korean language skills, all of the Korean-English bilingual children attended Korean language school regularly for 2-3 years (which took place once a week for 3-5 hours) in large U.S. Midwestern cities. The Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986) and Clinical Evaluation of Language Fundamentals-4 (CELF-4; Semel, Wiig, Secord, 2004) Screening test were administered in order to identify English articulation and language skills of the bilingual children. The test results indicated that all children possessed articulation and language



skills within normal ranges. Korean language skills were evaluated by informal Korean test results administrated in the Korean language schools. Their articulation was tested using Assessment of Phonology and Articulation for Children (APAC; Kim, Pae & Park, 2007). All children demonstrated fairly good Korean language skills and their articulation skills were within normal range.

Fifteen age-equivalent monolingual English-speaking and fifteen monolingual Korean children also participated. No child had any history of speech, hearing, cognitive, and/or social impairments, based on reports from parents and classroom teachers. The CELF-4 screening test and GFTA were also administered for English-speaking children in order to identify normal development. Normal speech and language development of the Korean monolingual children was identified by informal and formal test results obtained from classroom teachers. The monolingual English-speaking children used a Midwestern dialect of English and the monolingual Korean children used the standard Seoul variety. These monolingual children did not know or had very little knowledge of any language other than their native language.

## (2) Data Collection & Speech materials

All data were collected by the first author at schools, churches, or each participant's home. Either English or Korean was used with the bilingual children depending on which language was being tested. When English words were being elicited, all conversation with the experimenter was in English only, and when Korean words were elicited all conversation was in Korean. Several picture cards displaying target sounds were shown to each child. The children were asked to say each word (see table 1) displayed on the picture card three times in isolated position. A digital flash recorder (Marantz Model PMD670), which was connected to a head-worn Cardioid Dynamic microphone (Shure SM 10A), was used to record each participant's speech.

## (3) Data Analysis

Computerized Speech Lab software (CSL, model 4300, Kay Elemetrics) was used to analyze the recordings. The best two out of the three productions of each word for each subject were chosen for the average data set. VOT values were measured from the beginning of stop release to the onset of voicing in the following non-high vowel, using both waveforms and wide-band



spectrograms. Vowel-onset  $f_0$  in the following vowel was also measured from the first harmonic values in an FFT with a 25ms window.

Table 1. *Target words to elicit English and Korean stops*

	English			Korean	
	Voiced	Voiceless	Lenis	Aspirated	Fortis
bilabial	<i>bye</i>	<i>pie</i>	<i>pal</i>	<i>phal</i>	<i>ppang</i>
			‘foot’	‘arm’	‘bread’
alveolar	<i>dot</i>	<i>top</i>	<i>tal</i>	<i>thal</i>	<i>ttok</i>
			‘moon’	‘mask’	‘cake’
velar	<i>got</i>	<i>cop</i>	<i>kong</i>	<i>khal</i>	<i>kkot</i>
			‘ball’	‘knife’	‘flower’

### 3. Results

Figure 1 shows means and standard deviations of English VOT values in monolingual English-speaking and Korean-English bilingual children.

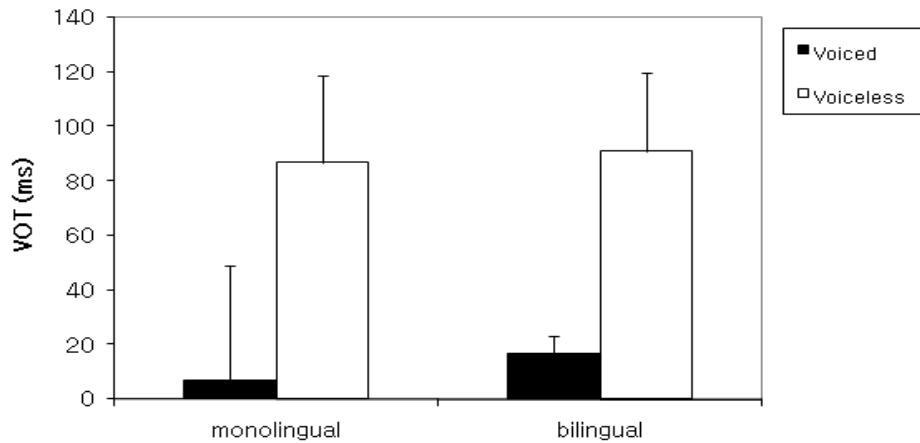


Figure 1. *English VOT in monolingual and bilingual children*

A mixed ANOVA (Analysis of Variance) indicated that there was a significant main effect on VOT ( $F(1, 28) = 122.3, p < 0.001$ ). However, no significant main effect on group ( $F(1, 28) = 1.12, p = 0.297$ ) or interaction effect



( $F(1, 28) = .17, p = 0.679$ ) was found. VOT for voiceless stops was significantly longer than that of voiced stops in both groups. The 7 year-old Korean-English bilingual children (who were exposed to English for at least 4 years) produced English stops with VOT values similar to those of the monolingual English-speaking children. The VOT values of the voiceless English stops for bilinguals were almost the same as for monolingual children. Although the VOT values of the English voiced stops produced by bilingual children were higher than those of monolingual children, this was not statistically significant.

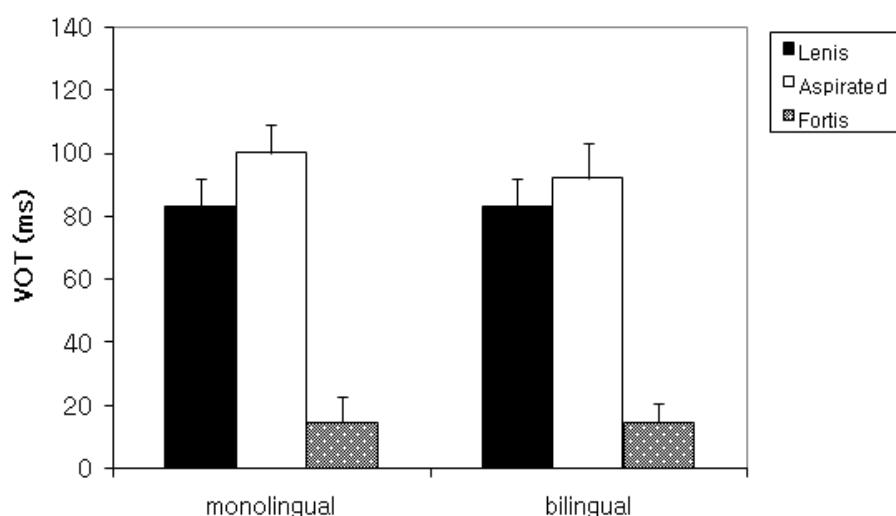


Figure 2. *Korean VOT in monolingual and bilingual children*

Figure 2 shows the means and standard deviations of VOT values of three Korean stop consonants in monolingual Korean and Korean-English bilingual children. An ANOVA indicated that there was a significant main effect on VOT ( $F(2, 56) = 1895.95, p < 0.001$ ). However, no significant main effect on group ( $F(1, 28) = 1.25, p = 0.272$ ) nor an interaction effect ( $F(2, 56) = 2.82, p = .076$ ) was found. There was no significant difference in VOT values between monolingual and bilingual children. A post hoc comparison indicated that, similar to monolingual children, Korean-English bilingual children distinguished all three Korean stop contrasts. The VOT values for the aspirated series were significantly higher than those for the lenis series, and the VOT



values for fortis stops were lowest among the three laryngeal contrasts.

Figure 3 shows means and standard deviations of vowel-onset  $f_0$  values of the three Korean stop series among monolingual Korean and Korean-English bilingual children. An ANOVA indicated that there was a significant difference in vowel onset  $f_0$  ( $F(2, 56) = 82.93, p < 0.001$ ). However, no significant main effect on group ( $F(1, 28) = .73, p = 0.409$ ) as well as interaction effect ( $F(2, 56) = .85, p = .425$ ) was found. There was no significant difference in vowel-onset  $f_0$  values between monolingual and bilingual children, and post hoc comparison indicated that both monolingual and bilingual children distinguished all three Korean stop contrasts in terms of vowel-onset  $f_0$ . The vowel-onset  $f_0$  for aspirated stops was significantly higher than that for fortis stops, and the vowel-onset  $f_0$  for fortis stops was significantly higher than that for lenis stop consonants.

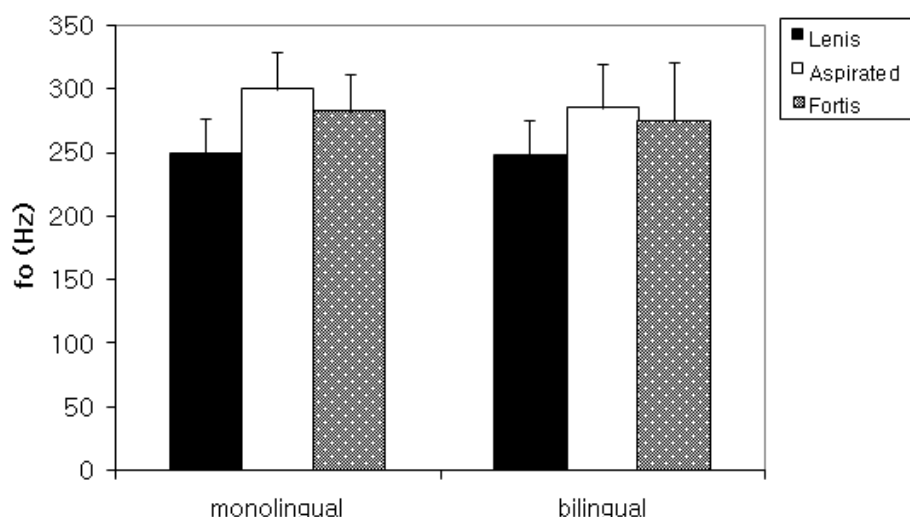


Figure 3. Korean vowel-onset  $f_0$  in monolingual and bilingual children

So far, we have compared VOT and vowel-onset  $f_0$  values between monolingual and bilingual children. We turn now to VOT and vowel-onset  $f_0$  comparisons of English and Korean stops among bilingual children, but first we establish the respective values of these properties for monolingual children in these languages in order to establish a foundation on which to compare the stops of bilingual children.



Figure 4 show means and standard deviations of VOT (X-axis) and vowel-onset  $f_0$  (Y-axis) of the English and Korean stops in monolingual Korean and English-speaking children. Six independent  $t$ -tests for all comparisons between English and Korean were conducted. The six comparisons were English voiced-Korean lenis (voiced-lenis), English voiced-Korean aspirated (voiced-aspirated), English voiced-Korean fortis (voiced-fortis), English voiceless-Korean lenis (voiceless-lenis), English voiceless-Korean aspirated (voiceless-aspirated), English voiceless-Korean fortis (voiceless-fortis). The  $t$ -tests (see Table 2) confirmed that English voiced and Korean aspirated stops were significantly different in terms of both VOT and vowel-onset  $f_0$ . The other pairs were significantly different with respect to either VOT or vowel-onset  $f_0$ .

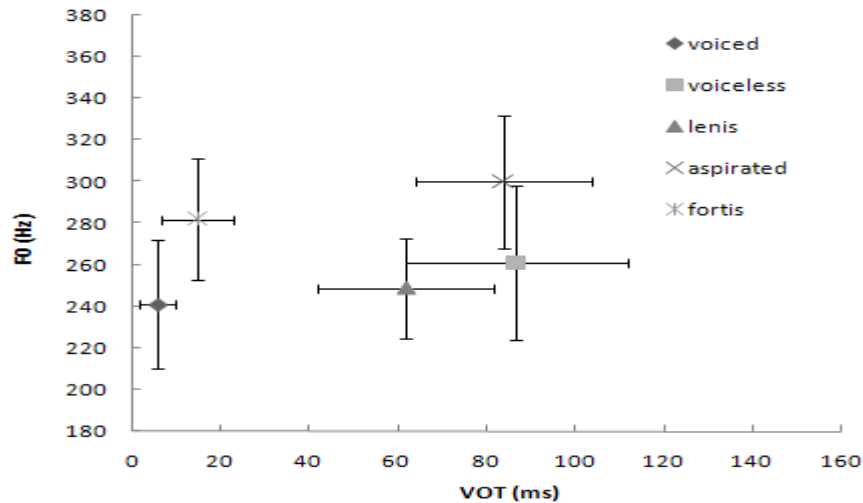


Figure 4. Korean and English stops produced by monolingual children

Figure 5 charts the English and Korean stops produced by Korean-English bilingual children. The six paired  $t$ -tests confirmed that each of the stop pairs produced by bilingual children were distinguished in terms of either VOT or vowel-onset  $f_0$ . Similar to monolingual children, voiced-lenis and voiceless-lenis pairs differed in terms of VOT, whereas voiced-fortis and voiceless-aspirated pairs differed with respect to vowel-onset  $f_0$ . The voiced-aspirated pair differed in terms of both values, as did the voiceless-fortis pair, which, however, differed only with respect to VOT in monolingual children.



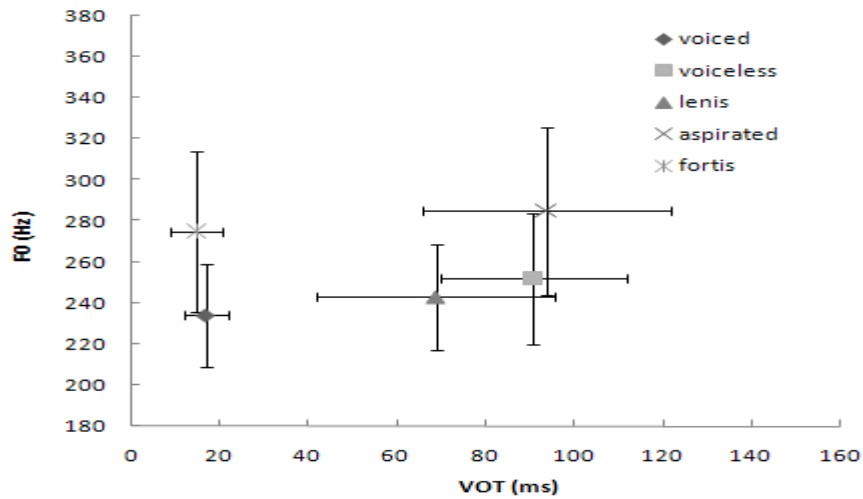


Figure 5. *Korean and English stops produced by bilingual children*

#### 4. Discussion

This paper has presented results on measurements of VOT and vowel-onset  $f_0$  for 7 year-old Korean-English bilingual children in comparison with age-equivalent monolingual English-speaking and Korean children. In a previous study (Lee & Iverson, 2011), we found that Korean and English stops were phonetically distinct as produced by monolingual 5 year-old children, but not for bilingual children at the same age who had English exposure of 2 years. In the current study, 7 year-old Korean-English bilingual children who had at least 4 years of exposure to both languages fully distinguished stop categories across the two languages in terms of either VOT or vowel-onset  $f_0$ , or both. These findings suggest that bilingual children require a certain amount of exposure duration in order to develop detailed phonetic categories across languages.

Our previous study also examined stop productions of 10 year-old Korean-English bilingual children. Ten year-old bilingual children maintained fully distinctive stop categories; however, their VOT and vowel-onset  $f_0$  values were significantly different from those of their monolingual counterparts. Ten year-old bilingual children produced shorter VOT for English voiced stops but longer VOT for Korean aspirated stops.



Table 2. *t*-test comparisons of six English and Korean stop pairs

Korean-English comparisons	Monolingual children (dF=28)		Bilingual children (dF=14)	
	VOT	$f_0$	VOT	$f_0$
voiced-lenis	-4.89***	.76	-7.96***	-2.50
voiced- aspirated	-6.22***	-4.95***	-11.91***	-7.33***
voiced-fortis	-0.30	-3.79***	-1.84	-7.45***
voiceless-lenis	5.24***	1.09	3.80***	1.67
voiceless- aspirated	-.35	-2.69***	-0.58	-4.57***
voiceless-fortis	10.09***	-1.71	15.85***	-3.24***

We concluded that bilingual children tended to maximize phonetic contrasts in order to establish distinct phonetic categories for each phone. In our current study, however, we did not find the same pattern among 7 year-old bilingual children, who did not maximize phonetic contrasts by increasing or decreasing VOT or vowel-onset  $f_0$  values. Rather, their VOT and vowel-onset  $f_0$  values were very close to those of their monolingual English or Korean counterparts. As mentioned earlier, both the English and Korean language skills of the bilingual children who participated in the current study were similar to those of monolingual children. Thus, native-like articulation may play an important role in forming phonetic categories across languages. With our previous research findings, the results of the current study suggest that the phonetic system of bilingual children continues to develop during the maturational process. The phonetic system is formed with dynamic interactions between both of the languages that bilingual children use.

We are currently examining VOT and vowel-onset  $f_0$  values of 3 year-old Korean-English bilingual children in order to obtain a more comprehensive understanding of the development of phonetic category formation in bilingual children. We are also examining the values of VOT and vowel-onset  $f_0$  of Korean children exposed to English for only a few months in order to



understand better how exposure duration plays a role in phonetic category formation. We hope that the results of these studies will contribute to a deeper understanding of speech acquisition among bilingual children.

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