Perception of Korean Plosives by L2 Learners of Korean

Chong-Woon Kim
Griffith University, Australia

Abstract

Korean plosives have a rather uncommon three-way contrast (i.e. normal, tense and aspirated) and this apparently causes some initial learning difficulty for many L2 learners of Korean both in perception and production. The primary aim of the present study is to confirm empirically that the problem is real and to describe systematically the nature of the difficulty involving the Korean plosives using experimental data (identification test on Korean plosives presented in a CV carrier frame). The subject group includes both non-native and native speaker of Korean. The non-native subject group comprises mainly of Chinese and Japanese L1 speakers. The results from the identification experiment provide concrete evidence for the apparent difficulty for the L2 learners of Korean regarding the Korean plosives. On the basis of the results from recent studies in first language acquisition and language learning impaired children, a number of promising avenues in tackling the L2 speech sounds acquisition were sketched.

1. Introduction

Even a cursory classroom observation of the Korean speech production by students with different L1 background reveals, in addition to the readily perceivable prosody related problems, a variety of clearly noticeable and recurring pronunciation problems with regard to a number of Korean sounds. These problems are observed not just from a beginners group but sometimes across the whole range including the intermediate level students with two or three years of formal learning of Korean. One of the most serious among them, from a pedagogical point of view, seems to be the ones involving the Korean plosive sounds. The problematic nature of these Korean sounds for the students is also confirmed by frequent anecdotal remarks by students complaining how difficult they are and the never ending request to pronounce them repeatedly. The errors involving Korean stops are well beyond the level of acceptable foreign accent and actually threaten intelligibility (e.g. contrast between /tal/ 'moon', /t*al/ 'daughter' and /t^hal/ 'mask'), thereby creating a serious pedagogical problem. A precursor to any attempt to find a solution (e.g. more satisfactory training mechanism) is being able to identify more clearly and systematically the nature of the difficulty involving the perception and production of the Korean sounds by the L2 learners.

The main purpose of this paper, then, is to examine and describe more systematically this apparent difficulty involving Korean plosives for the L2 learners of Korean. It can be regarded as a first step toward a more comprehensive response in which the exact nature of the problem can be studied in more detail and possibly establish the groundwork upon which we can generate an effective pedagogical solution. In order to address the above objective, identification experiments were conducted to collect performance data from a group of L2 learners of Korean. The experiment generates information on how well learners categorize or identify the target sounds in L2. The patterns of identification and misidentification reflect the primary performance of learners accommodating a new sound system
A brief description on Korean plosive sounds is given first and a number of hypotheses are put forward in this section. The methodology section describes in detail the subject groups and the experiment setting. The next section analyses the data and presents discussion of the results obtained. In the conclusion some suggestions are made in terms of future research direction, particularly in relation to the development of a more effective training mechanism for L2 learners.

1.1 Korean Plosives

It is probably not an overstatement to say that no other area of the Korean language has received more attention than the Korean stop sounds in linguistics. Since the work of Kim (1965) where the tensity feature was proposed as an additional feature independent of the voicing and aspiration for the classification of stop sounds, there has been a steady flow of research on Korean stops. Most of the earlier works were based on detailed articulatory and acoustic studies (Kim 1965, 1970, Hardcastle 1973, Han and Weitzman 1970). In these and more recent studies (M. R. Kim 1994, Cho and Keating 2001, Park 2002), it was generally agreed that the Korean stop sound system has three series of underlying voiceless plosives (i.e., tense /p*, t*, k*/, lax or normal /p, t, k/ and aspirated / p^h, t^h, k^h /).

This generally accepted view is not without problems. In their study Kim and Duanmu (2004) pointed out that the system is problematic from a view point of phonological theory because it overgenerates stop sounds so far unattested in world languages (e.g. voiced and voiceless tense aspirated). Kim and Duanmu (ibid) suggested an alternative system which contains voiceless aspirated, voiceless unaspirated

and voiced (which becomes devoiced at the word initial position) so as to avoid the inclusion of the problematic tensity feature. Although quite important it may be, the main issue is to come up with the most plausible phonological explanation. Far more important and immediate for the L2 learning of the Korean stops would be the precise characterization of acoustic and perceptual cues that enables the native Korean speakers successfully contrast these sounds.

All Korean plosives are voiceless pulmonic egressives, at least on acoustic and articulatory evidence, and a number of acoustic cues differentiate them. Voice onset time (VOT) was regarded as the most notable acoustic cue (Lisker and Abramson 1964) but work by Kim (1965, 1970), Hardcastle (1973) and Han and Weitzman (1970) put some doubt on whether it is the primary acoustic cue because of the VOT overlap. These and other subsequent studies (Hombert 1978, Cho 1996) put forward the view that F0 value at the stop release provide supplementary cues for the Korean laryngeal contrast whereby aspirated has the highest F0 values followed by tense and plain series. In other words, L2 learners of Korean need to perceive VOT and F0 contrast, among other things, to successfully distinguish the Korean stop series. Consequently one would assume that an effective training material of the Korean stop sounds for L2 learners should facilitate selective attention to these acoustic cues in someway so as to heighten the perceptual awareness of them by the learners.

1.2 Hypotheses

There were two main subject groups. Group I comprises L2 learners while Group II has only native Korean subjects and functions as a control group. It is expected that the identification experiment results would show a ceiling/near ceiling performance by Group II and a substantially lower performance level from Group I (Hypothesis 1 and 2). Additional predictions were generated on the basis that there were more than one L1 background in the first subject group. Utilizing the perspective of L1 transfer effect on L2 performance provided by the classic Contrastive Analysis Hypothesis (CAH), a stop phoneme inventory table was generated.

Table 1. Plosives in Chinese (CHN), Japanese (JPN) and Korean (KOR)

	Bilabial		Dental/Alveolar		Velar	
Voicing	voiced	voiceless	voiced	voiceless	voiced	voiceless
KOR		/p/ /p^h/ /p*/		/t/ /t^h/ /t*/		/k/ /k^h/ /k*/
CHN		/p/ /p^h/		/t/ /t^h/		/k/ /k^h/
JPN	/b/	/p/	/d/	/t/	/g/	/k/

A quick comparison of the inventory of stops in the above table would yield the following predictions within the traditional CAH framework with regard to the identification function. CHN subjects would have difficulty with the tense series stop sounds but would perform well with the normal and aspirated stops (Hypothesis 3). On the other hand, JPN subjects would have problems in identifying the aspirated and tense series stops while normal ones should not cause any trouble (Hypothesis 4). Finally, for both CHN and JPN subjects, tense stops would be the most difficult ones to identify since there is no L1 counterpart (Hypothesis 5). CAH would not be able to predict any varying tendency in the degree of difficulty in identifying these sounds on the basis of place of articulation since all of them utilize the three places.

2. Methodology

2.1 Subjects

The non-native Korean subjects (Group I) were from four different L1 groups. They are Australian English (henceforth AE), Indonesian (INDN), Japanese (JPN) and Mandarin Chinese (CHN). Among the native Korean speaker group (Group II), two subjects were in their twenties and the other three were in their forties .The non-native Group was composed of first year Korean major undergraduate students without any prior in-country training or experience. The experiment was conducted near the end of the 2nd semester where all Group I subjects had 115 hours of formal training in Korean and were quite confident with the reading and writing of the Korean orthography. For this group of subjects, one would not expect a large variation in their L2 experience since the main source of their L2 exposure has been more or less limited to their lecturers, tutors and the audio resources made by the same teachers. All Group I subjects were asked to volunteer for the experiments and a small amount of course credit was given to those who participated. Because the subjects who participated in the experiments were volunteers, there was no control over the balance of number in each language groups or their subgroups (e.g. AE had only 1 and INDN, 2 subjects). This presents a less than ideal situation for statistical analysis and interpretation. None of the subjects in both groups reported any hearing or speech problems.

Table 2. Number of Group I and II subjects participating in the experiment

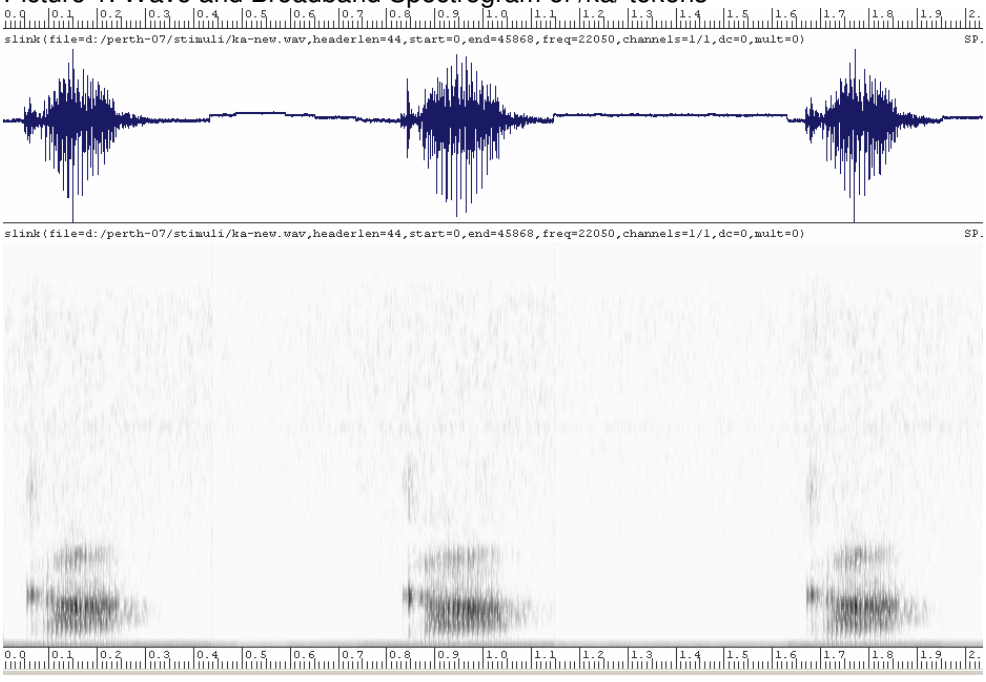
	CHN	JPN	INDN	AE	KOR
Male	5	3	1	1	3
Female	6	2	1		2
Total	11	5	2	1	5

2.2 Stimuli

It is conventional in experimental works on cross-language speech perception (Werker and Logan, 1985; Polka, 1995) to select the best and most similar tokens for L2 target. The recording of stimuli was initially done in stereo on a DAT recorder (SONY TCD-D80 using ECM900 microphone) at 16 bit 48 Khz. It was then encoded as a PCM mono wave format file at 16 bit 22 Khz. A native Korean speaker made 10 tokens for each of the 9 Korean plosives in CV carrier frame where the vowel is /a/. The recordings were then evaluated for their prototypicality by two other native Korean speakers using a 10 point scale where a score of 10 stands for the best representation of the target sound. Virtually all of the tokens received the score of 10 and a few 9. Three tokens for each target sound were then selected using the following procedure. Firstly, from the 10 tokens for each sound the first and the last tokens were discarded because of the time needed for the speaker to adapt to the citation reading environment and the typical intonation contour change involved in the final token of a citation reading list. In the remaining 8 tokens, there are always more than two tokens with the best possible score of 10.

In order to select the final three tokens, additional selection criteria of stimulus length and amplitude were utilized. This was motivated in order not to confound consonant quality with the length of the stimuli and the amplitude difference. The point is that length or amplitude of a stimulus can be very salient features for listeners. To do that, all those tokens with the score of 10 were measured for their length and compared for their amplitude using Sound File System software. Three tokens for each target sound with the most similar length and amplitude were then finally selected for the perception experiment. The total number of stimuli for the perception test was 27 (i.e. 9 plosives x 3 tokens). A screen shot of wave and broadband spectrogram for /ka/ is given in picture 1.

Picture 1. Wave and Broadband Spectrogram of /ka/ tokens



2.3 Experiment

The main purpose of the identification experiment was to elicit listener categorization of stimuli with respect to L2 phonological categories. The experiment contained 18 trials (9 plosives, run twice) that were arranged in a pseudo random order. In each trial three tokens of a plosive were heard. The inter stimulus interval (ISI) was half a second. Subjects made their responses by circling a chosen L2 keyword from a series of word lists that were given on the response sheet. The inter-trial interval (ITI) was 3 seconds. All of the pre-recorded stimuli were delivered binaurally through a pair of loud speakers at a comfortable listening level. The experiment contained a series of familiarization trials. Subjects were

reminded prior to each experiment that they should complete all trials and make a guess if they were uncertain about their choice.

3. Results and Analysis

In order to test Hypothesis 1 (that the experiment results would show a ceiling/near ceiling performance by Group II) and Hypothesis 2 (that a substantially lower performance level would be observed from Group I), percentage correct values were generated from the raw data (table 2).

Table 3. Percentage Correct for Place and Manner (Group II in bracket)

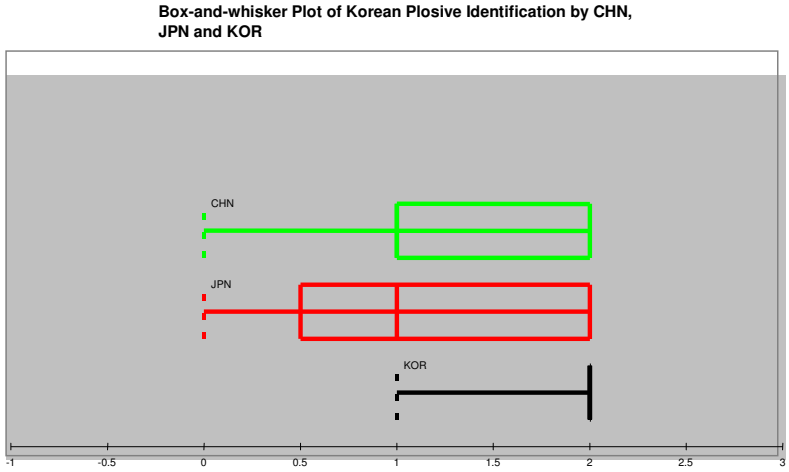
	Labial	Alveolar	Velar
Normal	58 (90)	50 (100)	42 (100)
Aspirated	74 (100)	45 (100)	63 (100)
Tense	63 (100)	58 (100)	63 (100)

The results in Table 3 clearly support the predictions made in Hypothesis 1 and 2. The Group II data shows a ceiling level performance while there was some variation depending on the particular stop sound. The performance level of Group I was substantially below Group II. In order to examine the within group variation level, CHN, JPN and KOR subjects performance results were tabulated for average score and standard deviation (INDN and AE data were discarded due to small number of subjects). The results are shown in Table 4. In addition a box-and whisker plot was also generated (Picture 2).

Table 4. Average Score and Standard Deviation for KOR, CHN and JPN

	KOR	CHN	JPN
Average	1.98	1.09	1.24
SD	0.15	0.76	0.83

Picture 2. Box and Whisker Plot of CHN, JPN and KOR



The box and whisker plot shows that JPN and CHN have more variability while Korean has virtually no variability (i.e. no box and short whisker). It also shows that CHN data was left-skewed by a small number of outliers. These findings clearly indicate that native Korean speakers have no problem at all while L2 learners in general have serious problems in identifying Korean plosive sounds.

In order to examine whether there is a varying degree of difficulty for different sounds, percentage correct scores for each plosive were arranged as in Table 5. The results show that the most difficult sound is /k/, followed by /t^h/ and /t/. The easiest sound to identify is /p^h/ with 74% correct. This is much higher than /k/, /t^h/ and /t/ but is still no where near the native Korean group performance. However, it seems that there is no clearly observable pattern.

Table 5. Rank Ordered Degree of Difficulty for Korean Plosives

	Place	Manner		% Correct (KOR)
More Difficult	Velar	Normal	k	42 (100)
	Alveolar	Aspirated	t^h	45 (100)
	Alveolar	Normal	t	50 (100)
	Labial	Normal	p	58 (90)
	Alveolar	Tense	t*	58 (100)
	Labial	Tense	p*	63 (100)
	Velar	Aspirated	k^h	63 (100)
	Velar	Tense	k*	63 (100)
Less Difficult	Labial	Aspirated	p^h	74 (100)

Table 6. Identification Experiment Percentage Correct for Place

L1	Labial	Alveolar	Velar	Whole
Group I	65.0	51.0	54.3	56.8
Group II	96.7	100.0	100.0	98.9

Table 7. Identification Experiment Percentage Correct for Manner

L1	Normal	Aspirated	Tense	Whole
Group I	50.0	57.9	61.4	56.4
Group II	96.7	100.0	100.0	98.9

In order to remove the possible confounding effect of Place and Manner in Table 5, two additional tables were generated to separate Place (Table 6) and Manner (Table 7).The results in Table 6 indicate that labial sounds are easier to identify than alveolar and velar. In terms of manner of articulation, tense plosives are easier than aspirated and normal series. It is not clear, given that none of L1s of Group I have tense plosives in their consonant inventory, why Korean tense series got the higher score for correct identification. One would normally expect, within the classical CAH framework, that the reverse would be the case. A possible explanation may come from the Speech Learning Model (SLM) by Flege.

Flege's SLM, although not specifically affiliated with any of the general perception theories, seeks to identify the extent to which non-native contrasts share acoustic and/or articulatory cues with native distinctions and whether such overlap predicts ease of acquisition of perceptual and productive ability with L2 sounds. SLM is an extended and refined version of Flege's (1987) perceptual equivalence classification theory. This theory postulates that a new phonetic category can be established for an L2 sound which differs phonetically from the closest L1 sound but the formation of a new phonetic category will be blocked if an L2 sound is not sufficiently different from an L1 sound.

In his earlier study Flege (1987), using data from English learners of French, claimed support for the theory where an L2 sound which is perceived as new will be learned by the L2 learner where as the learning of an L2 sound which is perceived as similar to an existing L1 sound may be prevented by the equivalence classification mechanism. The study reported that the productions of French /y/ (a new sound) by English speakers of French with varying degree of French experience, except for the least experienced group, were in closely approximated forms. On the other hand the productions of the French /u/, which would be a similar sound for English speakers, were, regardless of the amount of French experience, significantly different from the native French norm. In other words, it may be the case that Korean tense series are perceived as a new phone where there is a no clear L1 counterpart and as such more successfully accommodated into the L2 learner's interlanguage and as such better identified than the other series which have their counterparts in the L1s of Group I subjects.

In order to test the remaining CAH based hypothesis (i.e. Hypothesis 3, 4 and 5), CHN and JPN data were filtered through from the raw data. The resulting figures are given in Table 8. Hypothesis 3 stated that CHN subjects would have difficulty with the tense series stop sounds but would perform well with the normal and aspirated stops. This is only partially supported by the results. Indeed CHN has a very low score of 41% correct for tense series which is below the chance of level performance. The problem is that the worst one is in fact the normal series which, according the Hypothesis 3, should have been easier.

Table 8. Identification Percentage Correct for Manner by JPN, CHN and KOR

L1	Normal	Aspirated	Tense	Whole
JPN	70.0	90.0	40.0	53.3
CHN	27.0	73.0	41.0	54.3
KOR	96.7	100.0	100.0	98.9

According to the Hypothesis 4, JPN subjects would have problems in identifying the aspirated and tense series stops while normal ones should not cause any trouble. Again we have mixed results where the normal series was better identified than the tense series but not as good as the aspirated series. One can push the SLM-based argument for both hypotheses, arguing that the tense series for CHN and the aspirated series for JPN are new phones for each L1 group which are being accommodated as a phoneme category in the developing interlanguage. The difference between the score (i.e. 90% for JPN and 41% for CHN) could be explained in terms of how advanced these phones are in the process of being established as a new phone. The low score obtained for normal series by CHN (i.e. 27%) can be attributed to the possible treatment of this sound as similar phones by the CHN subjects, hence being prevented by the perceptual equivalence classification. However, SLM-based explanation does not seem to provide a plausible answer for why the tense series (which should be a new phone) causes the worst identification performance for JPN. Clearly, these are all highly speculative and would require further data especially in terms of how these Korean plosives are categorized as similar, identical or new phones by each L1 group.

The last hypothesis stated that for both CHN and JPN subjects, tense stops would be the most difficult ones to identify since there is no L1 counterpart. The results for JPN in Table 8 clearly support this hypothesis but not so with CHN. To summarize, the experiment results fully supported the first two hypotheses. However, those predictions put forward by the hypotheses based on the classic CAH framework were only partially supported by the experiment data.

Finally, in order to examine whether there is any marked trend in the error types, an error matrix (i.e. misidentification) table was generated for Group I subjects. The results are in Table 9 and one of the most noticeable trends is the misidentification of aspirated series as normal series. Regardless of the place of articulation, this particular pattern of misidentification scores a much higher level of error than any other type. It is not clear why this is the case while Group II subjects (native Korean) never made this type of error. In terms of voicing lag there is some overlap in the case of tense and normal series but there is no overlap between aspirated and tense ones (Lisker and Abramson, 1964). It is obvious that the current data do not provide enough insight and further empirical research is clearly required to answer this question.

Table 9. Percent of Misidentification by Group I

ta > t^ha	ta > t*a	t^ha > ta	t^ha > t*a	t*a > ta	t*a > t^ha
59.8	42.1	71.4	28.6	56.3	43.7
pa > p^ha	pa > p*a	p^ha > pa	p^ha > p*a	p*a -> pa	p*a > p^ha
37.5	62.5	100	0	71.4	28.6
ka > k^ha	ka > k*a	k^ha > ka	k^ha > k*a	k*a > ka	k*a > k^ha
50.0	50.0	88.2	11.8	64.3	35.7

4. Conclusion

The results from the identification experiment provide some concrete evidence for the apparent difficulty for the L2 learners of Korean regarding the Korean plosive sounds. The first two hypotheses were fully supported by the data. However, there was only marginal support for the other three hypotheses. No doubt there is a clear need for more varied types of experiment data such as the discrimination performance experiment utilizing AXB format to characterise more precisely the nature and the magnitude of the problem. However, near chance performance by the Group I subject in the identification test clearly indicate that the L2 learner of Korean does have serious problem in correctly identifying the Korean plosive sounds. A crucial pedagogical question is whether the problem requires an active intervention or not.

Should we let the learners gradually overcome the problem in their own way as they progress through the more advanced courses? One of the main problems with this approach is that, as the results from present study indicate, there is no clear evidence of improvement. The experiment was done near the end of the first year course and the results, with roughly a chance level performance, clearly suggests that there was either minimal or no improvement. Another problem with this approach is that the learners' exposure to the Korean plosive sounds is bound to be biased. The main textbook (Learning Korean, New Directions) used by the subjects, who participated in the experiment, was analysed using a manual counting to generate a frequency of occurrence table for all the syllables which have an obstruent sound at the onset position. The result from the analysis is given in Table 10 and it shows that there is a severe bias toward the normal series plosive sounds. The natural discourse that the learners may have with native Korean speakers (e.g. with language partners) and other types of language input such as the internet media would be similarly skewed, if not more severely. To be able to contrast the three types of Korean plosives more successfully, one would require a more balanced amount of exposure to these contrasting sounds. In that respect, the first approach clearly fails to address this issue.

Table 10. Frequency of obstruents at the syllable initial position in LKND

	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	Total	%
/k/	15	15	15	16	11	31	31	35	43	5	217	22.8
/ k^h /	0	15	2	2	0	0	3	1	1	0	24	2.5
/ k*/	0	0	0	0	0	0	0	1	4	1	6	0.6
/t/	12	18	5	11	6	3	9	14	11	6	95	10.0
/ t^h /	0	20	1	3	1	1	1	0	9	2	38	4.0
/ t*/	3	0	0	0	1	2	0	0	1	0	7	0.7
/p/	7	17	8	7	8	4	5	10	25	5	96	10.1
/ p^h /	0	10	3	4	2	1	2	2	8	2	34	3.6
/ p*/	0	0	0	0	0	0	0	2	0	0	2	0.2
/c/	1	14	7	22	12	13	11	24	23	4	131	13.8
/c^h/	3	6	1	11	5	1	6	5	11	1	50	5.3
/c*/	0	0	0	0	0	0	0	0	4	0	4	0.4
/s/	35	22	15	19	36	16	31	23	43	4	244	25.6
/s*/	0	0	0	0	0	0	2	1	1	0	4	0.4
Total	76	137	57	95	82	72	101	118	184	30	952	

An alternative approach would involve a direct intervention whereby the learners are artificially exposed to the target speech sounds in a systematic and balanced way so as to encourage the development of perceptual awareness of the contrast. The exact nature of the training material and the pedagogical apparatus would need a more precise characterization of the learning problem than what has been described in this paper. However, it is possible to contemplate the general characteristics of such training material on the basis of what has been researched in the developmental and experimental psychology and other related disciplines.

More recent studies conducted in first language acquisition and on language learning impaired children may shed some light on a number of promising avenues in tackling the L2 speech sounds acquisition problems. The studies on motherese (Ferguson 1977, Snow 1972) showed that this speech style is preferred by infant over adult speech and the exaggerated prosodic cues and over-articulation assists infants in discriminating speech sounds. Also in motherses, echoing of the same word by different style (i.e. multiple exemplars) is quite common. The work by Lively et al (1994) showed that the use of multiple exemplars can be an effective training mechanism for L2 sound acquisition. Given these findings, the training material for the Korean stop sounds should contain multiple exemplars which not only differ in voice quality (e.g. male and female) but also in the vowel types that follow the stop sounds since F0 and formant transitions are an important part of the perceptual cues for plosive sounds.

Research work on language learning impaired (LLI) children by Tallal et al. (1996) and Merzenich et al (1996) showed that the use of artificially modified (i.e. speech rate and amplitude modification) speech stimuli facilitated substantial improvement for the LLI children. One possible area of research that can potentially have serious implications for the generation of effective training material is the use of 'text to speech' (TTS) in L2 speech learning. The use of speech a synthesizer can provide an effective way of generating training stimuli utilising the findings from motherese and LLI research because it allows much easier ways of manipulating the speech rate and amplitude as well as slicing and mixing the resulting speech sounds to highlight important acoustic and perceptual cues. How effective the computer generated synthetic speech stimuli can be in ameliorating the difficulties in L2 speech learning is an empirical question awaiting further research. A follow up study has been started by the author to complement the findings in this study (i.e. using data from discrimination experiment). Concurrently another research work is being undertaken using a computer generated Korean plosive training stimuli to test the effectiveness of TTS.

References

Cho, T. H. & Keating, P. 2001. 'Articulatory and acoustic studies of domain-initial strengthening in Korean.' *Journal of Phonetics* 29.2:155-190

Ferguson, C. A. 1977. Baby-talk as a simplified register. In C. E. Snow and C. A. Furguson (Eds), *Talking to Children*. Cambridge University Press

Flege, J. E. 1987. 'The production of 'New' and 'Similar' phones in a foreign language: evidence for the effect of equivalence classification,' *Journal of Phonetics,* 15-1, 47-65.

Han, M. S. & Weitzman, R. S. 1970. 'Acoustic Feature of Korean /P, T, K/, /p, t, k/ and /ph, th, kh/.' *Phonetica*, 22, 112-128

Hardcastle, William J. 1973. 'Some Observations on the Tense-lax Distinction in Initial Stops in Korean.' *Journal of Phonetics* 1, 263-272
Kim, C. W. 1965. 'On the Autonomy of he Tensitiy Features in Stop Classification (with Special Reference to Korean Stops).' *Word* 21, 339-359
Kim, C.W. 1970. 'A Theory of Aspiration.' *Phonetica,* 21, 107-116
Kim, M. R. 1994. *Acoustic Characteristics of Korean Stops and Perception of English Stop Consonants*. Ph.D. dissertation, University of Wisconsin , Madison.
Kim, M. R. & Duanmu, S. 2004. 'Tense and lax stops in Korean.' *Journal of East Asian Linguistics*, 13, 59-104
Lively, S. E., Logan, J. S. & Pisoni, D. B. 1993. 'Training Japanese listeners to identify English /r/ and /1/: The role of phonetic environment and talker variability in learning new perceptual categories,' *JASA,* 94, 1242-1255.
Merzenich, M. M., Jenkins, W. M., Johnston, P., Schreiner, C., Miller, S. L. & Tallal, P. 1996. 'Temporal Processing Deficits of Language-Learning Impaired Children Ameliorated by Training' *Science*, 271, 77-81
Park, H. S. 2002. 'The time courses of F1 and F2 and a descriptor of phonation types.' *EonEoHak* (Speech Sciences) 33, 87-108
Polka, L. 1995. 'Linguistic influences in adult perception of non-native vowel contrasts.' *JASA,* 97-2, 1286-1296.
Snow, C. E. 1972. 'Mother's speech to children learning language.' *Child Development* 43, 549-565
Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., Schreiner, C., Jenkins, W. M. & Merzenich, M. M. 1996. 'Language Comprehension in Language-Learning Impaired Children improved with Acoustically Modified Speech' *Science*, 271, 81-84
Werker, J. F. & Logan, J. 1985. 'Cross-language evidence for three factors in speech perception.' *Perception and Psychophysics,* 37, 35-44.

Contact Address

Chong-Woon Kim
School of Languages and Linguistics
Faculty of Arts, Griffith University, Nathan, QLD 4152
PH: 07-3875-5132
FAX: 07-3875-6766
EMAIL: c.kim@griffith.edu.au