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The Developmental Aspects of Phonetic Contrasts of Korean Word-Initial Stops in Young Korean Children

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Objectives: A variety of studies on speech sound development have reported that children tend to develop speech sounds through the acquisition of phonetic contrasts. However, most of the studies conducted on the development of Korean speech sounds have been completed primarily through a transcription analysis. There are only a few studies that examined the phonetic development of Korean through an instrumental analysis. This study investigates the developmental aspects of phonetic contrasts of Korean stops that are characterized by a three-way contrast (i.e., fortis, aspirated, and lenis) in word-initial positions. **Methods:** Data were collected from eight children, aged (year;month) 2;6 and 3;0, who exhibited no contrast, two-way contrast, or three-way contrast for three types of Korean stops. Three acoustic-phonetic parameters (i.e., voice onset time, fundamental frequency, and amplitude differences between the first and second harmonics of the post-stop vowels) were measured. **Results:** The acoustic analysis revealed the presence of covert contrast that was not evidenced by transcription data. The covert contrast was found in acoustic properties that are used to differentiate Korean stop consonants. **Conclusion:** This study suggests that acoustic measures may provide additional information with regards to the development of Korean speech sounds.

Keywords: Korean stops, Phonetic contrast, Acoustic measures

Korean stops have a three-way distinction and are all voiceless in word-initial position. These three types of Korean stops (i.e., fortis, aspirated, and lenis stops) can be differentiated by three acoustic-phonetic parameters: voice onset time (VOT), fundamental frequency, and amplitude differences between the first and second harmonics of the following vowel. In general, the mean VOT values are shortest for fortis stops, intermediate for lenis stops, and longest for aspirated stops. While fortis stops and aspirated stops are distinguished noticeably by the VOT values, the differentiation of lenis stops from fortis or aspirated stops requires another acoustic correlate which is the fundamental frequency (f_0) of the following vowel. f_0 at the onset of the vowels following lenis stops is generally lower than that following fortis or aspirated stops. The difference in amplitude between the first and second harmonics ($H1$-$H2$) at the onset of voicing is greater for lenis stops and aspirated stops relative to fortis stops in Korean (Cho, Jun, & Ladefoged, 2002).

Most of the studies examined the development of Korean speech sounds primarily through a transcription analysis (e.g., Kim, 1996; Kim & Pae, 2005; Kim & Shin, 1992). Only a few studies described developmental patterns of Korean speech sounds through an acoustic analysis. Kim & Stoel-Gammon's (2009) study examined the phonetic development of Korean word-initial stops by measuring three acoustic-phonetic parameters. This study reported that young Korean children exhibit both universal phonetic patterns and phonetic variation associated with articulatory complexity specific to Korean. In other words, as found in children acquiring other languages—e.g., French (Allen, 1985), Cantonese (Clumeck, Barton, Macken, & Huntington, 1981), Hindi (Davis, 1995), Thai (Gandour, Petty, Dardarananda, Dechongkit, & Mukngoen, 1986), English

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(Macken & Barton, 1980a), and Spanish (Macken & Barton, 1980b), children acquiring Korean produce stops with short VOT values first, and eventually develop a two-way contrast with both short and long VOT values. On the other hand, the language-specific f_0 variation that is required to differentiate aspirated stops from lenis stops is acquired last.

As indicated by a variety of studies on speech sound development, children tend to develop speech sounds by acquiring phonetic contrasts. Some studies, on the other hand, suggest that a stage of "covert contrast" is found between the stage with no contrast and the stage with over contrast. Covert contrast refers to statistically significant acoustic differences between two sounds although they are not reliably perceived as being different. That is, the two different sounds are perceived as only one category based on the transcription data. Studies reported the presence of covert contrast for a variety of contrasts such as voicing contrast for stop consonants (e.g., Macken & Barton, 1980a), place of articulation for stop consonants (Forrest, Weismer, Hodge, Dinnsen, & Elbert, 1990), and place of articulation for fricatives (Li, Edwards, & Beckman, 2009). Tyler, Figurski, & Langsdale (1993) reported that amongst children with phonological disorders, the children who produce covert contrast have a better prognosis than those who produce no contrast at all.

The present study investigates the developmental aspects on phonetic contrast of Korean stops that are characterized by a three-way contrast word-initially, as well as how the covert contrast appearing in other languages is presented in the development of Korean stops. There are no previous studies that have examined covert contrasts for Korean speech sounds through instrumental analysis. In addition, Korean stops are differentiated by three different acoustic-phonetic parameters as opposed to most other languages that have stops differentiated primarily by VOT. Therefore, this study examines covert contrast by measuring each acoustic-phonetic parameter in stop productions of young Korean children.

METHODS

Participants

Child speech samples were collected from eight typically developing children, four boys and four girls who had participated in Kim & Stoel-Gammon's (2011) phonological study. These children were grouped based on the results of phonetic transcription when they produced Korean three-way stops. The first group (group 1) consisted of one boy and one girl, both aged 2;6 (year;month), and one girl aged 3;0, respectively. These children produced fortis stops for most of the Korean stops. Two children (one boy and one girl) aged 2;6, who produced the two-way contrast of fortis and aspirated stops, were in the second group (group 2). The third group (group 3) included one girl aged 2;6 and two boys, both aged 3;0, who produced the three-way contrast of Korean stops. All the children lived in Seoul or Gyeonggi province, where the Seoul dialect is spoken. The children's mothers spoke the Seoul dialect as well. The children had no speech, language, hearing or cognitive problems as reported by their parents, and scored above the 16th percentile on the Korean Picture Vocabulary Test (Kim, Jang, Yim, & Paik, 2004). Participants were recruited either through a church community, daycare centers or the experimenter's acquaintances.

Data collection

Target words were monosyllabic near-minimal triplets for word-initial fortis, aspirated, and lenis stops at each place of articulation. All these words were familiar words to children at the target ages and were listed from McArthur Communicative Development Inventory-Korean (Pae, Chang-Song, Kwak, Sung, & Sim, 2004). Although an effort was made to choose triplets with the same neighboring segments in order to minimize possible effects of vowels and final consonants on the VOT of prevocalic stops, such triplets included words with different vowels or final consonants due to the limited size of the young children's vocabularies. The differences in vowel identity or neighboring segments across words with different types of stops were not considered to be a significant problem because all children produced the same target words with almost an equal number of tokens. To avoid the influence of phrase- or sentence-level factors, only single-word utterances were analyzed. The target words are shown in Table 1.

Data were collected in a quiet room at the participants' homes through naming activities with toys, objects, or picture cards. Speech samples were audiotaped by using a Sony digital audio tape recorder. Children wore a vest with an Azden WMS-PRO wireless mi-

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Table 1. Target words with Korean stops in word-initial position

Fortis	Aspirated	Lenis
/p*aŋ/ "bread"	/pʰal/ "arm"	/pal/ "foot"
/t*ʌk/ "rice cake"	/tʰʌk/ "chin"	/tak/ "hen"
/k*ot/ "flower"	/kʰoŋ/ "bead"	/koŋ/ "ball"

crophone attached approximately 10 cm from the mouth, along with a small transmitter placed in a pocket inside the vest. Most of the target words were produced in response to questions, such as "what is this?". Children were provided with multiple opportunities to produce the target words and an attempt to obtain at least five tokens for each stop consonant was made.

All speech samples were re-digitized at a 44.1 kHz sampling rate by using COOL EDIT PRO 2 (Adobe Systems, San Jose, CA, USA), and then, the tokens of words with target phonemes word-initially were identified. Five tokens for each stop consonant were randomly selected for acoustic analysis; only the tokens that were produced as stops at the correct places were chosen. Tokens that were considered to be extremely elongated, too loud or too soft, or had ambient noise were excluded. A total of 359 CVC (consonant+vowel+consonant) tokens (8 children×9 stops×mostly 5 tokens) were analyzed.

Data analysis

Acoustical analysis was conducted by using the speech analysis software, PRAAT 4.4.13 (Boersma & Weenink, 2006). VOT, fundamental frequency f_0, and the amplitude difference between the first and second harmonics $H1$-$H2$ were obtained. VOT measures were made by marking the interval between the beginning of the stop burst and the onset of the periodic glottal vibrations as displayed in the waveform and the 200 Hz broad bandwidth spectrogram. The voice onset was determined directly from the waveform, supplemented by the signal of the voice bar from the spectrogram. f_0 values were taken at the onset of the following vowel, that is, the end point of VOT. However, some tokens with breathy or creaky phonations did not display a pitch track at the onset of the vowel. In such cases, f_0 was measured at near points within 10 ms (i.e., within one time step of the analysis program from the true onset).

Amplitudes (dB) of the first ($H1$) and the second ($H2$) harmonics were measured based on the 2,048-point fast Fourier transform spectrum with a 25-ms window sliced from the voice onset, and the difference of the amplitudes ($H1$-$H2$) was calculated. Three tokens, which presented unreliable harmonic peak values, possibly due to extreme roughness or creakiness at voice onset, held no energy values.

Table 2. Means (standard deviations) of VOT, f_0, and $H1$-$H2$ for each child at the stage of no contrast

Measure stop category	Child (yr;mo)		
	OTG (2;6)	GSM (2;6)	PHN (3;0)
VOT (ms)			
Fortis	9.4 (11.4)	7.2 (17.9)	18.8 (20.1)
Aspirated	9.3 (14.1)	10.6 (9.4)	27.9 (14.3)
Lenis	11.5 (10.8)	-1.1 (13.9)	28.8 (28.5)
f_0 (Hz)			
Fortis	405.6 (96.8)	324.0 (41.0)	353.5 (39.9)
Aspirated	398.9 (69.3)	301.5 (28.3)	344.6 (23.8)
Lenis	360.3 (45.4)	320.6 (20.8)	333.7 (24.4)
$H1$-$H2$ (dB)			
Fortis	-7.2 (7.8)	-5.3 (7.9)	-3.5 (3.7)
Aspirated	-4.9 (9.8)	-6.0 (7.7)	0.3 (3.1)
Lenis	-7.8 (7.4)	-0.7 (2.2)	-0.4 (4.0)

VOT = voice onset time.

As for statistical analysis, one-way repeated measures of ANOVAs were conducted for VOT, f_0, and $H1$-$H2$, respectively, with the stop category as a within-subject factor. In order to maximize the number of tokens and allow for better statistical analyses, all the productions across the three places of articulation (i.e., bilabial, alveolar, velar) were grouped together for each stop category. To avoid violating the sphericity assumptions associated with repeated measures designs, a Huynh-Feldt corrected degree of freedom was adopted for all F tests. All pairwise post-hoc comparisons were carried out with the Bonferroni adjustment of the alpha level ($\alpha = .05$) for each individual test. All statistical analyses were performed by using the SPSS ver. 20.0 (IBM Co., Armonk, NY, USA).

RESULTS

Table 2 displays the results of acoustic analyses of stop consonants as produced by the three children (group 1: OTG and GSM aged 2;6 and PHN aged 3;0) who did not exhibit any contrasts across three stop categories through a transcription analysis. Means and standard deviations of three acoustic measures (i.e., VOT, f_0, and

$H1$-$H2$) for each child are being presented.

Results of one-way repeated measures of ANOVAs revealed no significant stop category effects for all three acoustic-phonetic parameters in OTG and GSM. As for PHN, a significant stop category effect was found for $H1$-$H2$ values ($F_{(1.68, 23.50)} = 4.17, p < .05$), with no effect for VOT and f_0. Multiple comparisons with a Bonferroni adjustment showed that $H1$-$H2$ values for PHN was significantly smaller for fortis stops than aspirated stops ($p < .05$). The results indicate that PHN exhibits covert contrasts between fortis and aspirated stops by $H1$-$H2$ values.

The three acoustic measures of stop consonants produced by two children in group 2 are shown in Table 3. These children (KMJ and KSJ), aged 2;6, demonstrated the phonetic contrast between fortis and aspirated categories merely through a transcription analysis. They produced the most lenis stops as aspirated stops. The results of one-way repeated measures of ANOVAs for these children' s stop productions showed a significant main effect of stop category for all acoustic measures: VOT ($F_{(1.60, 46.44)} = 73.20, p < .001$), f_0 ($F_{(1.68, 48.68)} = 506.76, p < .001$), and $H1$-$H2$ ($F_{(1.93, 56.08)} = 26.69, p < .001$). Pairwise comparisons showed that VOT was significantly longer for aspirated and lenis stops than for fortis stops in both children ($p < .001$). There was no significant difference between the aspirated and lenis stops. As for f_0 that served to distinguish lenis stops from fortis and aspirated stops, KMJ demonstrated a significant difference for fortis vs. aspirated stops ($p < .001$) and aspirated vs. lenis stops ($p < .01$). On the other hand, KSJ only showed a significant difference between fortis and aspirated stops ($p < .001$). In the case of $H1$-$H2$, while there was a significant difference between fortis and lenis stops for KMJ ($p < .001$), the $H1$-$H2$ was significantly different for both fortis vs. aspirated stops and fortis vs. lenis stops in KSJ's productions ($p < .001$ and $p < .01$, respectively). These results indicate that KMJ exhibits covert contrast between aspirated and lenis stops by f_0 difference, with no significant difference of VOT, whereas KSJ demonstrated no contrast between aspirated and lenis stops, with no significant difference in all three acoustic measures.

Table 4 presents the results of acoustic measures for children in group 3 (CDI aged 2;6 and KCY aged 3;0) who demonstrated a three-way distinction through a transcription analysis. In other words, this group produced all three types of Korean stops. The results from one-way repeated measures of ANOVAs for CDI showed a significant main effect of stop category for all acoustic measures: VOT ($F_{(1.75, 24.52)} = 56.41, p < .001$), f_0 ($F_{(2, 28)} = 38.25, p < .001$), and $H1$-$H2$ ($F_{(1.7, 23.8)} = 24.08, p < .001$). Pairwise comparisons indicated that CDI produced fortis stops with significantly shorter VOT than that for aspirated and lenis stops ($p < .001$). In other words, similar to the children from group 2, CDI displayed a bimodal VOT distinction by producing fortis stops with short VOT and lenis and aspirated stops with long VOT. The statistical results for $H1$-$H2$ for CDI was the same as VOT, indicating the differentiation of fortis stops vs. lenis and aspirated stops. In the case of f_0, a significant difference was found in fortis vs. lenis stops ($p < .001$)

Table 3. Means (standard deviations) of VOT, f_0, and $H1$-$H2$ for each child at the stage of a two-way contrast

Measure stop category	Child (yr;mo)	
	KMJ (2;6)	KSJ (2;6)
VOT (ms)		
Fortis	-8.1 (32.1)	9.6 (17.2)
Aspirated	107.4 (24.6)	52.7 (33.8)
Lenis	103.6 (20.8)	65.6 (30.4)
f_0 (Hz)		
Fortis	480.8 (45.9)	391.6 (18.0)
Aspirated	604.6 (78.3)	429.3 (33.1)
Lenis	523.3 (62.6)	390.7 (45.1)
$H1$-$H2$ (dB)		
Fortis	-13.6 (12.1)	-8.5 (6.8)
Aspirated	-4.6 (15.9)	6.2 (5.0)
Lenis	1.9 (10.4)	4.7 (6.7)

VOT = voice onset time.

Table 4. Means (standard deviations) of VOT, f_0, and $H1$-$H2$ for each child at the stage of a three-way contrast

Measure stop category	Child (yr;mo)		
	CDI (2;6)	KCY (3;0)	KJW (3;0)
VOT (ms)			
Fortis	9.4 (9.4)	3.3 (16.3)	10.6 (11.3)
Aspirated	88.3 (31.8)	81.9 (20.8)	96.4 (26.6)
Lenis	92.9 (32.1)	47.5 (17.5)	68.8 (15.4)
f_0 (Hz)			
Fortis	388.9 (33.3)	370.5 (63.8)	298.1 (22.5)
Aspirated	372.1 (32.6)	394.7 (87.2)	317.3 (37.0)
Lenis	301.3 (19.1)	341.4 (73.5)	272.1 (40.9)
$H1$-$H2$ (dB)			
Fortis	-5.7 (7.4)	-14.1 (7.3)	-4.7 (5.4)
Aspirated	9.0 (7.1)	5.2 (8.0)	1.7 (3.9)
Lenis	6.5 (6.5)	5.9 (6.9)	3.9 (3.6)

VOT = voice onset time.

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and aspirated vs. lenis stops ($p < .001$). Thus, the lenis category was separated from the aspirated category with significantly lower f_0 values.

The results of one-way repeated measures ANOVAs with KCY's acoustic measures also revealed a significant stop category effect for all acoustic measures: VOT ($F_{(2, 28)} = 71.84$, $p < .001$), f_0 ($F_{(2, 28)} = 1.55$, $p < .001$), and $H1$-$H2$ ($F_{(2, 28)} = 34.96$, $p < .001$). Pairwise comparisons showed that VOT for KCY was significantly the shortest for fortis stops, intermediate for lenis stops, and the longest for aspirated stops ($p < .001$ for each comparison). The f_0 values, on the other hand, were not significantly different for any other comparisons of stop categories, despite the higher f_0 in aspirated stops than lenis stops. As for $H1$-$H2$, there was a significant difference in fortis vs. aspirated stops and fortis vs. lenis stops. The results indicated that KCY used VOT to differentiate all three types of stops, while separating the fortis category from the aspirated and lenis categories with $H1$-$H2$.

The results of one-way repeated measures ANOVAs for KJW's stop productions also revealed a significant stop category effect for VOT ($F_{(1.64, 23)} = 83.92$, $p < .001$), f_0 ($F_{(2, 28)} = 9.04$, $p < .01$), and $H1$-$H2$ ($F_{(2, 28)} = 16.11$, $p < .001$). Pairwise comparisons showed that VOT was significantly the shortest for fortis stops, intermediate for lenis stops, and the longest for aspirated stops ($p < .001$ for fortis vs. aspirated and fortis vs. lenis comparisons; $p < .01$ for aspirated vs. lenis comparison). As for f_0 values, only the aspirated vs. lenis stops were significantly different ($p < .01$). The $H1$-$H2$ were significantly different for fortis vs. aspirated stops and fortis vs. lenis stops, which is similar to the results found in two other children from this group.

CONCLUSION

This study investigated the development of phonetic contrasts among Korean stop consonants by measuring multiple acoustic properties from three groups of children: a group at the stage of no contrast, a group at the stage of two-way contrast, and a group at the stage of three-way contrast based on a transcription analysis. The findings are summarized as follows.

First, two children (OTG, GSM) at the stage of no contrast did not exhibit any significant differences for all acoustic measures. Conversely, although the other child's (PHN) productions of both fortis and aspirated stops were perceived by adults as fortis stops, she demonstrated a significant $H1$-$H2$ difference between fortis and aspirated stops, which is considered to be covert contrast. This child appeared to reflect phonological knowledge about the fortis vs. aspirated category in her productions.

Secondly, as for children at the stage of two-way contrast, one child (KSJ) exhibited a phonetic contrast between fortis stops and aspirated or lenis stops with significantly different VOT and $H1$-$H2$ values. The bimodal VOT distinction between fortis stops and aspirated or lenis stops was reported to be a general pattern in the development of stops among young Korean children (Kim & Stoel-Gammon, 2009). Another child (KMJ) similarly demonstrated the pattern found in KSJ. However, she also showed presence of covert contrasts between aspirated and lenis stops, which was not identified by the adults' perceptions. These results imply that KMJ's understanding of phonetic contrasts was not only between fortis vs. aspirated or lenis categories, but also between aspirated vs. lenis categories as shown by the significantly different f_0 values between these categories.

Lastly, two children (CDI, KJW) at the stage of three-way contrast utilized all acoustic-phonetic parameters to differentiate among the three types of Korean stops. Both children produced significantly different VOT and $H1$-$H2$ values to separate fortis stops from aspirated or lenis stops, and significantly different f_0 values for aspirated vs. lenis stops. In contrast to these two children, the other child (KCY) produced significantly different VOT values that served to differentiate between the aspirated and lenis stops along with the $H1$-$H2$ difference for fortis vs. aspirated or lenis stops. No significant difference of f_0 values for the aspirated vs. lenis category was found. The results from this group suggest that there could be individual differences when using acoustic properties to realize phonetic contrasts in the process of acquiring Korean stop consonants.

With respect to the order of acquisition for Korean three-way stops, the findings of this study are similar to those of the previous group-based developmental studies (Kim & Pae, 2005; Kim & Stoel-Gammon, 2009). Young Korean children first produced fortis stops, which are realized as short VOT values. Next, they produced the two-way contrast of Korean stops that were perceived as fortis and aspirated categories. These two categories were contrasted by a significant difference in the VOT values. Only after displaying the bimodal VOT distribution, did children develop the variation of f_0 that is used to differentiate between aspirated and lenis stops. Kim & Stoel-Gammon (2009) explained the late acquisition of lenis stops by certain phonetic characteristics that are inherent to this stop category. Lenis stops tend to be produced with weaker articulations, and therefore, are less prominent in relation to fortis and aspirated stops. In addition, the production of lenis stops may be more complex with the involvement of additional laryngeal adjustments for lowering f_0 given that the VOTs for these stops are similar to those for aspirated stops.

A closer investigation of developmental patterns of Korean stops also revealed that young Korean children demonstrated covert contrast while acquiring the three-way contrast. However, in comparison to children learning other languages that mainly utilize VOT to make stop contrasts (e.g., voiceless vs. voiced for English and Spanish, and voiceless unaspirated vs. voiceless aspirated vs. voiced for Thai), Korean children tend to demonstrate covert contrast in all the acoustic properties that are used to differentiate Korean stop consonants.

At the stage of no contrast, one child exhibited covert contrast between fortis vs. aspirated stops by the significant $H1$-$H2$ difference, which indicates the different voice quality of the vowel after fortis vs. aspirated stops. In general, the voice quality of the vowels tends to be breathy after lenis and aspirated stops, and also laryngealized or creaky after the fortis stops (Ahn, 1999). Fortis and aspirated stops are clearly separated by short vs. long VOT values with the $H1$-$H2$ as the supplementary feature whereas lenis stops are produced with intermediate VOT values in adult speech. The presence of covert contrasts between fortis and aspirated stops with no acoustic differences between fortis and lenis stops may be explained through clearer acoustic distinctions between fortis and aspirated stops. It is interesting to find that this child only showed covert contrast between fortis and aspirated categories with significantly different $H1$-$H2$ values. None of the three children at the stage of no contrast demonstrated covert contrast by VOT values between fortis vs. aspirated or lenis stops. With the limited number of participants, it is unclear whether or not Korean children also exhibit covert contrast by VOT differences as seen in children when learning different languages. With regard to covert contrast by significantly different f_0 values, Korean children displayed the f_0 variation only after they produced a bimodal VOT distribution. That is, they used different f_0 values to make a contrast between aspirated and lenis stops.

In conclusion, the current study reports the presence of covert contrasts in the development of Korean stop consonants. In comparison to children when learning other languages, Korean children tend to demonstrate covert contrasts in all acoustic properties that are used to differentiate Korean stop consonants. The results of this study suggest that Korean children may reflect their knowledge on phonetic contrasts among Korean stops by producing significantly different acoustic values even though their productions of different categories are not identified by adult listeners. Therefore, acoustic measures may provide additional information with regards to the development of Korean speech sounds.

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국문초록

한국어 단어 초 폐쇄음의 음소 대립의 발달 양상

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배경 및 목적: 말소리 발달에 대한 다양한 선행연구를 통해, 아동의 말소리 발달은 음소 대립의 습득 과정을 통해 이루어짐이 보고되었다. 그러나 대부분의 한국어 말소리 발달에 대한 연구들은 음성 전사를 통해 이루어졌고, 기기분석을 통해 한국어 음성 발달을 조사한 연구는 단지 몇몇에 불과하다. 본 연구에서는 단어 초에서 세 가지 발성 유형의 대립을 보이는 한국어 폐쇄음의 음소 대립의 발달 과정을 음향적, 통계적 분석을 통하여 살펴보았다. **방법:** 음성 전사를 통한 분석에서 무대립(no contrast), 이중 대립, 삼중 대립을 보이는 세 그룹의 아동 8명의 발화에서 한국어 폐쇄음을 구별하는 데 중요한 세 가지 음향적 매개 변수, 즉, VOT, f_0, $H1$-$H2$의 값을 측정하였다. **결과:** 연구 결과, 한국어를 습득하는 아동의 폐쇄음의 발달 과정에서 음향적 값의 차이에 의해 나타나는 숨은 대립(covert contrast) 현상이 발견되었다. 즉, 한국 아동은 음성 전사 자료에서 나타나지 않는 폐쇄음의 음소 대립을 음향적인 차이를 통하여 실현하고 있음을 알 수 있었다. **논의 및 결론:** 본 연구는 음향적 분석을 통해 음성 전사에 의해 나타나지 않는 말소리 발달에 대한 추가적인 정보를 얻을 수 있음을 시사하고 있다.

핵심어: 한국어 폐쇄음, 음소 대립, 음향 분석

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