The Journal of Studies in Language

The Journal of Studies in Language 34(3), 425-438 (2018)

The Interface between Perception and Production in L2 English Vowels

Lee, Shinsook* and Cho, Mi-Hui**
Korea University
Kyonggi University

*First Author / **Corresponding Author

ABSTRACT

The Journal of Studies in Language 34.3, 425-438. The study explores the interface between perception and production in L2 English vowels focusing on the precedence relationship and the correlation between perception and production. To that end, 34 Korean EFL learners identified 12 English vowels presented in the bVt word structure and their productions of the same English vowels were identified by native English speakers. The results revealed that overall the precedence relationship of perception over production was attested but not across all the target vowels. The results also showed that similar error patterns were observed in perception and production for the same vowels. However, no correlation was found between perception and production, suggesting that L2 speech perception and production may not develop concurrently. The findings of the study are discussed in light of L2 learning, especially in light of the development of L2 perception and production skills. **(Korea University · Kyonggi University)**

Keywords: English vowels, perception and production, precedence, correlation, L2 learning

OPEN ACCESS

https://doi.org/10.18627/jslg.34.3.201811.425

pISSN : 1225-4770

Received: October 01, 2018

Revised: November 06, 2018

Accepted: November 14, 2018

This is an Open-Access article distributed under the terms of the Creative Commons Attribution NonCommercial License which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright©2018 the Modern Linguistic Society of Korea

본인이 투고한 논문은 다른 학술지에 게재된 적이 없으며 타인의 논문을 표절하지 않았음을 서약합니다. 추후 중복게재 혹은 표절된 것으로 밝혀질 시에는 논문게재 취소와 일정 기간 논문 제출의 제한 조치를 받게 됨을 인지하고 있습니다.

1. Introduction

The Spoken speech communication involves talker-listener parity and thus the relationship between speech perception and production has received much discussion in the language acquisition literature (Bradlow et al., 1997; de Jong et al., 2009a, b; Flege, 1995; Pater, 2004). Specifically, motor theory (Liberman and Mattingly, 1985, 1989) contends that listeners perceive speech sounds according to their own articulatory gestures, indicating that there is a close link between speech perception and production. In a similar vein, the direct-realist approach (Best, 1994; Folwer, 1986) maintains that listeners directly perceive talkers' articulatory gestures, claiming that speech perception and production are closely connected.

- The first author was supported by the College of Education, Korea University Grant in 2018. We are grateful to the anonymous reviewers for providing helpful comments on an earlier version of the paper.

On the other hand, the acoustic-auditory approach of speech perception (Stevens and Blumstein, 1981) contends that listeners perceive speech sounds in terms of the acoustic signals independently of articulation that generated them but does not make any specific claims about the relationship between perception and production, as noted by Bradlow et al. (1997).

Concerning the relationship between speech perception and production for L2 learners, several studies reported that there is a moderate correlation between the two (Flege et al., 1997; Flege et al., 1999; Schmidt and Flege, 1995). For instance, Flege et al. (1997) examined the perception and production of English front vowels by L2 learners from different L1 backgrounds. The results showed that the learners' production accuracy of the vowels was related to the learners' perception accuracy to some degree (p. 437). However, some studies found no correlation between speech perception and production (Peperkamp and Bouchon, 2011). Specifically, Peperkamp and Bouchon (2011) looked into the perception and production of English front vowels /i/ and /ɪ/ by French-English bilinguals and reported that no correlation was found between the bilinguals' perception and production of the vowel contrast. Other studies further documented that perception and production skills in L2 do not develop in tandem (de Jong et al., 2009b).

As for English vowel studies, Yang and Whalen (2015) investigated the interface between American English speakers' perception and production of English vowels. Native English speakers identified ideal English vowels from synthetic vowel stimuli and they also produced the same vowel stimuli in a clear speech. The formants of the native speakers' vowel productions were measured and the native speakers' produced vowel space was compared to their perceived vowel space. The results showed that the native speakers' produced vowel space diverged from their perceived vowel space, indicating that the speakers' vowel productions do not necessarily reflect their perception of the vowels.

Hong (2015) examined American and Korean speakers' English vowel identification using the stimuli from the database of Hillenbrand et al. (1995). He reported that native American English speakers used dynamic spectral cues and duration when identifying English vowels whereas Korean speakers showed a tendency to use duration and static spectral cues. Similarly, in the production study Hong (2016b) found that native American English speakers' vowel signals showed dynamic spectral properties while those of Korean speakers exhibited static spectral properties. The findings of Hong (2015, 2016b) seem to suggest that native English speakers showed similar patterns when perceiving and producing English vowels. Korean speakers also exhibited similar perceptual and production patterns for English vowels.

Given that whether there is a direct link between speech perception and production in L2 is still controversial, one important question that should be addressed in L2 acquisition is the degree to which L2 speech perception and production are linked. However, not many studies have investigated the interface between the two, especially the relationship between vowel perception and production by the same L2 learners. Thus, the present study explores the relationship between perception and production of English vowels by Korean EFL learners. Specifically, the present study investigates the precedence relationship between English vowel identification and production and also the correlation between the two in order to shed light on the long-standing issue of the interface between speech perception and production.

2. Literature Review

2.1 Precedence Relationship between Perception and Production

In first language acquisition it is well-known that speech perception and production do not develop hand in hand. That is, infants' productive abilities lag behind receptive abilities in that infants' receptive skills are a prerequisite to productive skills (Best, 1994; Gnanadesikan, 2004; Jusczyk, 1997; Pater 2004; Schiller and Meyser, 2003). Likewise, Flege (1995) argued for a perceptual basis for foreign accents. Specifically, Flege contended that L2 learners tend to perceive L2 sounds in terms of the closest L1 sound categories, especially when L2 sounds and their L1 counterparts share the phonetic space to a greater extent. This causes L2 learners to fail to notice subtle acoustic and phonetic differences between L2 sound categories and their L1 analogues, which hinders L2 learners from establishing new phonetic sound categories for the L2. This in turn leads L2 learners to have accented speech as their production in L2 is guided by incomplete L2 sound categories. Similar arguments were made by Flege and his colleagues (Flege et al., 1997; Flege et al., 1999).

The precedence of perception over production has been documented in the L2 acquisition literature. For instance, Flege et al. (1997) maintained that L2 learners' errors in producing English front vowels could be attributed to their perceptual errors of the vowels. Bradlow et al. (1997) also reported that Japanese learners' perceptual training of English /l/ and /r/ alone led to noticeable improvements in pronunciation, even without explicit training to produce the target sounds. Along the similar lines, Lee (2011) reported that advanced Korean EFL learners' perception abilities were ahead of their production abilities in the acquisition of English fricatives.

On the other hand, several studies showed that speech production took precedence over speech perception in L2 acquisition. For example, Sheldon and Strange (1982) reported that Japanese learners produced English /l/ and /r/ far better than perceiving them. Likewise, Korean learners' production abilities were significantly ahead of their perception abilities in the acquisition of English voiceless coronal fricatives (Joh and Lee, 2001), English consonant clusters (Lee and Cho, 2005), and English /l/ and /r/ (Sung, 2006). However, Cho and Jeong (2013) investigated the acquisition of 11 American English vowels by Korean learners and reported that the precedence relationship between perception and production varied with individual target vowels. Specifically, the Korean learners were better at perceiving English [oʊ] than producing it while they were better at producing English [eɪ] and [u] than perceiving them. Given that two opposite patterns of the precedence relationship between perception and production were reported in the L2 acquisition literature, one of the goals of the current study is to examine the precedence relationship between English vowel perception and production by Korean learners in order to provide another testing ground for this issue.

2.2 Correlation between Perception and Production

Bohn and Flege (1997) contended that perception may precede production in the initial stages of L2 acquisition but perception is more likely to be resistant to pliability than production as L2 learners' experience with the target language increases, indicating that the two skills may not develop in tandem. Strange (1995) maintained that the degree of alignment between perception and production varies with L2 learners' experience with the target language. No

correlation may exist between perception and production for experienced L2 learners whereas perceptual errors may predict production errors for inexperienced L2 learners.

Fabra and Romero (2012) examined the perception and production of English vowels by Catalan learners with different levels of English proficiency; high, mid, and low English proficiency groups. The learners discriminated between English /i/-/ɪ/, /ɛ/-/æ/, /ɑ/-/ʌ/, and /u/-/ʊ/ vowel contrasts and they also produced English words containing one of the following vowels: /i/, /ɪ/, /ɛ/, /æ/, /ɑ/, /ʌ/, /u/, and /ʊ/. The results revealed that the Catalan learners were overall poor at discriminating between the vowel contrasts but the learners, in particular high and mid English proficiency group learners, were good at discriminating between English /i/-/ɪ/ and /u/-/ʊ/ contrasts. Acoustic measurements of the learners' productions (only female speakers' productions) indicated that the Catalan learners gave heavy weight to the F2 dimension compared to native English speakers. That is, the learners showed narrowed distances in the vowel space between the two members in the pairs /i/-/ɪ/, /ɛ/-/æ/, /ɑ/-/ʌ/, and /u/-/ʊ/ (p. 502). However, productions of more proficient learners progressed toward native-like norms with respect to vowel expansion and duration. Also, native English speakers' judgments of the vowels produced by the Catalan learners indicated that their productions of /i/, /ɛ/, /ʌ/, and /ɑ/ were more problematic compared to other vowels but their productions tended to show better identification as their English proficiency became high. The results further revealed no significant correlation between perception and production either at the individual level or at the group level.

Peperkamp and Bouchon (2011) tested French-English bilinguals' perception and production of the English /i/-/ɪ/ contrast. The bilinguals discriminated between the vowel contrast in an ABX discrimination test[1)] and they also produced the vowels embedded in sentences. The bilinguals' vowel productions were assessed for global nativeness by native English speakers and also identified by a native English speaker. Peperkamp and Bouchon (2011) reported that there was no correlation between the French-English bilinguals' perception and production of the English vowel contrast.

As for the acquisition of English vowels by Korean learners, most studies focused either on vowel perception or vowel production. For example, Hong (2015) examined 57 Korean university students' and 5 native American English speakers' perception of American English vowels /i, ɪ, ɛ, æ, ɑ, ɔ, ʌ, ʊ, u/ in the *h_d* forms taken from the database of Hillenbrand et al. (1995), using a forced-choice identification test. Hong found that Korean students had a tendency to use duration along with static spectral properties while native American English speakers used dynamic spectral properties and duration when they identified the target vowels. In a follow-up study, Hong (2016a) reported that Korean university students with a high-level of English proficiency tended to use dynamic spectral cues and duration similar to native American English speakers, whereas those with a low-level of English proficiency used static spectral cues and duration.

Hong also (2016b) conducted a production experiment where 18 Korean university students produced 9 American English vowels /i, ɪ, ɛ, æ, ɑ, ɔ, ʌ, ʊ, u/ in the *h_d* forms. The results showed that the Korean students' productions of English vowels /ʌ/, /ɪ/, /æ/, /ɑ/, and /ʊ/ deviated from the target vowels but those of English /i/, /u/, and /ɛ/ approximated the targets vowels. Specifically, the Korean students' productions of English /ʌ/ were confused with English /ɑ/ and /ɔ/ and their productions of English /ɪ/, /æ/, /ɑ/, and /ʊ/ were also confused with English /i/, /ɛ/, /ɔ/, and /u/, respectively. Hong noted that Korean students' production difficulties of English /ʌ/, /ɑ/, and /ɔ/ were likely to be related to their

1) The participants were requested to judge whether the stimulus word X was the same as the stimulus words A or B.

perceptual difficulties given that Korean students also showed perceptual difficulties identifying English /ʌ/, /ɑ/, and /ɔ/ as reported in Hong (2014). Importantly, however, the Korean students in the perception experiment and those in the production experiment in Hong (2014, 2015, 2016a, 2016b) were not the same learners. Accordingly, it is not clear whether Korean learners' production difficulties of English vowels were closely related to their perceptual difficulties of the vowels. Thus, studies that investigate both perception and production of English vowels by the same learners are called for.

3. Experiment

3.1 Participants

The participants were 34 Korean learners of English enrolled in English language education courses at a university in Seoul. They consisted of 10 male and 24 female students and their mean age was 22.5 years when the experiment was carried out. Their English proficiency was rated either upper-intermediate or advanced in that their average IBT-TOFEL score was 102 with the range from 85 to 115. No participants had the experience of residing in English-speaking countries more than 8 months.

3.2 Materials

The target vowels were 12 American English vowels: /i, ɪ, eɪ, ɛ, æ, ɝ, ɑr, ʌ, ɑ, ɔ, oʊ, u/. The target vowels were embedded in the *b_t* forms (*beat, bit, bait, bet, bat, burt, bart, but, bot, bought, boat, boot*). Due to a possible variation in word frequency among the stimuli, high frequency English words with the same target vowels were also provided (*seed, sit, eight, set, hat, world, card, cut, hot, law, go, fruit,* respectively), as in Evans and Iverson (2007). The stimulus words were produced by a female native speaker of American English in the frame of "Say _____ again". The native speaker was from Ohio in the US and 20 years old. The recording was conducted in a soundproof lab at a university at a sampling rate of 16-bit/44.1kHz. Speech Filing System (SFS) and a RODE-NT1A microphone were used in the recording. The recordings of the native speaker were inspected by 2 native American English speakers with several years of phonetic training at University College London (UCL) and also by a phonetician who had been teaching pronunciation training courses at UCL.

3.3 Procedure

English words with the target vowels were displayed on the computer monitor and the participants produced the words in the frame of 'Say _____ again' three times. Before the test, the participants went over the stimuli for familiarization. The vowel production test was conducted in a sound-attenuated room with a Sony ECM-MS907 microphone using Speech Filing System (SFS). The recordings were digitized at 44,1kHz and stored as wave files at a laptop computer. After the recording, audio files were edited for native English speakers' identification of the words (i.e., vowels). Specifically, no more than three sequences of front/back or high/mid/low vowels occurred in a row and

the ordering of the vowels was randomized for identification.

Five native speakers of North American English identified the target words produced by the Korean participants. Two native speaker raters were from the US: one male rater from California (41 years old) and one female rater from Philadelphia (24 years old). The remaining three native speaker raters were from Canada: one male rater from Vancouver (35 years old) and two female raters from Toronto (29 and 35 years old). The native speaker raters were teaching English at a private university in the Seoul-Metropolitan area or graduate students majoring in English language education at a university in Seoul. The native speaker raters were asked to listen to the stimulus words and to check the word they thought they heard on an answer sheet. There were 12 alternatives and also a blank for writing down was provided if the native speaker raters could not find the words they heard among the alternatives. The native speaker raters also provided confidence ratings for the target words on a 7-point scale in which "1" indicates "not confident at all" and "7" "very confident". There were 1224 token stimuli (34 participants[2)] × 12 vowels × 3 repetitions).

The Korean participants also completed a perception (i.e., vowel identification) test using Praat in a sound-attenuated room. The participants wore headphones and listened to the target words recorded by the female native English speaker from Ohio. The words were repeated 4 times at random and thus there were 48 trials for each participant (12 vowels × 4 repetitions). The participants were asked to mouse-click the word they thought they heard among the stimulus words displayed on the computer monitor. They could replay the stimuli up to two times and finished practice items recorded by a male native speaker of American English before the test.

3.4 Analysis

The accuracy of the native English speakers' identification of the Korean participants' productions was calculated by the participants and by the words (i.e., vowels). The error patterns were also coded. Similarly, the Korean participants' identification accuracy in the perception test was calculated, along with the coding of the perceptual error patterns.

4. Results

4.1 Overall Results

The overall results of the perception and production tests were shown in Figure 1. The percentage correct of perception was slightly higher than that of production and the paired samples *t*-test indicated that there was a significant difference between the perception and production accuracy ($t(33)=2.204$, $p<.05$). The overall results thus supported the previous findings that perception generally precedes production.[3)]

2) Among the 5 native English raters, two raters, one from the US and the other from Canada, said that they distinguished between the vowels /ɑ/ and /ɔ/. The remaining 3 native English raters said that they did not consciously distinguish between /ɑ/ and /ɔ/ but that they were able to differentiate between the two vowels when hearing the vowels. Additionally, the native speaker raters' confidence ratings were overall very high (mean: 5.5).

3) The participants' perception results were analyzed from a different perspective in Lee and Shin (2015) with other data. Also, part of the participants' production data was acoustically analyzed in Lee et al. (2017).

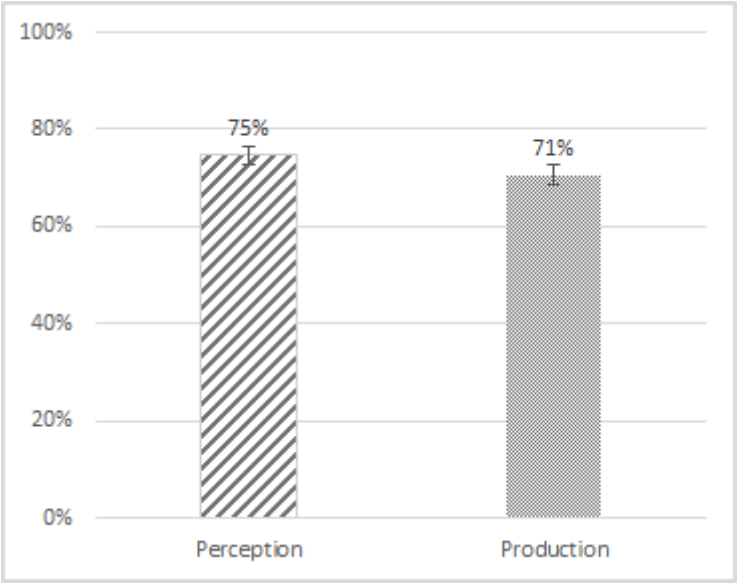
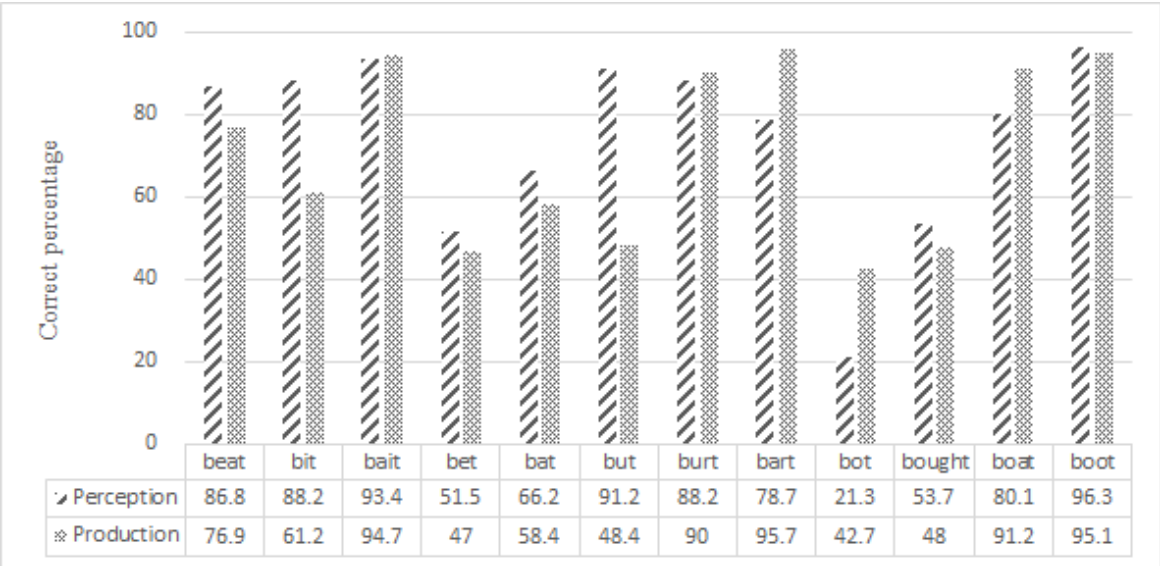


Fig. 1. Mean percentage correct of perception and production

Each of the individual vowels was also analyzed in terms of perception and production. As can be seen in Figure 2, the correct percentage of perception was higher than that of production for several vowels such as /i/ (*beat*), /ɪ/ (*bit*), /ɛ/ (*bet*), /æ/ (*bat*), /ʌ/ (*but*), and /ɔ/ (*bought*). On the contrary, vowels such as /ɑr/ (*bart*), /ɑ/ (*bot*), and /oʊ/ (*boat*) showed the reverse pattern. There was not much difference in correct percentages between perception and production of vowels such as /eɪ/ (*bait*), /ɝ/ (*burt*), and /u/ (*boot*). Statistical analyses of the vowel pairs revealed that the differences between perception and production of the following vowels were significant, as shown in Table 1.



	beat	bit	bait	bet	bat	but	burt	bart	bot	bought	boat	boot
Perception	86.8	88.2	93.4	51.5	66.2	91.2	88.2	78.7	21.3	53.7	80.1	96.3
Production	76.9	61.2	94.7	47	58.4	48.4	90	95.7	42.7	48	91.2	95.1

Fig. 2. Mean percentage correct of perception and production by individual vowels

Table 1. Paired samples t-test for perception and production of individual vowels

Vowel pairs	Mean difference	Standard deviation	t	d	p value
/i/-/i/	.099	.283	2.038	33	.049
/ɪ/-/ɪ/	.271	.216	7.293	33	.000
/ʌ/-/ʌ/	.428	.233	10.689	33	.000
/ɑr/-/ɑr/	-.170	.323	-3.067	33	.004
/ɑ/-/ɑ/	-.214	.323	-3.753	33	.001
/oʊ/-/oʊ/	-.110	.257	-2.505	33	.017

Accordingly, the results of the individual vowels revealed that the precedence relationship between perception and production could vary depending on vowels, even though the overall results showed that perception preceded production.

4.2 Error Patterns in Perception and Production

The results of the perception and production were further analyzed in term of the error patterns of words, as shown in Table 2.

Table 2. Error patterns in perception and production by words

Stimulus words	Perception	Production
beat	bit 13.2% (18/136)	bit 22.5% (115/510)
bit	beat 11.0% (15/136)	beat 38,2% (195/510)
bait		
bet	bat 47.8% (65/136)	bat 49.0% (250/510)
bat	bet 33.8% (46/136)	bet 38.6% (197/510)
but	bought 4.4% (6/136)	bought 23.3% (119/510) bot 20.8% (106/510) boat 4.9% (25/510)
burt	boat 8.1% (11/136)	bart 9.2% (47/510)
bart	burt 17.6% (24/136)	burt 3.5% (18/510)
bot	bought 27.2% (37/136) but 25.0% (34/136) bart 9.6% (13/136) boat 8.8% (12/136)	bought 36.1% (184/510) but 14.1% (72/510)
bought	boat 14.0% (19/136) but 12.5% (17/136) bot 8.8% (12/136)	boat 34.5% (176/510) bot 9.0% (46/510) but 5.7% (29/510)
boat	bought 15.4% (21/136)	bought 5.1% (26/510)
boot		

Note: Error rates less than 3% are not shown.

As shown in Table 2, error patterns of perception and production were similar. More specifically, the English vowel pair /i/-/ɪ/ in the words *beat* and *bit* showed a reciprocal error pattern in both perception and production, but the error rate was higher in production than in perception. The English vowel pair /ɛ/-/æ/ (*bet* and *bat*) also demonstrated a bidirectional error pattern but smaller differences in error rates between perception and production. English /ʌ/ was misidentified as English /ɔ/ in a small proportion while it was mainly misproduced as /ɔ/ and /ɑ/. The English rhotic vowel /ɝ/ (*burt*) was unexpectedly misperceived as /oʊ/ in *boat*, but it was misproduced as /ɑr/ (*bart*) with not much difference in error rates between perception and production. Another English rhotic vowel /ɑr/ in *bart* was mainly confused with the rhotic vowel /ɝ/ in *burt* with a higher error rate in perception than in production. The English vowel /ɑ/ in *bot* was mostly confused with /ɔ/ (*bought*) both in perception (27.2%) and production (36.1%). This is understandable given that English /ɑ/ and /ɔ/ are merged into /ɑ/ in many parts of the United Sates (Boberg, 2015). In addition, English /ɑ/ was misidentified as /ʌ/ (25%), followed by /ɑr/ and /oʊ/, whereas it was mispronounced as /ʌ/ in production (14.1%). On the contrary, English /ɔ/ was not mainly confused with English /ɑ/ but with English /oʊ/ in perception (14%) and the same error pattern was also observed in production (34.5%). English /ɔ/ was further confused with English /ɑ/ and /ʌ/ in both perception and production. The English vowel /oʊ/ in *boat* was mostly confused with English /ɔ/ in *bought* but the error rate of /oʊ/ was much higher in perception than in production. As for the vowels /eɪ/ (*bait*) and /u/ (*boot*), no salient error patterns emerged.

4.3 Correlation between Perception and Production

One of the research questions addressed in the present study was to investigate whether the participants' perception and production abilities develop closely or independently. In order to answer the question, the correlation between perception and production was analyzed by the participants.

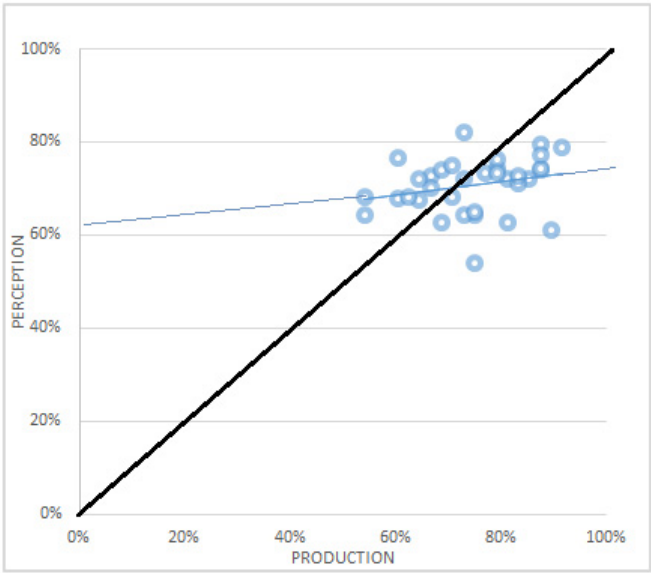


Fig. 3. Correlation between perception and production by participants (Each empty circle represents individual participants.)

The results revealed that there was no significant correlation between perception and production (R^2=0.063, p>,05), suggesting that the participants' production ability does not necessarily go hand in hand with their perceptual ability. For instance, the participants above the diagonal line (y=x) in Figure 3 demonstrate that their perceptual ability is better than their production ability. By contrast, the participants below the diagonal line indicate that their production accuracy was higher than their perception accuracy. When a correlational analysis was conducted by individual word pairs, no significant correlations were found across all the words pairs (all p>.05).

5. Discussion and Implication

The current study investigated the interface between perception and production in L2 American English vowels focusing on the precedence relationship and the correlation between perception and production. To that end, 34 Korean EFL learners completed English vowel identification and production tasks with English vowel stimuli. The results revealed that the Korean learners overall perceived the target vowels more accurately than producing them, thus showing the precedence relationship of perception over production.

However, the precedence relationship was not observed across all the target vowels. Specifically, only the vowels /i/ (*beat*), /ɪ/ (bit), and /ʌ/ (*but*) demonstrated a significant predominance of perception over production. The Korean learners in the current study identified the vowels /i/ and /ɪ/ at a high accuracy rate (over 85%) but their production of the vowels tended not to be target-appropriate. The learners' production of /i/ was identified as /ɪ/ while that of /ɪ/ as /i/ by the native English raters, thus showing bidirectional error patterns. This suggests that the learners were less likely to differentiate between /i/ and /ɪ/ in production than in perception. As for the low accuracy rate in production, it may partly be due to a negative transfer effect from Korean. Korean /i/ has been considered to be more similar to English /i/ than English /ɪ/ (Yang, 1996). Thus, the Korean participants seemed to have more difficulty producing English /ɪ/ (accuracy rate: 61.2%) than English /i/ (accuracy rate: 76.9%). The perception accuracy of /ʌ/ was also high (91.2%) but its production accuracy was very low (48.4%). This was because the learners' production of /ʌ/ was mostly identified as /ɔ/ and /ɑ/ by the native English raters. The result seems to suggest that many Korean learners in the current study had not attained the production skills of English /ʌ/ unlike the perception skills of the vowel (de Jong et al., 2009a, b). The result may also be ascribable to the fact that the acoustic/auditory space between English /ʌ/ and /ɑ/ tends to be close (Johnson, 2003), causing the native English raters to misidentify /ʌ/ as /ɑ/. Further, North American English shows low-back vowel merger between /ɑ/ and /ɔ/ (Boberg, 2015), making the distinction between /ɑ/ and /ɔ/ a little bit difficult.

By contrast, the vowels /ɑr/ (*bart*), /ɑ/ (*bot*), and /oʊ/ (*boat*) showed a significant predominance of production over perception. The rhotic vowel /ɑr/ was confused with another rhotic vowel /ɝ/ at the rate of 17.6% in perception. However, the native English raters identified the Korean learners' production of /ɑr/ at a high accuracy rate possibly due to the salient acoustic *r*-coloring of the vowel. As mentioned above, the confusion among English /ɑ/, /ʌ/, and /ɔ/ affected the low accuracy rates of /ɑ/ both in perception and production. The low accuracy of English /ɑ/ may partly stem from an L1 negative transfer in that Korean /a/ is a low central vowel whereas English /ɑ/ is a low back vowel. The Korean learners also misidentified the target /ɑ/ with other vowels such as /ɑr/ and /oʊ/, which resulted in lower accuracy of the vowel in perception than in production. English /oʊ/ was confused with /ɔ/ mostly in perception, but not

in production, showing high accuracy in production. The confusion of /oʊ/ with /ɔ/ in perception (15.4%) could be attributable to the fact that the duration of English /ɔ/ is somewhat long, thus causing the Korean learners to misidentify /oʊ/ as /ɔ/. Other vowels did not exhibit any significant precedence relationship between perception and production. However, it is worth noting that the low accuracy of English /ɛ/ and /æ/ in both perception and production may result from the ongoing merger of Korean /ɛ/ and /æ/ into /ɛ/ to some extent (Kang, 2003; Yang, 1996).

The findings of the current study seem to imply that it is not prerequisite to perceive an L2 sound in order to produce it target-appropriately, which does not support the postulate of the Speech Learning Model (SLM) that L2 speech perception guides L2 speech production (Flege, 1995). The current study also showed that the precedence relationship between perception and production varied depending on the target English vowels, indicating that L2 vowels are not acquired in an across-the-board fashion.

The study also examined the correlation between perception and production. As reported in Section 4.3, there was no significant correlation by the participants or by the individual vowels, implying that the Korean learners' perceptual abilities do not develop in tandem with their production abilities or vice versa. Similar findings were also reported by de Jong et al. (2009b), Peperkamp and Bouchon (2011), and Fabra and Romero (2012). Notice, however, that there were some studies that reported a moderate correlation between L2 speech perception and production, as mentioned earlier (Flege et al., 1997; Flege et al., 1999; Schmidt and Flege, 1995). As for the different results among several studies, Peperkamp and Bouchon (2011) contended that different experimental methodologies could account for different outcomes. Specifically, Peperkamp and Bouchon (2011) maintained that the lack of correlation in French-English bilinguals' perception and production of the English /i/-/ɪ/ contrast was due to the fact that the French bilinguals participated in an ABX discrimination test with a short interstimulus interval (ISI, 500ms) and thus they were not able to use the phonological loop during the discrimination test. Peperkamp and Bouchon (2011) further contended that several studies which showed a moderate correlation between perception and production mainly used identification and goodness ratings rather than an ABX discrimination test with a short ISI.

On the other hand, concerning the divergent results between the perception and production tasks, de Jong et al. (2009b) contended that the acquisition of L2 perception is different from that of L2 production. More specifically, the acquisition of perceptual skills "operate at the level of features, which cross-cut segments." (p, 370). However, the acquisition of production skills involves "the acquisition of a set of gestures, affecting all segments that share the gesture." (p. 370). de Jong et al. (2009b) further maintained that featural generalization exhibits early perceptual development whereas featural generalization in production develops later since the motor system is less pliable compared to the auditory perceptual system (p. 372).

Given that the current study used an identification task and found no correlation between speech perception and production, it seems to indicate that L2 learners' perceptual skills and their production skills do not develop in tandem, thus supporting the findings of de Jong et al. (2009a, b). That is, certain aspects of L2 learners' perceptual ability may develop ahead of or lag behind those of the learners' production ability. Also, some changes in the L2 learners' perceptual ability may occur without corresponding changes in the learners' production ability or vice versa (Flege et al., 1997). In sum, the findings of the current study imply that the changes in L2 speech perception may not necessarily transfer to changes in L2 speech production unlike the prediction of the SLM which assumes a common auditory-acoustic/phonetic space for both perception and production (Bradlow et al., 1997). Accordingly, the current

study adds a fragment to L2 acquisition literature concerning the precedence relationship and the correlation between speech perception and production. However, more research should be warranted to enlighten this issue in that the interface between perception and production has not been fully investigated for all L2 sound contrasts.

References

Best, T. C. 1994. Learning to Perceive the Sound Pattern of English. In C. Rovee-Collier and L. Lipsett (eds.), *Advances in Infancy Research*. Hillsdale, NJ: Ablex Publishers, Vol. 8. 217-304.

Boberg, C. 2015. North American English. In M. Reed and J. M. Levis (eds.), *The Handbook of English Pronunciation*. John Wiley & Sons, Inc., 229-250

Bohn, O.-S. and J. E. Flege. 1997. Perception and Production of a New Vowel Category by Adult Second Language Learners. In A. James and J. Leather (eds.), *Second Language Speech: Structure and Process*. Berlin and New York: Mouton de Gruyter, 53-74.

Bradlow, A., D. Pisoni, R. Akahane-Yamada, and Y. Tohkura. 1997. Training Japanese Listeners to Identify English /r/ and /l/: Some Effects of Perceptual Learning on Speech Production. *The Journal of the Acoustical Society of America* 101.4, 2299-2310.

Cho, M.-H. and S. Jeong. 2013. Perception and Production of English Vowels by Korean Learners. *Studies in Phonetics, Phonology and Morphology* 19.1, 155-177.

de Jong, K., N. Silbert, and H. Park. 2009a. Segmental Generalization in Second Language Segment Identification. *Language Learning*, 59.1, 1-31.

de Jong, K., Y.-C. Hao, and H. Park. 2009b. Evidence for Featural Units in the Acquisition of Speech Production Skills: Linguistic Structure in Foreign Accent. *Journal of Phonetics* 37.4, 357-373.

Evans, B. G. and P. Iverson. 2007. Plasticity in Vowel Perception and Production: A Study of Accent in Young Adults. *Journal of the Acoustical Society of America* 121.6, 3814-3826.

Fabra, L. R. and J. Romeo. 2012. Native Catalan Learners' Perception and Production of English Vowels. *Journal of Phonetics* 40.3, 491-508.

Flege, J. E. 1995. Second Language Speech Learning: Theory, Findings and Problems. In W. Strange (ed.), *Speech Perception and Linguistic Experience: Issues in Cross-language Research*. Timonium, MD: York, 233-277.

Flege, J. E., O.-S. Bohn, and S. Jang. 1997. Effects of Experience on Non-native Speakers' Production and Perception of English Vowels. *Journal of Phonetics* 25.4, 437-470.

Flege, J., I. MacKay, and D. Meador. 1999. Native Italian Speakers' Perception and Production of English Vowel. *Journal of the Acoustical Society of America* 106.5, 2973-2987.

Fowler, C. A. 1986. An Event Approach to the Study of Speech Perception from a Direct-realist Perspective. *Journal of Phonetics* 14.1, 3-28.

Gnanadesikan, A. 2004. Markedness and Faithfulness Constraints in Child Phonology. In R. Kager, J. Pater, and W. Zonneveld (eds.). *Constraints in Phonological Acquisition*. Cambridge: Cambridge University, 73-108.

Hillenbrand, J., L. Getty, M. Clark, and K. Wheeler. 1995. Acoustic Characteristics of American English Vowels. *Journal of the Acoustical Society of America* 97.5, 3099-3111.

Hong, S. 2014. Training Effects after Training Korean Listeners for the Contrast of /ɑ, ɔ, ʌ/. *Language and Linguistics* 65, 299-329.

Hong, S. 2015. Pattern Recognition Modeling of Korean Listeners' Perception of American English Monophthongs. *Language and Linguistics* 68, 209-239.

Hong, S. 2016a. Pattern Recognition Modeling of American English Vowel Identification by Four Different Identification-proficiency Levels of Korean Listeners. *Studies in Phonetics, Phonology and Morphology* 22.1, 147-175.

Hong, S. 2016b. Vowel Inherent Spectral Properties Characterized in Korean and American English Talker's English Vowel Signals: A Production-based Pattern Recognition Modeling Study. *Studies in Phonetics, Phonology and Morphology* 22.3, 583-609.

Joh, J. and S. Lee. 2001. Relationship Between Sound Perception and Production in L2 Phonology Acquisition. *Journal of the Applied Linguistics* 17.2, 127-145.

Johnson, K. 2003. *Acoustic and Auditory Phonetics*. Blackwell Publishing.

Jusczyk, P. 1997. *The Discovery of Spoken Language*. Cambridge: MIT Press.

Kang, O. 2003. *Korean Phonology*. Taehaksa.

Lee, S. 2011. Perception and Production of English Fricative Sounds by Advanced Korean EFL Learners. *Studies in Phonetics, Phonology and Morphology* 17.2, 259-281.

Lee, S. and M.-H. Cho. 2005. Perception and Production of English Anterior Obstruents. *English Language and Literature* 50.5, 1101-1132.

Lee, S. and D.-J. Shin. 2015. Estimating Korean EFL Listeners' Perception of English Vowels with Reference to Cross-language Labelling. *Studies in Phonetics, Phonology and Morphology* 21.2, 297-321.

Lee, S., H. Nam, J. Kang, D.-J. Shin, and Y. S. Kim. 2017. The Impact of Language-learning Environments on Korean Learners' English Vowel Production. *Phonetics and Speech Sciences* 9.2, 69-76.

Liberman, A. M. and I. G. Mattingly. 1985. The Motor Theory of Speech Perception Revised. *Cognition* 21.1, 1-36.

Liberman, A. M. and I. G. Mattingly. 1989. A Specialization for Speech Perception. *Science* 245, 489-494.

Pater, J. 2004. Bridging the Gap Between Receptive and Productive Development with Minimally Violable Constraints. In R. Kager, J. Pater, and W. Zonneveld (eds.), *Constraints in Phonological Acquisition*. Cambridge: Cambridge University, 219-244.

Peperkamp, S. and C. Bouchon. 2011. Conference: INTERSPEECH 2011, 12th Annual Conference of the International Speech Communication Association, Florence, Italy, August 27-31.

Schiller, N. O. and A. S. Meyer. 2003. Introduction to the Relation Between Speech Comprehension and Production. In Schiller, N. O and A. S. Meyer (eds.), *Phonetics and Phonology in Language Comprehension and Production*. Berlin: Mouton de Gruyter, 1-8.

Schmidt, A. and J. E. Flege. 1995. Effects of Speaking Rate Changes on Native and Non-native Production. *Phonetica* 52.1, 41-54.

Sheldon, A. and W. Strange. 1982. The Acquisition of /r/ and /l/ by Japanese Learners of English: Evidence that Speech Production can Precede Speech Perception. *Applied Psycholinguistics* 3.3, 243-261.

Stevens, K. N. and S. E. Blumstein. 1981. The Search for Invariant Acoustic Correlates of Phonetic Features. In P. D. Eimas and J. L. Miller (eds.), *Perspectives on the Study of Speech*. Hillsdale, NJ: Lawrence Erlbaum, 1-38.

Strange, W. 1995. Phonetics of Second-language Acquisition: Past, Present, Future. In K. Elenius and P. Branderud (eds.), Proceedings of the XII International Congress of Phonetic Sciences. Stockholm: Arne Stombergs, 76-83.

Sung, E. 2006. L2 Sound Perception and Production by Korean Adults and Children. *Studies in Phonetics, Phonology and Morphology* 12.3, 577-596.

Yang, B. 1996. A Comparative Study of American English and Korean Vowels Produced by Male and Female Speakers.

Journal of Phonetics 24, 245-261.

Yang, B. and D. H. Whalen. 2015. Perception and Production of English Vowels by American Males and Females. *Australian Journal of Linguistics* 35.2, 121-141, http://dx.doi.org/10.1080/07268602.2015.1004998.

Shinsook Lee, Professor
145, Anam-ro, Seongbuk-Gu
Seoul, Korea, 02841
Department of English Language Education
Korea University
Email: leesseng@korea.ac.kr

Mi-Hui Cho, Professor
154-42, Gwanggyosan-ro, Yeongtong-Gu
Suwon-Si, Gyeonggi-Do, Korea, 16227
Department of English Language and Literature
Kyonggi University
Email: mcho@kyonggi.ac.kr