Perception and production of English fricative sounds by advanced Korean EFL learners*

Shinsook Lee
(Korea University)

Lee, Shinsook. 2011. Perception and production of English fricative sounds by advanced Korean EFL learners. *Studies in Phonetics, Phonology and Morphology* 17.2, 259-281. This study explored the perception and production of English voiceless fricatives among advanced Korean EFL learners by conducting on-line experiments. Thirty two college students who had overall high English proficiency participated in the experiments and nonce words beginning with one of the voiceless fricatives /f/, /ɵ/, /s/, and /š/ were used in the experiments. In particular, 48 pairs of English nonce words, 24 identical (e.g., *findert-findert, thomber-thomber*) and non-identical pairs (e.g., *findert-thindert, thomber-fomber*) each, were employed in the perception test and the same 24 nonce words (e.g., *findert*, *thimbert*, *simbert, shipkin*; *fomber, thombul, sombul, sholtem*) were used in the production test. The results showed the precedence of perception over production but no correlation between them, indicating that the learners' perceptual deficiency of target fricatives was not necessarily tied to their production defect of those sounds or vice versa.

Importantly, the results from the perception test revealed that the participants had a great difficulty with the /f/-/ɵ/ contrast, as opposed to the /s/-/š/ contrast. The participants' ability to contrast between /ɵ/ and /s/ was relatively good, unlike findings of previous studies (Joh and Lee 2001). As for production, the participants had most difficulty with the interdental fricative /ɵ/ followed by /f/, but they did not have much difficulty with /s/ or /š/. Even though the results of the production test are overall consistent with those of the perception test, some discrepancy was found especially in the perception and production of /f/ and /ɵ/. Further, replacement patterns in production were analyzed in terms of phonetic and/or articulatory properties of the target sounds and the L1 phonemic inventory. Some implications for the teaching of fricative sounds were also drawn. **(Korea University)**

Key words: English fricatives, perception and production, English proficiency, perceptual sensitivity, error patterns, pronunciation teaching

1. Introduction

Research on second language/foreign language (hereafter L2) learning has documented that the similarities and differences between the phonemic inventories of a native language (hereafter, L1) and an L2, an L2 learner's chronological age, his/her age of L2 acquisition, quantity and quality of the L2, and learner differences in aptitude and motivation are important factors in accounting for the acquisition of L2 speech sounds (Munro and Bohn

* This paper was supported by Korea University Research Grant of 2010. I give thanks to anonymous reviewers for their valuable comments on the paper.

2007, Flege 2009). Among these factors, L1 transfer has drawn much attention due to the influence of Contrastive Analysis (henceforth, CA, Lado 1957). CA accounts for learners' errors in an L2 by comparing the sound system in their L1 with that in the L2. If the sound systems in the L1 and L2 are different, learners are predicted to have difficulty in acquiring the sounds in the L2. For example, Korean does not show a contrast between the lateral /l/ and the retroflex /r/, similar to Japanese, and thus Korean EFL learners are often reported to have difficulty in perceiving and/or producing English /l/ and /r/. However, not all predictions of CA are turned out to be true, as some Korean and Japanese EFL learners do not have difficulty in learning English /l/ or /r/. CA also fails to predict which sound contrasts or processes should be more challenging to acquire than others (Major 2008). Accordingly, Oller and Ziahosseiny (1970) claimed that 'similar sounds' in L1 and L2 are harder to acquire than dissimilar sounds, even though they still adopted the CA approach.[1]

The notion of 'similarity', especially 'phonetic/articulatory similarity' plays a key role in the models of L2 speech perception espoused by Flege (1995), Best (1995), and Best and Tyler (2007). The similarity criteria are defined on the basis of acoustic measurements, articulatory gestures, phonetic transcription, and listener judgments (Major 2001: 57). Flege's Speech Learning Model (hereafter, SLM) and Best's Perceptual Assimilation Model (hereafter, PAM) claimed that sounds in L2 which are similar to those in L1 in terms of perceived phonetic/acoustic details and/or articulatory measures pose perceptual difficulties for language learners, as similar sounds are more likely to be categorized as L1 sounds than dissimilar sounds from L1. For example, Flege (1987) showed that adult English speakers who have had sufficient exposure to French can produce the French /y/ vowel since it is unlike any English vowel. The SLM also posits that if L2 learners do not perceive sounds in L2 target-appropriately, they are less likely to produce the sounds accurately. More specifically, Flege (1995, 2009: 177) argued that learners' L1 sound system tends to filter out L2-specific phonetic details and hence they may not be stored in learners' long-term memory representations, which leads to the lack of guidance for the development of correct L2 articulation patterns. This indicates that good perception is a prerequisite for correct pronunciation and that there is a close tie between speech perception and production.

With regards to the relationship between speech perception and production, many studies on L2 sound acquisition have shown that speech perception tends to precede speech production, similar to L1 sound acquisition (Gnanadesikan 2004, Pater 2004). According to Rochet (1995), Canadian English speakers and Brazilian Portuguese speakers showed not only the precedence of perception over production but also a close tie between perception and production. Joh and Lee (2001) reported that

[1] Oller and Ziahosseiny's (1970) claim is based on the learners' spelling errors.

Korean college students performed better on perceiving English voiceless coronal fricatives than on producing them, but that their subjects' good perceptual abilities were not necessarily correlated with their good production abilities even though a moderate correlation between perception and production was found. By contrast, Sheldon and Strange (1982) found that their Japanese subjects' production of English /l/ and /r/ was better than their perception of the sounds. Mack (1989) also showed that early English-French bilinguals' production of English /i/-/ɪ/ and /t/-/d/ contrasts was better than their perception of those contrasts. However, Bohn and Flege (1997) examined the perception and production of the English vowel /æ/ by experienced and inexperienced German learners of English and reported that L2 experience affected the perception and production of the vowel, but that no parallel progress was found between them. Frieda and Nozawa (2007) also found that L2 experience is related to L2 learners' listening abilities. This shows that there are some conflicting results on the precedence relationship between perception and production and also on the correlation between them, possibly due to the influence of other factors such as age of L2 acquisition, L2 input, and L2 experience.

The present study examines the relationship between perception and production of English voiceless fricatives by advanced Korean EFL learners in order to shed some new light on this issue. Namely, this study addresses not only the precedence relationship between speech perception and production but also the correlation between the two, thus providing a new piece of evidence to elucidate this controversial issue. Importantly, previous studies on the acquisition of English sounds by Korean EFL learners mainly conducted off-line experiments with the aid of orthography especially in the production test, which may lead to a potential negative influence of orthography on the interpretation of the experimental results, as suggested by many scholars (Young-Scholten 2002, Bassetti 2009). The present study runs on-line experiments for both perception and production so as to prevent the influence of English spelling on the test results.

2. Literature review

It has been claimed that speech perception plays a pivotal role in the acquisition of L2 sounds. For example, Trubetzkoy (1939/1969) contended that the phonological system of L1 functions as a filter, as L2 learners have a tendency to perceive and classify sounds in L2 in conformity with their L1 phonological system. Flege (1987, 1995) also maintained that sounds in L2 which are similar to those in L1 in terms of phonetic/acoustic measures are more likely to be equated with their matching L1 sounds, further inhibiting the production of L2 sounds. This is because L2-specific phonetic details provide sensory information, which should be stored in phonetic representations in order to be available for target-appropriate productions of L2 sounds, as mentioned above. This suggests that if L2

learners do not perceive sounds in L2 accurately, they are less likely to produce the sounds correctly, thus indicating that the perception of an L2 sound should precede its production.

Joh and Lee (2001) investigated the perception and production of three English voiceless fricative sounds /s/, /ɵ/, and /š/ before the vowels /i/, /ə/, and /u/ by Korean college students. They ran an off-line multiple-choice test for perception and their subjects were asked to produce each target word in sentential contexts for production. Overall the subjects' performance on perception was better than that on production, hence indicating that perception precedes production. More specifically, many subjects had difficulty in producing /ɵ/ accurately regardless of the following vowels and /s/ especially in the context of /i/. Some subjects also failed to perceive /ɵ/ target-appropriately, even though most subjects did not show any difficulty in perceiving or producing /š/ in all the vowel contexts. Joh and Lee further reported that the correlation between perception and production was mediocre and that their subjects' good perception of specific sounds was not necessarily correlated with their good production of those sounds, which suggests that the learner's perceptual ability may not be closely tied to his/her production ability. However, Joh and Lee's perception and production test results may have been influenced by English orthography, as their experimental design in both perception and production crucially had recourse to English spelling.

The influence of English spelling on L2 learning can be positive in some cases. For instance, Japanese ESL learners were able to pronounce English /l/ and /r/ correctly when they knew the spelling of a target word (e.g., *lip* vs. *rip*) (Eckman 2004). However, there are also negative effects of L2 written input on L2 pronunciation. For example, L2 learners frequently pronounce silent letters /l/ and /s/ in the words *walk* and *island*, respectively. Young-Scholten (2002) reported that English learners of German produced word-final obstruents as voiced sounds, presumably due to the spelling influence of the target words (e.g., [t] in *Bund* was produced as [d] instead of [t]). The negative influence of L2 spelling is also observed when L2 learners are repeating spoken word stimuli in a task as well as when they are reading (Bassetti 2009). As for the influence of L2 written input on L2 speech learning, Bassetti contended that L2 orthographic input affects L2 auditory input whose influence is reflected in L2 learners' non-targetlike phonological representations of L2 sounds. L2 learners' target-inappropriate phonological representations are in turn assumed to be responsible for their inaccurate realizations of L2 sounds. Accordingly, it would be advisable to avoid the influence of English spelling when conducting speech production and perception experiments.

Borden et al. (1983) also investigated the relationship between perception and production of English /r/ and /l/ by Korean adult learners of English. They found that self-perception appears to be a prerequisite for correct production, since the learners' self-perception precedes their

production. However, Sheldon (1985) reanalyzed the results of the Korean learners of English obtained by Borden et al. (1983), adopting a different statistical approach, and reported that the learners' self-perception did not develop earlier than their production. Rather, based on the reanalysis of the results, she claimed that the relationship between perception and production was influenced by the amount of time that the Korean learners spent in the US. The more time the learner spent in the US, the less likely the learner's perceptual ability exceeded his production ability. This indicates that experience with the L2 pertains to the relationship between perception and production.

Bohn and Flege (1990) studied the perception and production of English /ɛ/ and /æ/ by German learners of English with different L2 experience. Inexperienced German learners who had lived in the US around 6 months were not able to produce the vowel contrast but they were able to label the vowels in the perception test. By contrast, experienced German learners with an average of 5 years stay in the US succeeded in producing the vowels accurately and their labeling results were better than those of the inexperienced learners. However, Bohn and Flege found that even experienced learners' use of vowel durational and spectral cues in the labeling test was different from that of monolingual English speakers. They also claimed that the learners' abilities for perceiving a new vowel distinction may lag behind their abilities for producing the vowel contrast even after many years of L2 experience.

Flege and Eefting (1987) examined the perception and production of the /t/-/d/ contrast by L1 Dutch L2 English learners and reported that the learners showed a discrepancy between speech perception and production. This is because the Dutch learners demonstrated a small boundary-shift in identifying the phonemes /t/ and /d/ in a /ta/-/da/ continuum, while they produced the sound contrast between Dutch and English with a sizable VOT difference. Sheldon and Strange (1982) examined the acquisition of English /l/ and /r/ by Japanese learners of English living in the US. They reported that the Japanese learners' production of the sounds was better than their perception of the sound contrast, thus claiming that learners' perceptual skills do not necessarily precede their production abilities. Sheldon (1985) emphasized the role of production than perception in L2 acquisition, saying that learners with heavily accented pronunciation are more likely to undergo greater social pressure than those with a perceptual deficit.

The studies reviewed do not show coherent conclusions concerning the precedence relationship between perception and production or the correlation between them. As Llisterri (1995) pointed out, L2 speech perception and production is a complicated issue, which is subject to many factors like the L1 sound system, age of acquisition, amount/length of the exposure to L2, quality of L2 input, and social pressure, along with contextual dependency and acoustic cues. He further contended that it may not be possible to infer production skills from perceptual abilities or

perceptual abilities from production skills and that high social pressure to improve pronunciation may be responsible for the cases of the precedence of production over perception. Accordingly, it is necessary to investigate the relationship between perception and production of L2 sounds in order to shed some new light on this issue.

3. Methods

The present study explored the acquisition of English voiceless fricative sounds among advanced Korean EFL learners by conducting experiments.

3.1 Participants

Thirty-two participants were recruited from a private university in Seoul. They were all from the College of Education and were enrolled in an English phonetics and phonology class or in an introductory English linguistics class; twenty-eight of them were English education majors and the remaining four were home economics education majors. Most of the participants could be rated as advanced level learners of English because their English language proficiency test scores were generally very high. (Refer to Section 3.5 for a detailed English proficiency test.) Besides, they had at least 10 year history of English learning when the experiments were run.

3.2 Speech material[2]

3.2.1 The perception test

The participants' perceptual ability to contrast English fricative sounds was measured using nonce words in order to prevent a potential influence of word frequency or word familiarity on the experimental results. Twenty-four bisyllabic nonce words with either CVC.CVC or CVC.CVCC structure were first constructed. All of the words started with one of the voiceless fricative sounds /f/, /ɵ/, /s/, and /š/ and stress was placed on the initial syllable. The target fricatives were presented in the front vowel (i.e., /i/) and the back vowel (/a/ and /ɔ/) contexts (e.g., *findert*, *thimbert*, *simbert, shipkin*; *fomber, thombul, sombul, sholtem*). As the present study employed a discrimination test, two sets of stimuli were constructed from the basic 24 words: There were 24 identical (e.g., *thindert-thindert*, *soltem-soltem*) and non-identical (e.g., *findert-thindert, soltem-sholtem*) pairs each, totaling 48 pairs.

The present study investigated the perception and production of English

[2] The same perception and production stimuli, along with the same experimental procedure, were used in Lee (2010) and Lee et al. (2011), respectively, where the acquisition of English sounds by children with different English-learning experience was investigated.

voiceless fricatives, because Korean has only a couple of alveolar fricative sounds (i.e., the plain /s/ and the tense /s'/) and also because the alveopalatal fricative [š] is a phonetic variant of /s/ before /i/ and further its articulation is made near the alveolar ridge rather than the alveopalatal region unlike English /š/. This often hinders Korean EFL learners from producing English /s/ target-appropriately before /i/ in words like *sea* and *she* (e.g., *sea* and *she* as [ši]) due to the Korean palatalization process, thus creating intelligibility problems. Moreover, as /f/ and /ɵ/ are not phonemes or allophones in Korean, Korean EFL learners are often observed to substitute /p/ for /f/ and /s/, /s'/, /t/ or /t'/ for /ɵ/ (e.g., *foul* [paul], *think* [s'ɪŋk]). As previous studies have shown (Strevens 1960, Edwards 2003, Cho and Lee 2007), /f/ and /ɵ/ share many acoustic features as both the sounds are low in intensity and have a similar location of spectral peaks, which creates a great confusion even for native English speakers, especially for English children. Cho and Lee also reported that some Korean EFL learners tend to perceive /ɵ/ as [f], especially when /ɵ/ occurs in prosodically weak position such as the coda. Accordingly, it is important to consider whether Korean EFL learners' target-inappropriate production of English sounds is related to their perceptual deficit of the sounds or vice versa. In the present study, the voiceless and voiced alveolar stops /t/ and /d/ were also included as fillers; there were 4 /t/- and /d/-initial words each. The nonce words with initial stop sounds had the same syllable structures as the target words and the stops were also presented in the front (/i/ and /ɛ/) and back vowel (/a/ and /ɔ/) contexts (e.g., identical pairs: *tekton-tekton dolmick-dolmick;* non-identical pairs: *tekton-dekton, dolmick-tolmick*). Consequently, there were 64 pairs in total (48 target-word pairs, 16 filler pairs).

The test materials were recorded by a male American English speaker who had a phonetic training. He was born and raised in Michigan but lived in California for several years. He read the target words three times presented in the context of "Say the word _____". The testing materials were recorded in a soundproof booth using a SONY ECM-MS907 microphone and Audacity on a PC at 44.1 kHz. Sample stimuli are provided in Appendix A.

3.2.2 The production test

The basic stimuli created for the perception test were used in the production test and thus there were 24 bisyllabic nonce words beginning with one of the fricative sounds (e.g., *findert*, *thimbert*, *simbert, shipkin*; *fomber, thombul, sombul, sholtem*). In addition, 8 stop initial words were included as fillers similar to the perception test: There were 4 /t/-initial and /d/-initial words each (e.g., *tekton, dekton, tolmick, dolmick*). Accordingly, there were 32 stimuli in total (24 target words and 8 fillers).

Unlike the perception test, however, the stimuli in the production test

were matched with pictures of cartoon characters selected through the google image site (http://www.google.co.kr/). In order to avoid participants' knowing the names of cartoon characters, caution was exercised so that only rather unfamiliar cartoon characters were chosen from the image site. Sample stimuli are provided in Appendix B.

3.3 Procedure

3.3.1 The perception test

An AX discrimination task was administered to assess the participants' ability to contrast English fricative sounds using E-prime 2.0. The 64 stimulus pairs were presented at random order across participants. The participants sat at a laptop computer with headphones on in a sound-attenuated room. They were instructed to press the 'same' or 'different' button on the keyboard after listening to the given stimuli. They were requested to press the button as fast as possible and the inter-trial interval was 1500 ms. The participants completed 4 practice trials before the main test.

3.3.2 The production test

The participants wore headphones and sat at a laptop computer, whose screen size was 14 inches, in a soundproof room. The participants were informed that they would hear the names of cartoon characters through headphones and they were instructed to repeat the names right after listening to the native speaker's production of the names. Each of the target items was aurally presented with its pre-matched picture of a cartoon character shown on the computer screen using E-prime 2.0.[3] The inter-trial interval varied with the participants' elicitation time. This is because the next trial began after the participant finished a previous one. The participants' productions were saved as wave files for analysis on a PC at 44.1 kHz. There were 4 practice trials before the main test. The stimulus items were randomly presented across participants. There were 1,024 tokens (32 participants × 32 words). All the participants took the production test before the perception test in order to prevent the effect of perceptual training on the production test.

[3] The production test might be considered as an imitation test, because participants were asked to repeat the names of the cartoon characters right after listening to the native speaker's production of the names. However, it was found that imitation tests can be regarded as reliable tests. For example, according to Kent (1979), native English children and adults were able to reproduce synthesized vowels in an imitation test, even though this was especially true when the synthesized vowels sounded more like English vowels.

3.4 Analysis

For the analysis of the sound files in the production test, the participants' productions were transcribed by 3 research assistants who were trained in phonetic transcription. The research assistants listened to the stimuli separately and judged whether they were produced correctly or not. The most salient error type was sound substitution, even though a few cases of consonant deletion were witnessed for target-inappropriate productions. Whenever there were conflicts among the raters, they listened to the discrepant items jointly and resolved the discrepancy by reading the spectrograms of the target items using Praat and by consultation. Further, the researcher double-checked around 10% of the participants' productions using Praat. When a target item was correctly produced, it was coded as 1; otherwise it was coded as 0. The inter-rater reliability was .93

3.5 English proficiency

The participants' overall proficiency in English was measured in terms of their self-reported scores on English proficiency tests they had taken before the experiments were conducted. They took one of the following tests: TOEIC (Test of English International Communication), TOEFL CBT (Test of English as a Foreign Language Computer-based Test), TOEFL IBT (Test of English as a Foreign Language Internet-based Test) or TEPS (Test of English Proficiency Developed by Seoul National University). As the participants took different English proficiency tests, their test scores were uniformly converted to TOEFL IBT scores based on the comparison tables. As shown in Appendix C, overall the participants' scores were very high, as their average score was 97.3 out of 120 given that most state-level universities in the US require a minimum of 80 for admission. More specifically, their scores ranged from a low of 71 to a high of 117 and most of their scores were above 90 except 7 students' scores. The participants' English test scores were considered in the data analysis in order to find out whether their English proficiency affected the overall results.

4. Results and discussion

4.1 General results

Figure 1 displays mean proportion of correct perception and production test scores. It can be seen that overall the participants' perceptual ability was better than their production ability, similar to the findings obtained from previous studies (Pater 2004, Joh and Lee 2001). The paired-samples *t*-tests also revealed that the difference in mean proportions of correct scores between perception and production was significant ($t(31)=-6.087$, $p<.0001$).

However, as the perception test was a discrimination test, correct scores

of each discrimination pair in the perception test were compared to the production scores of the corresponding target sounds in each pair, as shown in Figure 2. The mean rates of accuracy in all the pairs were higher in perception than in production except the comparison between /ɵ-s/ and /s/. The results of the *t*-tests, given in Table 1, showed that the comparisons between the following pairs were significant: /f-ɵ/ vs. /f/; /f-ɵ/ vs. /ɵ/; /ɵ-s/ vs. /ɵ/. Thus, the results again indicate that overall the participants performed better on perception than on production and that they had difficulty producing /ɵ/ and /f/ as well as discriminating between the two sounds.

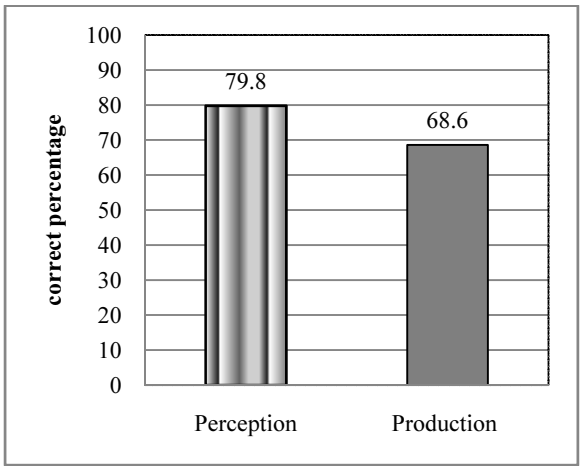
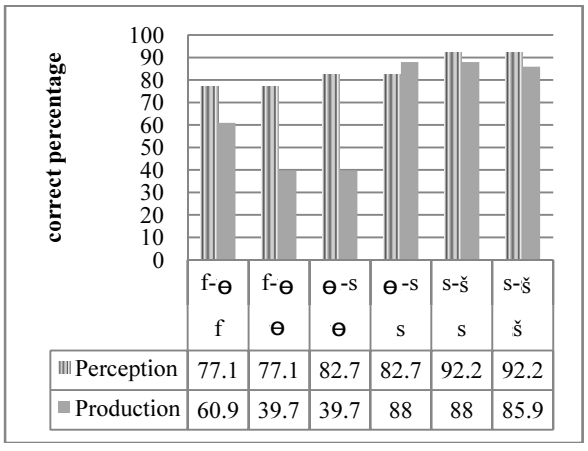


Figure 1. Mean proportion of correct perception and production scores



	f-ɵ f	f-ɵ ɵ	ɵ-s ɵ	ɵ-s s	s-š s	s-š š
Perception	77.1	77.1	82.7	82.7	92.2	92.2
Production	60.9	39.7	39.7	88	88	85.9

Figure 2. Mean proportion of correct perception and production scores in each comparison pair

Table 1. T-tests for mean proportion of correct scores between each discrimination pair in perception and the corresponding targets in production

Pairs of comparison	Mean	S.D.	*t*	*p*-value
Per: /f-ɵ/ vs. Pro: /f/	16.14	29.62	3.083	.005
Per: /f-ɵ/ vs. Pro: /ɵ/	37.42	20.38	10.388	.000
Per: /ɵ-s/ vs. Pro: /ɵ/	43.02	18.41	13.216	.000
Per: /ɵ-s/ vs. Pro: /s/	-5.34	18.37	-1.646	.110
Per: /s-š/ vs. Pro: /s/	4.15	16.07	1.463	.154
Per: /s-š/ vs. Pro: /š/	6.25	19.07	1.853	.073

As discussed in Section 2, previous studies have shown some conflicting results on whether L2 learners' perceptual abilities are connected to their production skills. Table 2 shows that no correlations were found between the participants' perception and production scores in all the compared pairs, as the correlation scores were quite low. This indicates that the participants' difficulty in producing target fricative sounds is not necessarily related to their perceptual deficiency of the sounds. Accordingly, the results from the experiments show that only the precedence relationship between perception and production was observed but not a correlation between them.

Table 2. Correlation for mean proportion of correct scores between perception and production

Pairs of comparison	*r*	*p*
Perception vs. Production: Total	.147	.423
Per: /f-ɵ/ vs. Pro: /f/	-.312	.082
Per: /f-ɵ/ vs. Pro: /ɵ/	.125	.494
Per: /ɵ-s/ vs. Pro: /ɵ/	.335	.061
Per: /ɵ-s/ vs. Pro: /s/	-.056	.762
Per: /s-š/ vs. Pro: /s/	.176	.334
Per: /s-š/ vs. Pro: /š/	.202	.268

Additionally, the learners' English proficiency was not correlated with their perception (r=.098, p>.05) or production scores (r=.158, p>.05), possibly due to their high English proficiency.

4.2 Perception

As mentioned earlier, the perception test contained both identical and non-identical pairs. The mean proportion of correct scores attained from identical pairs was significantly higher than non-identical pairs (92.5% vs. 67.5%; $t(31)$=9.758, p<.0001). Even the correct percentage of /ɵ/ in identical pairs was 93% and the correct percentage of the stops used as

fillers was 94% for identical pairs and 92% for non-identical pairs, respectively. This indicates that the stimuli employed in the experiments were appropriate and that the rather low mean proportion of correct scores for non-identical pairs was not due to stimuli defects. However, it is important to consider whether the participants were 'sensitive' enough to discriminate sound contrasts accurately or not.

Accordingly, the participants' performance in the categorical discrimination task was evaluated by calculating d prime (d') for each fricative contrast for each participant. D' is calculated on the basis of the proportion of 'hits' (accurately selecting the odd fricatives in different trials) and 'false alarms' (inaccurately selecting odd items in catch trials (the same trials)) and thus identical and non-identical pairs were pooled together for a d' analysis. The range of a d' score is from 0 to 4 in the present study (Sung 2003). A d' score of 0 reflects a random level of sensitivity and a score of 4 reflects perfect discrimination.

Table 3 displays mean d' discrimination scores for each target contrast averaged across all 32 participants. A repeated measures ANOVA performed on the d' data with sound contrast as the between-subjects factor revealed a significant main effect ($F(2,62)=34.894$, $p<.0001$). Post hoc comparisons (Bonferroni) showed significant differences for all the fricative contrasts (all $p<.05$). More specifically, the participants attained the lowest d' scores for the /f/-/ɵ/ contrast, whereas they obtained the highest d' scores for the /s/-/š/ contrast. This indicates that the learners had most perceptual difficulty with the /f/-/ɵ/ contrast followed by the /ɵ/-/s/ contrast, but they did not have much difficulty in discriminating between /s/ and /š/, which is similar to the results given in Figure 2. The results seem to suggest that the learners' pattern of sensitivity to fricative sounds is similar to that of native English speakers in that native English speakers tend to confuse /f/ with /ɵ/ but they are generally good at perceiving the contrast between /s/ and /š/ (Edwards 2003). The participants' d' scores for the /ɵ/-/s/ contrast was near 2.5 which may be considered 'good' and this seems to indicate that the /ɵ/-/s/ contrast does not pose much difficulty for the learners unlike previous findings on the distinction between the two sounds (Joh and Lee 2001). The mean d' score averaged for all the contrasts was 2.54 and thus overall the participants' discrimination ability to contrast English fricative sounds may be considered relatively good, which could be attributed to their high English proficiency. [4]Additionally, it is noteworthy that the participants did not show the effect of Korean palatalization on the distinction between /s/ and /š/, as they manifested good perceptual ability for the distinction even before the front vowel /i/ (front vowel: 93% vs. back vowel: 91%).

[4] There was a back vowel benefit in that overall the participants' mean proportion of correct scores was higher in the context of back vowels than front vowels.

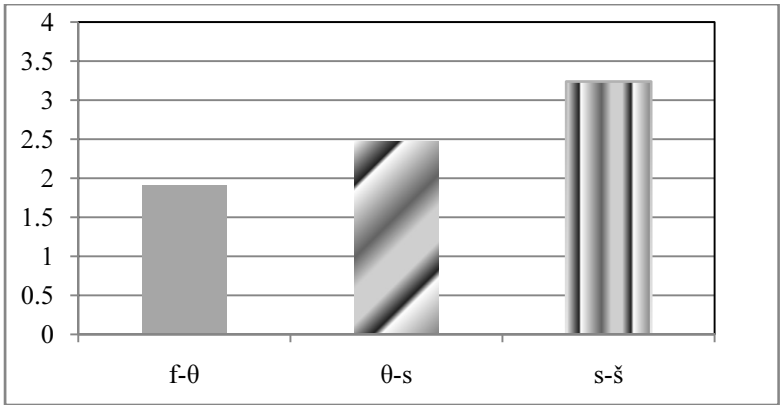


Figure 3. Mean d' discrimination scores for each fricative contrast

Table 3. Mean d' discrimination scores for each fricative contrast

Pairs of comparison		
f-ɵ	ɵ-s	s-š
1.91	2.47	3.24

4.3 Production

As discussed in Section 4.1, the participants' mean proportion of correct production scores was 68.6%, which was rather low given that the participants were advanced learners of English. The results were first analyzed in terms of the place of articulation. As given in Table 4, the alveolar /s/ was produced more accurately than the alveopalatal /š/ and the laviodental /f/ in order. The interdental /ɵ/ was produced very poorly, because its mean rate of accuracy reached only around 40%, as mentioned earlier (Figure 2). A repeated measures ANOVA on mean accuracy indicated a main effect of place contrast ($F(3,93)=40.657$, $p<.0001$). Bonferroni pair-wise comparisons showed that the difference in mean accuracy between each place of articulation was significant except that between /s/ and /š/: /f/-/ɵ/, /f/-/s/, /f/-/š/, /ɵ/-/s/, /ɵ/-/š/ (all $p<.0001$). This result is similar to that obtained from the perception test, as the participants had most difficulty in contrasting between /f/ and /ɵ/ whereas they were very good at contrasting between /s/ and /š/, and this pattern of difficulty in perception seems to be reflected in production. However, somewhat differently from the results of the perception test in which the participants demonstrated a good ability to contrast between /ɵ/ and /s/, the participants had a great difficulty in producing /ɵ/ and their production of /f/ was also rather poor relative to /s/ or /š/. This seems to contribute to the gap in the mean proportion of correct scores between perception and production.

Table 4. Mean proportion of correct production by place of articulation

Place of articulation	Accuracy
/f/	60.9
/ɵ/	39.7
/s/	88.0
/š/	85.9
Mean	68.6

The results in production were further analyzed in terms of error patterns, as given in Table 5. The participants showed mostly substitution errors with only a few cases of consonant deletion.

Table 5. Substitution patterns[5]

Sound	Substituted sounds
/f/	ɵ (9.4%), h (9.4%), v (6.3%), s (5.5%), p (5.5%)
/ɵ/	f (25.8%), s (22.3%), deletion (3.1%), d (2%)
/s/	ɵ (5.5%), f (2%), z (2%)
/š/	s (6.3%), tš (3.9%)

For /f/, it was mostly replaced by [ɵ] and [h] followed by other sounds like [v], [s], and [p]. The substitution of [ɵ] for /f/ was understandable given that both /f/ and /ɵ/ display a flat spectrum and their overall energy is rather weak, and thus causing much perceptual confusion even to native speakers of English. The results from the perception test also showed that even advanced Korean EFL learners had much difficulty in contrasting between /f/ and /ɵ/. Accordingly, the participants' substitution of [ɵ] for /f/ may partly be due to their incorrect perception of the target sound. Further, Edwards (2003) reported that /f/ tends to be confused with sounds such as /p/, /s/, /t/, or /k/ and that it may not be perceived in some cases. He went on saying that non-native speakers of English even produce the voiceless bilabial fricative [Φ] for /f/. Then, the participants' replacement of /f/ with [h], which was most noticeable in the back vowel contexts, may be because /h/ shows only a breathy noise without having its own articulatory gesture and /f/ has also weak noise without being perceived in some cases. Because of rather weak acoustic cues, /f/ may not have been clearly perceived, leading to its inaccurate production. Also, the replacement of /f/ with [p], [v], or [s] may be ascribable to the fact that /p/, /v/ and /s/ are similar to /f/ in that they share either place (i.e., labial) or manner cues (e.g., [+continuant]) and thus the learners may have noticed these phonetic or

[5] The numbers in parentheses represent the percent of the same error type for each sound. Only when the same error type occurred more than 2 percent, it is included in the table. When a target word was not produced, it was not reported in the error pattern analysis.

articulatory cues and have reflected them in the production of the sound.

The interdental fricative /ɵ/ was predominantly replaced by [f] followed by [s]. As mentioned above, the replacement of [f] for /ɵ/ is frequently attested in the speech of native English children due to the acoustic similarities between the two sounds. Consequently, the participants' substitution of [f] for /ɵ/, similar to that of [ɵ] for /f/, could be ascribable to the participants' poor contrast between the two sounds. Korean EFL learners' substitution of [s] for /ɵ/ is also well-documented by many researchers (Lee and Cho 2002), which can be attributed to the fact that /ɵ/ does not exist in Korean and that both /ɵ/ and /s/ are coronal fricatives and hence they show similar properties to some degree.

As for /s/, the most salient substitution was [ɵ], presumably due to phonetic similarities between the two, even though the error percentage was rather low (5.5%). Alternatively, the substitution of [ɵ] for /s/ may be considered as hypercorrection, since this error pattern was also observed in other studies (Sung 2006). Importantly, however, the learners did not show the effect of Korean palatalization on the production of /s/ in the /i/ vowel context, since only two cases of [š] for /s/ before /i/ were observed, which is similar to the results of the perception test.

Now, let us turn to the alveopalatal fricative /š/. Some participants replaced /š/ with [s] followed by [tš]. The replacement of [s] for /š/ may be due to the fact that [š] is an allophone of /s/ in Korean, which caused the participants to substitute [s] for /š/ showing another case of hypercorrection. Alternatively, Edwards (2003) reported that non-native speakers of English often depalatalize /š/ to [s], which may be ascribable to the fact that /s/ and /š/ are both strident fricatives and thus they share some phonetic/ articulatory properties together. He also found that non-native speakers of English affricate /š/ in some cases producing it as [tš], similar to the substitution pattern observed in the present study.

In sum, the learners' substitution patterns in production may be ascribable to their perceptual deficiency of the target sounds to some degree, even though no statistically significant correlation was found between perception and production. Namely, the learners may have misperceived the target sounds and this may have been linked to their misproduction, especially in the online production experiment like the present study where no clues of spelling were provided for the participants. However, the error patterns may also be due to other factors like the difference in the phonemic inventory between an L1 and an L2 and hypercorrection. Then, the results seem to at least partly support the postulate of SLM and PAM that good perception is a prerequisite for good production.

5. Conclusion and pedagogical implications

This study set out to investigate the perception and production of English

voiceless fricative sounds among advanced Korean EFL learners by running on-line experiments. The results of the experiments indicated that overall the precedence of perception over production was confirmed as the mean rate of accuracy in perception was higher than that of production (79.8% vs. 68.6%). The same results were also obtained when the perception scores of each discrimination pair were compared to the production scores of the corresponding sounds in the same pair. Yet, no correlation was found between perception and production, indicating that the learners' perceptual deficit of target fricative sounds was not necessarily tied to their production deficiency of those sounds or vice versa. Further, neither perception accuracy nor production accuracy was correlated with the participants' English proficiency, which was attributed to the participants' overall high English proficiency.

The results of the d' scores from the perception test showed that the participants obtained the lowest d' scores for the /f/-/ɵ/ contrast, which indicates that the /f/-/ɵ/ contrast poses a great challenge to the learners, similar to native English children (Smith 1973, Dinnsen and Barlow 1998). Yet, the participants attained the highest d' scores for the /s/-/š/ contrast and their d' scores for the /ɵ/-/s/ contrast were around 2.5, which reveals that even the /ɵ/-/s/ contrast did not cause much perceptual difficulty to the learners. This may be ascribable to the fact that the participants overall performed very good on perceiving /s/, even though they performed rather poor on perceiving /ɵ/. Nonetheless, the mean d' score averaged for all the fricative contrasts was 2.54, which shows that the participants' overall ability to contrast English fricative sounds is relatively good.

As for production, the participants had most difficulty in producing the interdental fricative /ɵ/ followed by /f/. By contrast, they did not have much difficulty in producing /s/ or /š/ and they even did not show any influence of Korean palatalization in the /i/ vowel context. The results obtained from the production test are overall consistent with those obtained from the perception test, although there was no statistically significant correlation between perception and production. However, some discrepancy was found between the perception and production test results. In particular, only around 40% of /ɵ/ was target-appropriately produced while 61% of /f/ was accurately produced despite the fact that the participants overall had a great difficulty in contrasting between the two sounds and that their ability to discriminate between /ɵ/ and /s/ was rather good. This indicates that the learners' perceptual difficulty of target sounds does not always imply their production deficiency of those sounds.

The error patterns in production showed that /f/ was mostly replaced by [ɵ] and [h], whereas /ɵ/ was predominantly replaced by [f] followed by [s]. The substitution of [ɵ] for /f/ or vice versa was attributed to the acoustic/phonetic similarities between the two sounds. However, the replacement of [s] for /ɵ/ was attributed to the fact that /s/ in Korean is the closest approximant to /ɵ/ in English in that /ɵ/ is not a phoneme in Korean and

both sounds are coronal fricatives, even though the former is a strident while the latter a non-strident. This seems to suggest that not only phonetic/acoustic properties but also the phonemic inventory plays a role in accounting for the error patterns. Further, it was pointed out that the substitution of [ɵ] for /s/ could be ascribable to hypercorrection, in addition to the phonetic similarities between the two sounds. The replacement of [s] for /š/ was accounted for in terms of phonetic similarities and the phonemic inventory; both of them are strident fricatives and [š] is a phonetic variant of /s/ in Korean.

As for the teaching of pronunciation, many studies reported that early L2 learners tend to attain more native-like pronunciation and perception than late L2 learners (Flege et al. 1995, 1999), which seems to support the policy of learning foreign language in primary school or even in preschool. This indicates the importance of explicit teaching of L2 sounds in classroom settings, as students may not be able to attain a high level of L2 proficiency without receiving a substantial amount of authentic or at least intelligible (or more native-like) L2 input. For example, Jenkins (2000) found that pronunciation errors caused a high proportion of communication breakdown among L2 learners. Moreover, some studies report that training in production helps L2 learners improve their perceptual abilities whereas other studies show the opposite, thus emphasizing the importance of perceptual training (Rochet 1995). Consequently, specific training in both perception and production of L2 sounds should be provided for L2 learners.

More specifically, based on the results of the present study, the following suggestions for the teaching of fricatives can be drawn. First, more emphasis should be given to the training of /f/ and /ɵ/, as the learners had most difficulty in discriminating between the two sounds and in producing them, especially /ɵ/. For perceptual training, the learners can benefit from drills using minimal pairs such as discrimination task, identification task, and isolation task. These drills can also be used in sentential contexts. For instance, the learners can drill pairs like *fin* and *thin* first in isolation and then in the sentential context, as given in (1) and (2) (Hewings and Goldstein 1998, Celce-Murcia et al. 1996/2006):

(1) Discrimination task: Listen to each pair of words and decide whether they are the same or different.

a. fin	fin	Answer: same	different
b. thin	fin	Answer: same	different
c. fin	thin	Answer: same	different

(2) Listen to the sentences and choose the word in parentheses that you hear.

a. How do you spell the word (‘fin’/‘thin’)?
b. What did the man say? (First or thirst)?

Similarly, the learners can practice with pairs such as *thick* and *sick* especially paying more attention to /ɵ/. This drill can be extended to other positions such as word-final. Further, the perceptual training can be connected to production training. Some examples are given in (3) (Hewings and Goldstein 1998).

(3) Listen to the sentences and choose the word in parentheses that you hear. Then repeat each sentence.
a. It's very (thick/sick).
b. He often (sinks/thinks) in the pool over there.
c. Which one is a picture of (mouse/mouth)?
d. Can you spell the word ('path'/'pass')?

For the production of /ɵ/, tongue twisters (e.g., A: *Beth Roth is thirty-three*; B: *Really? I thought she was thirty.*) may also be beneficial to the learners. In addition, Catford and Pisoni (1970) found that an articulatory training was more effective than auditory training to their subjects' improvement in the perception and production of exotic sounds. This indicates that articulatory-based training is necessary to the learners in addition to auditory-based training.

According to Logan et al. (1991), Japanese learners of English showed a great improvement in perceiving /l/ and /r/ after they had been trained with new stimuli as well as high-variable stimuli produced by different native speakers of English. This suggests that using new and high-variable stimuli instead of the same and low-variable stimuli is more effective to the teaching of pronunciation. Consequently, for the learners to obtain a high level of L2 proficiency, they should be exposed to more L2 inputs produced by diverse native speakers for a certain period of time.

Lastly, it was suggested that the learners' rather poor production of fricatives, especially /ɵ/ (and /f/) may partly be attributed to the learners' poor perception of the target sound(s), although no statistically significant correlation was obtained between perception and production. This is because the learners were instructed to produce target fricatives right after they had listened to the native speaker's production of the sounds. Thus, if the learners had not perceived the target fricatives accurately, they could not have produced them correctly, and this seems to support Flege's (1995) and Best's (1995) arguments that L2 or foreign language learners may not produce target sounds target-appropriately unless they perceive them accurately to some degree. However, it was pointed out that the learners' production errors may also be attributed to other factors such as the L1 phonemic inventory and hypercorrection.

As a final remark, the present study investigated only voiceless fricative sounds, and hence future studies should examine other groups of sounds including voiced fricatives and further the perception and production of L2 sounds by L2 learners with different levels of English proficiency in order

to obtain a more comprehensive picture of L2 sound acquisition, along with the role of speech perception in the production of L2 sounds.

Appendix A
Sample stimuli in the perception test

(1) Identical pairs:

findert-findert	thindert-thindert
fomber-fomber	thomber-thomber
simbert-simbert	thimbert-thimbert
sombul-sombul	thombul-thombul
sipkin-sipkin	shipkin-shipkin
soltem-soltem	sholtem-sholtem

(2) Non-identical pairs:

findert-thindert	thindert-findert
fomber-thomber	thomber-fomber
simbert-thimbert	thimbert-simbert
sombul-thombul	thombul-sombul
sipkin-shipkin	shipkin-sipkin
soltem-sholtem	sholtem-soltem

Appendix B
Sample stimuli in the production test

Target fricatives: *findert*, *thimbert*, *simbert, shipkin*; *fomber, thomber, sombul, sholtem*

Sample pictures:

Findert

Thomber

Simbert

Sholtem

Appendix C
English Proficiency Test Scores (TOEFL IBT Converted Scores)

Participant' number	TOEFL score	Participant' number	TOEFL score
1	100	17	100
2	84	18	109
3	71	19	98
4	117	20	95
5	107	21	102
6	104	22	98
7	80	23	80
8	105	24	86
9	110	25	94
10	108	26	92
11	76	27	108
12	110	28	94
13	115	29	100
14	94	30	101
15	100	31	109
16	74	32	94

REFERENCES

BASSETTI, BENEDETTA. 2009. Orthographic input and second language phonology. In Thorsten Piske and Martha Young-Shcolten (eds.). *Input Matters in SLA,*191-206. Multilingual Matters/Channel View Publications.

BEST, CATHERINE. 1995. A direct realist view of cross-language speech perception. In Winifred Strange (ed.). *Speech Perception and Linguistic Experience: Issues in Cross-Language Research,* 171-204. Timonium, MD: York Press.

_____ and MICHAEL TYLER. 2007. Nonnative and second-language speech perception: Commonalities and complementarities. In Ocke-Schwen Bohn and Murray Munro (eds.). *Language Experience in Second Language Speech Learning: In Honor of J. Flege*, 13-34. Amsterdam/Philadelphia: John Benjamins.

BOHN, OCKE-SCHWEN and JAMES EMIL FLEGE. 1990. Interlingual identification and the role of foreign language experience in L2 vowel perception. *Applied Psycholinguistics* 11, 303-328.

_____ and _____. 1997. Perception and production of a new vowel category by adult second language learners. In Jonathan Leather and Allen James (eds.). *Second-Language Speech:*

Structure and Process, 53-73. Berlin: de Gruyter.

BORDEN, GLORIA, ADELE GERBER, and GARY MILSARK. 1983. Production and perception of the /r/-/l/ contrast in Korean adults learning English. *Language Learning* 33.3, 499-526.

CATFORD, JOHN CUNNISON and DAVID PISONI. 1970. Auditory vs. articulatory training in exotic sounds. *Modern Language Journal* 54, 477-481.

CELCE-MURCIA, MARIANNE, DONNA BRINTON, and JANET GOODWIN. 1996/2006. *Teaching Pronunciation: A Reference for Teachers of English to Speakers of Other Languages*. Cambridge: Cambridge University Press.

CHO, MI-HUI and SHINSOOK LEE. 2007. Category matching between English and Korean consonants in different prosodic environments. *English Language and Literature* 53.5, 731-753.

DINNSEN, DANIEL and JESSICA A. BARLOW. 1998. On the characterization of a chain shift in normal and delayed phonological acquisition. *Journal of Child Language* 25, 61-94.

ECKMAN, FRED. 2004. From phonemic differences to constraint rankings: Research on second language phonology. *Studies in Second Language Acquisition* 26.4, 513-549.

EDWARDS, HAROLD. 2003. *Applied Phonetics: The Sounds of American English*. Thomson.

FLEGE, JAMES EMIL. 1987. The production of "new" and "similar" phones in a foreign language: Evidence for the effect of equivalence classification. *Journal of Phonetics* 15, 47-65.

_____. 1995. Second language speech learning: Theory, findings, and problems. In Winifred Strange (ed.). *Speech Perception and Linguistic Experience: Issues in Cross-Language Research*, 233-272. Timonium, MD: York Press.

_____. 2009. Give input a chance! In Thorsten Piske and Martha Young-Shcolten (eds.). *Input Matters in SLA,* 175-190. Multilingual Matters/Channel View Publications.

_____, GRACE YENI-KOMSHIAN, and SERENA LIU. 1999. Age constraints on second-language acquisition. *Journal of Phonetics* 25, 169-186.

_____, MURRAY MUNRO, and IAN MACKAY. 1995. Effects of age of second language learning on the production of English consonants. *Speech Communication* 16, 1-26.

_____ and WIEKE EEFTING. 1987. The production and perception of English stops by Spanish speakers of English. *Journal of Phonetics* 15, 67-83.

FRIEDA, ELAINA and TAKESHI NOZAWA. 2007. You are what you eat phonetically: The effect of linguistic experience on the perception of foreign vowels. In Ocke-Schwen Bohn and Murray Munro (eds.). *Language Experience in Second Language Speech Learning: In Honor*

of James Emil Flege, 79-96. John Benjamins.

GNANADESIKAN, AMALIA. 2004. Markedness and faithfulness constraints in child phonology. In René Kager, Joe Pater, and Wim Zonneveld (eds.). *Constraints in Phonological Acquisition,* 73-108. Cambridge: Cambridge University Press.

HEWINGS, MARTIN and SHARON GOLDSTEIN. 1998. *Pronunciation Plus: Practice Through Interaction*. Cambridge: Cambridge University Press.

JENKINS, JENNIFER. 2000. *The Phonology of English as an International Language*. Oxford University Press.

JOH, JEONGSOON and SHINSOOK LEE. 2001. Relationships between sound perception and production in L2 phonology acquisition. *Journal of the Applied Linguistics* 17.2, 127-145.

KENT, RAY. 1979. Imitation of synthesized English and non-English vowels by children and adults. *Journal of Psycholinguistic Research* 8.1, 43-60.

LADO, ROBERT. 1957. *Linguistics Across Cultures*. Ahn Arbor, MI: University of Michigan Press.

LEE, SHINSOOK. 2010. The influence of L2 experience on the perception of nonnative phonemic contrasts. *Studies in Phonetics, Phonology and Morphology* 16.1, 123-145.

_____ and MI-HUI CHO. 2002. Sound replacement in the acquisition of English consonant cluster: A constraint-based approach. *Studies in Phonetics, Phonology and Morphology* 8.2, 255-271.

_____, JEONGSOON JOH, INJAE LIM, and HYUNSOOK KO. 2011. The production of English sounds by early learners with different English learning experience. *Korean Journal of Linguistics* 36.1, 215-241.

LLISTERRI, JOAQUIM. 1995. Relationships between speech production and speech perception in a second language. In K. Elenius, and P Branderud (eds.). *Proceedings of XIIIth International Congress of Phonetic Science* 4, 92-99.

LOGAN, JOHN, SCOTT LIVELY, and DAVID PISONI. 1991. Training Japanese listeners to identify English /r/ and /l/: A first report. *Journal of the Acoustical Society of America* 89, 874-86.

MACK, MOLLY. 1989. Consonant and vowel perception and production: Early English-French bilinguals and English monolinguals. *Perception & Psychophysics* 46.2, 187-200.

MAJOR, ROY. 2001. *Foreign Accent*: *The Ontogeny and Phylogeny of Second Language Phonology*. New Jersey: Lawrence Erlbaum Associates Publishers.

_____. 2008. Transfer in second language phonology. In Jette Hansen Edwards and Mary Zampini (eds.). *Phonology and Second Language Acquisition,* 63-94. Amsterdam/Philadelphia: John Benjamins.

MUNRO, MURRAY and OCKE-SCHWEN BOHN. 2007. The study of second

language speech: A brief overview. In Ocke-Sshwen Bohn and Murray Munro (eds.). *Language Experience in Second Language Speech Learning: In Honor of James Emil Flege*, 3-11. John Benjamins.

OLLER, JOHN and SEID ZIAHOSSEINY. 1970. The contrastive analysis hypothesis and spelling errors. *Language Learning* 20, 183-89.

PATER, JOE. 2004. Bridging the gap between receptive and productive development with minimally violable constraints. In René Kager, Joe Pater, and Wim Zonneveld (eds.). *Constraints in Phonological Acquisition,* 219-244. Cambridge: Cambridge University Press.

ROCHET, BERNARD. 1995. Perception and production of L2 speech sounds by adults. In Winifred Strange (ed.). *Speech Perception and Linguistic Experience: Theoretical and Methodological Issues in Cross-Language Speech Research,* 379-410. Timonium, MD: York Press.

SHELDON, AMY. 1985. The relationship between production and perception of the /r/-/l/ contrast in Korean adults learning English. A reply to Borden, Gerber, and Milsark. *Language Learning* 35.1, 107-113.

_____ and WINIFRED STRANGE. 1982. The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception. *Applied Psycholinguistics* 3, 243-261.

SMITH, NEILSON. 1973. *The Acquisition of Phonology: A Case Study.* Cambridge: Cambridge University Press.

STREVENS, PETER. 1960. Spectra of fricative noise in human speech. *Language and Speech* 3, 32-49.

SUNG, EUNKYUNG. 2003. *Flaps in American English and Korean: Production and Perception*. PhD Dissertation. University of Delaware.

_____. 2006. L2 sound perception and production by Korean adults and children. *Studies in Phonetics, Phonology and Morphology* 12.3, 577-596.

TRUBETZKOY, NIKOLAI. 1939/1969. *Principles of Phonology*. Translated by C.A. Baltaxe, Berkeley, CA: University of California Press.

YOUNG-SCHOLTEN, MARTHA. 2002. Orthographic input in L2 phonological development. In P. Burmeister, Thorsten Piske, and Andreas Rohde (eds.). *An Integrated View of Language Development: Papers in Honor of Henning Wode*, 263-279. Trier: Wissenschaftlicher Verlag Trier.

Shinsook Lee
Department of English Language Education
Korea University
Anam-Dong, Seongbuk-Gu
Seoul, 136-701, Korea
Email: leesseng@korea.ac.kr
Tel/Fax: +82-2-3290-2353

Received: July 1, 2011
Accepted: August 15, 2011