Perception and production of English vowels by Korean learners: A Case study*

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Cho, Mi-Hui, and Soonyong Jeong. 2013. Perception and production of English vowels by Korean learners. *Studies in phonetics, phonology and morphology* 19.1. 155-177. The main objective of this study was to investigate the relationship between perception and production of English vowels by Korean EFL learners. To this end, 21 Korean students participated in perception and production tests in order to probe the extent to which the perception and production accuracies conform to each other. Overall, the participants had difficulty perceiving and producing English vowels since the mean accuracies of perception and production only amounted to 60%. The results showed that perception accuracy was not always higher than production accuracy, which runs counter to the traditional assumption that perception precedes production. Moreover, it was revealed that no significant correlation between perception and production was found, thus suggesting that perception and production may not be related and that perception and production capabilities may be developing independently depending on vowels and individuals. As for the results of the perception test, monophthong and short vowels were more difficult to perceive in relation to their counterpart diphthong and long vowels. Regarding the results of the production test, the participants were better at producing tense vowels than lax vowels. In addition, confusion matrixes for perception and production were presented and confusion patterns as well as the direction of confusability are discussed in detail. **(Kyonggi University)**

Keywords: vowels in American English, perception, production, relationship between perception and production, precedence of perception over production, confusion matrix

1. Introduction

Unlike consonants the production of vowels does not involve clear-cut contact of articulators making the airstream in the mouth escape in an unobstructed manner. Accordingly, Ladefoged (2006: 87) mention that there are no distinct boundaries between one type of vowel and another in English. Thus, the degree of height and backness which classifies English vowels can vary along the continuum depending on speakers as well as the accents of English. This variability may cause EFL learners to have difficulties acquiring English vowels because it is hard to say exactly how the tongue is moving when producing the vowels. Moreover, the quality of English vowels (i.e. F1, F2) is reported to be affected by some parameters like word frequency and neighborhood density (Yun 2010, among others).

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There are studies which deal with the acquisition of English vowels by Korean speakers, but there are not many studies which systematically examine the extensive vowel system of American English. While some studies focus on the tense/lax distinction of vowels (Avery and Ehrlich 1992, Tench 2003, Kahng 2006, Lee and Lee 2011), some other studies focus on front vowels (Flege et al. 1997, Yoon 2007, Han et al. 2011). Also, there are studies that investigate English onglides and diphthongs (Cho et al. 2001, Cho et al. 2009). There are, however, not many studies that extensively investigate the acquisition of English vowels by Korean EFL learners.

Hong (2012) conducted a perception study that examines 9 monophthongs [i, ɪ, ɛ, æ, ɑ, ɔ, u, ʊ, ʌ] in American English. In his study Korean learners identified [i] and [ɛ] better than [ɪ] and [æ], respectively, while no difference was found between the pair [u] and [ʊ]. Also, the perception of the [i]/[ɪ] pair was better than the [u]/[ʊ] pair, which was in turn better than the [ɛ]/[æ] pair. Hong convincingly showed that Korean learners' perceptual performance of American vowels varied depending on vowels, but one may further inquire whether the Korean learners' perception pattern found also pertains to the production pattern. Therefore, this paper aims to investigate the following questions in L2 vowel acquisition: 1) how accurately Korean EFL learners perceive the extensive vowel system of American English [i, ɪ, eɪ, ɛ, æ, ɑ, ɔ, oʊ, u, ʊ, ʌ]? 2) how accurately the Korean learners produce the vowels in American English? 3) most importantly, how the perception and production accuracies are related? In the following section the backgrounds of this study are provided, raising a theoretical question concerning the relationship between perception and production.

2. Background of the study

2.1 Comparison of English vowels with Korean

There are 11 vowels [i, ɪ, eɪ, ɛ, æ, ɑ, ɔ, oʊ, u, ʊ, ʌ] in American English (Avery and Ehrlich 1992: 33, Celce-Murcia et al. 1996: 94).

Table 1. The vowel system of American English
(Adapted from Avery and Ehrlich 1992: 33)

		Front	central	back
high	tense	i		u
	lax	ɪ		ʊ
mid	tense	eɪ	ʌ	oʊ
	lax	ɛ		ɔ
low		æ		ɑ

In contrast, there are 10 vowels [i, ɛ, æ, wi, wɛ, ɨ, ʌ, a, u, o] in Korean. One of the predominant differences between the vowel systems of English and

Korean is the tense/lax distinction of English vowels. English High vowels have tense/lax pairs ([i] vs. [ɪ], [u] vs. [ʊ]). The main features that differentiate tense vowels [i] and [u] from lax vowels [ɪ] and [ʊ] are the quality of the vowels (i.e. F1, F2) and additionally the length (Ladefoged 2006). Most scholars regard tense vowels [eɪ] and [oʊ] as diphthongs due to a quality change within the same syllable.[1] While the pair [eɪ] and [ɛ] can be classified as a tense/lax pair, the pair [oʊ] and [ɔ] cannot because [ɔ] behaves differently from [ɛ]. Specifically, [ɔ] is considered as long (Carr 1999: 29) and as tense (Wolfram and Johnson 1982: 31) as well. Therefore, the terminology "monophthong" can be adopted instead of "lax" for both [ɛ] and [ɔ] whose counterpart diphthongs are [eɪ] and [oʊ], respectively. Since monophthongs have one element while diphthongs have two elements, monophthongs can be considered as shorter relative to diphthongs physically and/or psychologically.

2.2 The relationship between speech perception and production

It has been a common belief that perception precedes production because good perception is a prerequisite to a good production. Consequently, production ability is regarded as being closely related to perception ability. This common belief especially holds true especially for first language acquisition given that infants' production ability lags behind their perception ability (Best 1994, Jusczyk 1997, Pater 2004, Gnanadesikan 2004). The precedence of perception over production and/or the correlation between perception and production also have been supported in L2 acquisition literature. For instance, several studies report that the perception of English stress was more accurate than the production of the stress, thus arguing for the precedence of perception over production (Archibald 1993, 1997, Park 2006). Guion et al. (2004) report close link between perception and production based on early and late Spanish-English bilinguals' English stress acquisition. Flege et al. (1997) argue that non-native speakers' accuracy of producing English front vowels was related to their accuracy of perceiving the same vowels.

On the other hand, there are studies that deny the precedence of perception over production and/or the correlation between perception and production. Sheldon and Strange (1982) report that Japanese learners' production of English /l, r/ was better than their perception of the same targets. The reverse case in which production is ahead of perception also can be found in the Korean students' acquisition of English voiceless coronal fricatives in Joh and Lee (2001). A similar reverse case is also reported in Lee and Cho (2005) for Korean speakers' acquisition of English consonant clusters. Likewise, Sung (2006) reports the reverse precedence relationship of

[1] However, some scholars treat [eɪ] and [oʊ] as monophthongs (Bronstein 1960, Giegerich 1992). There are 3 additional diphthongs [aɪ], [aʊ], and [ɔɪ] in English. Since [aɪ], [aʊ], and [ɔɪ] involve more tongue movement than [eɪ] and [oʊ], they are called as true diphthongs.

production over perception in the acquisition of Korean adults' English /l-r/ contrast. Cho (2008) also finds an asymmetry in which Korean students' production of [oʊ] improved significantly while perception of the same diphthong did not.

Interestingly, Lee (2006) shows that in the acquisition experiment of English stress Korean students' perception accuracy was higher than the production accuracy, thus arguing for the precedence of perception over production. However, no correlation between perception and production was found, which suggests that good perception does not necessarily imply good production, and vice versa. Similarly, Lee (2011) reports the precedence relation of perception over production but no correlation between perception and production in the acquisition of English fricatives by advanced Korean EFL learners. Along the same line, Sung (2009) maintains that Korean learners' production difficulties are not directly related with their perception deficiency based on perception and production experiments of English nonce words consisted of –C/–CC codas and CC- onsets. Shin (2012) also claims that Korean learners' production is not related to perception in the acquisition of English segments and phonotactics.

Given the various claims from the previous studies, the main purpose of this paper is to test the traditional assumption that perception takes precedence over production to the extent that production ability is related to perception ability. For this purpose, Korean learners' perception accuracy of English vowels will be compared with their production accuracy. If perception accuracy is higher than production accuracy, the precedence relationship of perception over production is borne out. And if the production skills develop with respect to the perception skills, we expect Korean learners' production accuracy of the target English vowels to be correlated with their perception accuracy. The presence of correlations between perception accuracy and production accuracy would imply that the perception skills and production skills are learned in a parallel manner and would support the precedence relation of perception over production.

If, however, the production accuracy for the English target vowels bears no relationship to the perception accuracy for the same target vowels, we do not expect necessary correlations between the participants' perception accuracy and production accuracy. In this case, there may be the precedence relationship of perception over production like Lee (2006, 2011) or no precedence relationship of perception.

The absence of correlations between perception accuracy and production accuracy would imply that the perception skills and production skills are learned independently. This is also understandable given that perception and production belong to a different faculty of speech. Specifically, the faculty of perception is involved in the auditory system whereas the faculty of production is involved in the motor control/articulatory system.

3. Method

3.1 Participants

Participants were 21 (8 male, 13 female) Korean learners of English attending a university in the Seoul-Gyeonggi metropolitan area. Their mean age was 22.8 years and they were all enrolled in an English phonetics class when the experiment was conducted. There were 3 students who had experience of residing in an English-speaking country but their length of residence (LOR) was less than one year. Six among 21 students had official TOEIC scores and the average TOEIC scores were 802. Although some participants had relatively high TOEIC scores, their English proficiency was evaluated as low-intermediate through an interviewing process. The interview was done in English by the authors during the semester. Also, in the questionnaire the participants self-evaluated their English proficiency as being from low-intermediate to intermediate on average. The questionnaire offered to the participants before the test is provided in Appendix A.

3.2 Stimuli

Target vowels examined were 11 American English vowels [i, ɪ, eɪ, ɛ, æ, ɑ, ɔ, oʊ, u, ʊ, ʌ] and the target vowels were framed in "bVt" forms as in Ladefoged (2006: 99). Since it was hard to elicit the vowels [ɑ] and [ʊ] in "bVt" forms, [ɑ] and [ʊ] were framed in "pVt" forms. The stimulus words are presented in Table 2.

Table 2. Stimulus words

vowel	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ
word	beat	bit	bait	bet	bat	pot	bought	boat	boot	put	but

For the production test, the 11 stimulus words were used twice (11 words*2 repetitions=22 stimulus words) and the randomized list was printed on a paper response form. For the perception test, two native speakers of American English (1 male and 1 female with a mean age of 33.5 years) produced the stimulus words. The native speakers were asked to read the randomized list of the stimulus words twice (11 words*2 native speakers*2 repetitions=44 stimulus words). The interval between the stimuli was 5 seconds. The stimulus words were recorded in a quiet room by using the Goldwave program (http://goldwave.com) in a laptop computer with a microphone (Sony ECM-MS907) at a sampling rate of 22050 Hz.

3.3 Procedure

In order to avoid any training effect, the production test was carried out prior

to the perception test. Before the test, the participants filled in the language background questionnaire (Appendix A). In the production test held in a quiet room, each participant was provided with the list of the stimulus words on a paper form and asked to produce the stimuli with a pause 5 seconds between the stimulus words. Because the target vowels were circumscribed by onset [p/b] and coda [t], no carrier sentence was adopted. The recordings of the participants' stimulus production were done by means of the Goldwave program in a laptop computer at a 22050 Hz sampling rate.

The production of the participants was assessed by 10 native speakers of English.[2] The native speakers (9 male and 1 female with a mean age of 36 years) were recruited from the same university that the participants attended. They were all English instructors teaching Korean EFL students English at the university. The native English instructors were presented with each of the Korean participants' production via headphones in a quite room. They were asked to listen to the stimulus words with a 5 second inter-stimulus interval and to identify the vowels in each stimulus by circling the appropriate IPA symbols from a list of 11 alternatives on a paper response form, as shown below.[3]

Table 3. Paper response form

Key word	f**ee**l	sh**i**p	w**ai**t	t**e**n	h**a**t	h**o**t	c**augh**t	c**oa**t	p**oo**l	c**oo**k	c**u**p	
1.	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ	Other:
2.	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ	Other:
3.	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ	Other:

In addition to the 11 IPA symbols, the answer sheet also had the option of indicating an additional write-in response (Other:) for the case where the native listeners heard a vowel other than the 11 pre-selected IPA symbols. Because IPA symbols were included in the choices, prior to the evaluation, some familiar example words for each IPA symbol were presented to the native listeners so that they did not have any problems of interpreting the IPA response alternatives. Also, key words for each target vowel were given at the top of the answer sheet.

For the analysis, the results of the production evaluation were coded in the

[2] Traditional ways to evaluate Korean students' English production would be either through acoustic analysis or transcription by Korean (and native) experts with phonetic training. This study, however, did not adopt the traditional methods because one of the aims of the study is to directly compare the accuracies of perception and production based on the same answer sheet presented in Table 3. The same scoring system in this study can facilitate straightforward comparisons between perception and production, which results in Table 6 and Table 8, and thus can avoid methodological problems raised in Sung (2009: 256).

[3] A similar forced-choice identification task is also adopted in de Jong et al. (2009: 12) in which Korean students were asked to identify English consonants by choosing the IPA symbols from a list of 15 alternatives [d, t, θ, ð, f, v, s, z, p, b, r, l, h, w, y].

Excel program. For example, when the native listeners chose the IPA vowel symbol [i] for the Korean participants' production of the stimulus word "beat", the participants' production was coded as 1 meaning a correct answer. By contrast, when the listener chose [ɪ] for the same token, it was coded as 0 meaning an incorrect answer. Each native listener evaluated all of the 21 Korean participants' production (11 vowels*2 repetition*21 participants= 462 tokens) and was paid for the assessment.

After the production test, the perception test was administered to the Korean participants. The Korean students were asked to identify vowels in the 44 stimulus words by choosing one response among 11 alternatives, as in Table 3. The 44 stimuli recorded by the 2 native speakers of American English were presented to the participants via headphones connected to a laptop computer in a quiet room and the participants were told to mark the IPA vowel symbol they heard on the sheet. Since the participants were taking English phonetics class, they did not have any problem interpreting the IPA symbols.[4] The perception answer sheets were gathered and the results were coded in the Excel program (1 for correct answers and 0 for incorrect answers).

4. Result and discussion

4.1 General results

The total accuracy rates of perception and production amounted to an average of 60%, which shows little difference between perception and production ability of the participants.[5] However, there were substantial variations between perception and production capabilities of the participants depending on vowels. For instance, the perception accuracy rate of the vowel [eɪ] was much lower than the production accuracy rate (65% vs. 91%) while the perception accuracy rate of the vowel [ʌ] was much higher than the production accuracy rate (54% vs. 34%). The 95% Confidence Interval (CI) for each vowel depending on the tasks (perception, production) is also provided in Appendix B.

[4] The Korean participants learned the IPA symbols only through textbook and lecture and thus, they did not have opportunity to practice listening and speaking English vowels in class prior to the experiment.

[5] The mean perception accuracy of the participants who had official TOEIC scores was 64% and the mean production accuracy of the same participants was 55%. Since the perception and production accuracies were not so different from the mean accuracies, they were included in the analysis.

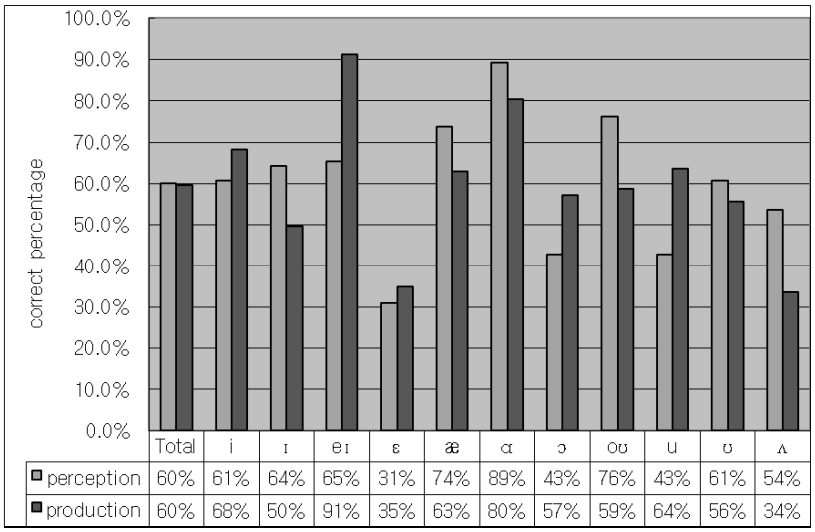

Figure 1. Mean rates of correct perception and production for English vowels

In order to see whether the difference of the accuracy rates between perception and production was significant, the paired-samples *t*-test was conducted, as given in Table 4.

Table 4. T-tests for the difference of mean accuracy rates between perception and production

Pairs of comparison	Mean	S.D.	*t*	df	*p*-value
Perception vs. production: Total	.00390	.11561	.154	20	.879
Perception vs. production: [i]	-.07619	.33452	-1.044	20	.309
Perception vs. production: [ɪ]	.14524	.36500	1.823	20	.083
Perception vs. production: [eɪ]	-.25714	.33177	-3.552	20	.002*
Perception vs. production: [ɛ]	-.04048	.34410	-.539	20	.596
Perception vs. production: [æ]	.10952	.33971	1.477	20	.155
Perception vs. production: [ɑ]	.08810	.22743	1.775	20	.091
Perception vs. production: [ɔ]	-.14286	.37626	-1.740	20	.097
Perception vs. production: [oʊ]	.17381	.33564	2.373	20	.028*
Perception vs. production: [u]	-.20714	.33700	-2.817	20	.011*
Perception vs. production: [ʊ]	.05000	.41952	.546	20	.591
Perception vs. production: [ʌ]	.20000	.48760	1.880	20	.075

*$p<.05$

The results of the t-tests revealed that only three vowels ([eɪ], [oʊ], [u]) among 11 showed a significant difference between perception accuracy and

production accuracy. No significant difference was found between perception accuracy and production accuracy for the other vowels. This result demonstrates that the participants were better at the perception ability than the production ability for the vowel [oʊ] while worse at the perception ability than the production ability for the vowels [eɪ] and [u]. This shows that the production ability of the participants may not be linked to the perception ability, which runs counter to the traditional assumption that the production ability lags behind the perception ability (i.e. the perception ability precedes the production ability). Rather, perception and production abilities seem to develop independently and the acquisition path may vary depending on vowels (and individuals).

The following table also shows there was no correlation between the perception and production accuracy rates of the participants, as the correlation coefficients were low except the vowel [u].

Table 5. Correlation for mean accuracy rates between perception and production

Pairs of comparison	*r*	*p*
Perception vs. production: Total	.273	.232
Perception vs. production: [i]	.031	.895
Perception vs. production: [ɪ]	.060	.795
Perception vs. production: [eɪ]	.056	.809
Perception vs. production: [ɛ]	.081	.727
Perception vs. production: [æ]	-.232	.312
Perception vs. production: [ɑ]	.107	.643
Perception vs. production: [ɔ]	.080	.730
Perception vs. production: [oʊ]	.103	.657
Perception vs. production: [u]	-.524	.015*
Perception vs. production: [ʊ]	-.130	.574
Perception vs. production: [ʌ]	-.070	.762

*p<.05

Although some previous studies on the relationship between perception and production have maintained there is a connection between perception and production such that good perception is a prerequisite to good production, the result indicates that perception and production abilities of the participants were not developing in a correlated fashion.[6] For instance, participants who had difficulty perceiving a target vowel did not necessarily have difficulty producing the same vowel. Likewise, participants with difficulty producing the target vowel may or may not have difficulty perceiving the same target.

[6] This holds true for all vowels including [u] in this study since the correlation between perception and production for [u] is inversely related due to the negative correlation, which means that the better the perception accuracy rates of the participants' [u] were, the worse the production accuracy rates were.

Hence, the precedence of perception over production and the correlation between perception and production are disconfirmed.

Figure 2 where the participants' production accuracy rates (on the y-axis) are plotted against their perception accuracy rates (on the x-axis) also verifies the above finding.

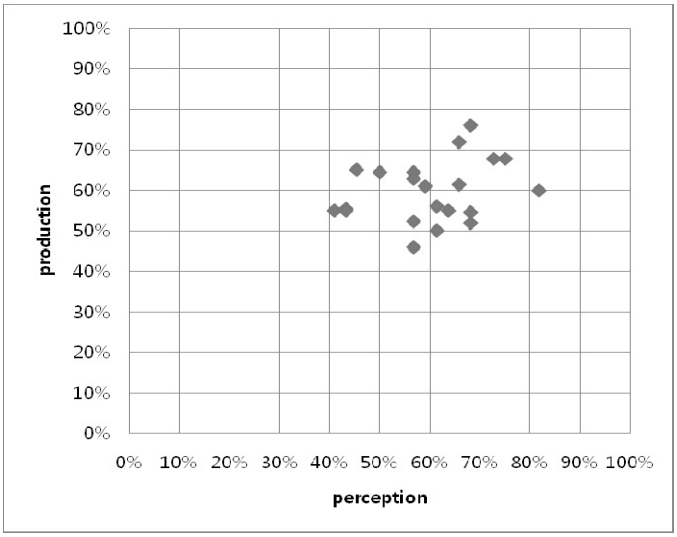

Figure 2. Accuracy rates for production plotted against rates for perception

In Figure 2 each data point represents a single participant and the participants vary in their ability to perceive and produce the target English vowels. When we compare the participants' perception abilities with production abilities, perception accuracy rates are not always systematically higher than production accuracy rates, thus ruling out the precedence of perception over production. Rather, there are data points which show various participants who are good at both perception and production (e.g., perception: 66% vs. production: 72%), poor at both (e.g., perception: 57% vs. production: 52%), good at perception but not production (e.g., perception: 82% vs. production: 60%), and good at production but not perception (e.g., perception: 45% vs. production: 65%) given that the mean accuracy rates of perception and production were around 60%.[7] If the production skill requires the development of the perception skill, we would not expect there to be the participants who are good at production but not perception. Therefore, the distribution of the participants' perception accuracy and production accuracy provides more evidence that neither the correlation between perception and

[7] For convenience sake, we assume that accuracy rates above the mean (60%) are good, which would be "fair" in terms of English proficiency.

production nor the precedence relation of perception over production is borne out. Therefore, it is possible to conclude that perception and production capabilities involving different faculties of speech may not be developing in parallel but may be acquired independently.

4.2 Perception

Although the mean proportion of correct perception for the target English vowels was around 60%, the correct percentages of individual vowel perception ranged from 31% to 89%. Table 6 summarizes the mean percentage (%) of vowel identification with confusion matrixes.

Table 6. Confusion matrix for Korean perception of English vowels (Correct responses are shaded and modal responses are in boldface.)

Responses in IPA	English vowels										
	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ
i	**61**	23	21								
ɪ	36	**64**	10								
eɪ			**66**								
ɛ				31	23						
æ				**65**	**74**						
ɑ						**89**					17
ɔ							**43**	14			19
oʊ							24	**76**			
u									43	29	
ʊ									**56**	**61**	
ʌ							26				**54**

(Percentages less than 10% are not shown.)

Identification accuracies were lowest for the vowels [ɛ, ɔ, u, ʌ] ranging from 31% to 54% while the accuracies were highest for the vowels [æ, oʊ, ɑ] ranging from 74% to 89%. The vowels [i, ʊ, ɪ, eɪ] were in between ranging from 61% to 66%. Although the modal responses were mostly correct responses, the modal response to [ɛ] is 65% of the responses as [æ] and modal response to [u] is 56% of the responses as [ʊ].

As for error patterns, the participants tended to misperceive [i] as [ɪ] 36% of the time while [ɪ] as [i] 23% of the time. Similarly, [u] was misheard as [ʊ] 56% of the time whereas [ʊ] was misheard as [u] 29% of the time. Because Korean vowels have no contrast between tense and lax pairs, the Korean EFL learners must learn the ability to differentially identify the tense vowels from the lax vowels and vice versa. Hence, one of the most difficult contrasts would be the tense/lax distinction (i.e. [i] vs. [ɪ], [u] vs. [ʊ]).

Also, Korean listeners seem to have more difficulty identifying monophthongs such as [ɛ] and [ɔ] than diphthongs such as [eɪ] and [oʊ].

While [oʊ] was misidentified as [ɔ] 14% of the time, [ɔ] was misidentified as [oʊ] 24% of the time and as [ʌ] 26% of the time. Unlike the pair [oʊ] and [ɔ], however, the pair [eɪ] and [ɛ] does not show bi-directional confusability.[8] Rather, [eɪ] was misperceived as [i] in 21% of the cases and as [ɪ] in 10% of the cases, thus showing uni-directional confusion of [eɪ] as [i] or [ɪ].[9] By contrast, [ɛ] was not misperceived as [eɪ] but as [æ] in 65% of the cases. The bi-directional confusion between English [ɛ] and [æ] (i.e. [ɛ] is misheard as [æ] and [æ] is misheard as [ɛ]) is frequently reported in L2 acquisition literature (Flege et al. 1997, Escudero et al. 2012, among others).

The difference between [ɛ] and [æ] other than the feature [high] is duration. According to Hillenbrand et al. (1995: 3103), in American English [ɛ] and [æ] are clearly distinguished with respect to duration in that the duration of [ɛ] (189 ms on average for 45 men) is short in relation to that of [æ] (278 ms for the same speakers). Also, American English makes a clear duration difference between [ʌ] and [ɑ] ([ʌ]: 188 ms vs. [ɑ]: 267 ms for the same speakers). Consequently, [ɛ] whose longer counterpart is [æ] and [ʌ] whose longer counterpart is [ɑ] can be grouped together as short. Interestingly, short vowel [ʌ] was confused with [ɑ] in 17% of instances and as [ɔ] in 19% of instances, whereas [ɑ] was not confused with [ʌ]. Further, bi-directional confusion for [ɔ] and [ʌ] was attested, given that [ɔ] was misperceived as [ʌ] in 26% of instances and [ʌ] as [ɔ] in 19% of instances.

Not many scholars have been reported the uni-directional confusion of [ʌ] with [ɑ] in perception (i.e. [ʌ] is misheard as [ɑ] but [ɑ] is not misheard as [ʌ]). To name but a few, Flege (1995) reports that Korean speakers had difficulty differentiating the /ɑ-ʌ/ contrast in the perception of 14 American English vowels. Tsukada et al. (2005: 275) also observe that both native English children and Korean children obtained low discrimination scores for the pair [ɑ] and [ʌ]. In addition, Hong (2012: 509) predicts that Korean speakers may have difficulty perceiving non-high monophthongs [ɑ], [ʌ] and [ɔ]. Importantly, however, they did not mention the direction of the confusability between [ʌ] and [ɑ].

To summarize the error patterns in perception, 5 bi-directional confusion patterns were found: [i] and [ɪ], [u] and [ʊ], [æ] and [ɛ], [oʊ] and [ɔ], [ɔ] and [ʌ]. Also, 2 uni-directional confusion were detected; the participants misheard [eɪ] and [ʌ] as [i]/[ɪ] and [ɑ], respectively, but not the reverse.

The pairs mentioned (i.e. [i] vs. [ɪ], [u] vs. [ʊ], [eɪ] vs. [ɛ], [oʊ] vs. [ɔ], [æ]

[8] However, Celce-Murcia et al. (1996: 97) claim, "A common source of learner error is for students to confuse the adjacent phonemes /eɪ/ and /ɛ/". This discrepancy may result from language-specific variation or may result from just speculation that is not tested by experiments.

[9] The unexpected uni-directional confusion of [eɪ] as [i] or [ɪ] can be accounted for by a language-independent acoustic factor. According to Cho (2008: 493), F1 and F2 of [eɪ] diverge by a fall of F1 and a rise of F2 so that listeners can easily identify the latter half part of [eɪ] (F1 onset: 550, F1 ending: 400, F2 onset: 2032, F2 ending: 2228) based on mean frequencies of F1 and F2 of [eɪ] in American English reported by Holbrook and Fairbank (1962).

vs. [ɛ], [ɑ] vs. [ʌ]) were submitted to the paired-samples *t*-tests in order to examine whether the perceptual differences between the pairs were significant. The results of the *t*-tests are given in Table 7.

Table 7. T-tests for the perception accuracy of each pair

Pairs of comparison	Mean	S.D.	*t*	df	*p*-value
[i] vs. [ɪ]	-.03571	.33806	-.484	20	.634
[u] vs. [ʊ]	-.17857	.31763	-2.576	20	.018*
[eɪ] vs. [ɛ]	.34525	.40679	3.889	20	.001*
[oʊ] vs. [ɔ]	.33333	.29930	5.104	20	.000*
[æ] vs. [ɛ]	.42857	.46866	4.191	20	.000*
[ɑ] vs. [ʌ]	.35714	.42258	3.873	20	.001*

*$p<.05$

The results of the t-tests showed that the comparisons between all the pairs were significant except the pair [i] and [ɪ]. Thus, the results indicate that the participants had a significant difficulty identifying tense [u] than lax [ʊ] while there were no significant difference in identifying tense [i] and lax [ɪ]. This result is similar to Lee and Lee (2011) in that the perception score of lax [ʊ] was significantly higher than that of tense [u] while the perception scores of tense [i] and lax [ɪ] did not show a significant difference in the perception of English vowels [i, ɪ, u, ʊ].

The participants also showed significant difficulty identifying monophthongs [ɛ] and [ɔ] than diphthongs [eɪ] and [oʊ]. This is understandable given that the duration of diphthongs is longer than that of monophthongs so as to provide more perceptual cues. Likewise, the perception scores of the short vowels [ɛ] and [ʌ] were significantly lower than those of the long vowels [æ] and [ɑ]. This result indicates that one of the factors in perceiving English vowels is the duration of the target vowel. That is, vowels with a short length (or less element) are more difficult to perceive in relation to their counterpart vowels with a long length (or more element).

Although the duration effect was observed in the perception of English vowels, it seemed not to be applied to the tense/lax pairs of high vowels. This is because no significant difference was found between tense [i] and lax [ɪ], and moreover the perception of tense [u] with a relatively long length was significantly lower than lax [ʊ] with a relatively short length. This result may imply that the length difference of the tense/lax pairs of [i, ɪ, u, ʊ] did not override the quality difference so it does not give salient durational cues to the Korean listeners.[10] Hong (2012: 508) also provides a similar

[10] This holds for true considering the average duration of tense/lax pairs of high vowels in Hillenbrand et al. (1995: 3103). While the length difference is relatively small for [i] (243 ms for 45 men) and [ɪ] (192 ms for the same speakers) as well as [u] and [ʊ] (237 ms and 192 ms, respectively, for the same speakers), the length difference between [eɪ] and [ɛ] is

observation that vowel length may not be a crucial cue to distinguish the tense/lax pairs. Further, the result also shows that Korean listeners were not sensitive to the quality difference between the tense/lax pairs, either, given the bi-directional confusion between the tense/lax pairs and the low accuracy rates.

4.3 Production

The mean proportions of correct production for the target English vowels are provided in shaded boxes, as shown in Table 8. Also, confusion matrixes were created for the target vowels.[11]

Table 8. Confusion matrix for Korean production of English vowels (Correct responses are shaded and modal responses are in boldface.)

Responses in IPA	English vowels										
	i	ɪ	eɪ	ɛ	æ	ɑ	ɔ	oʊ	u	ʊ	ʌ
i	**68**	46									
ɪ	27	**50**									
eɪ			**91**								
ɛ				35	29						
æ				**59**	**63**						
ɑ						**81**					11
ɔ						10	**57**	34			**46**
oʊ							34	**59**			
u									**64**	24	
ʊ									26	**56**	
ʌ										13	34

(Percentages less than 10% are not shown.)

English [eɪ] was correctly produced at a rate of 91% and the rate for [ɑ] was 81%. The participants mis-produced [ɑ] as [ɔ] in 10% of the cases.[12] As for

relatively big (267 ms and 189 ms, respectively, for the same speakers).

[11] A reviewer pointed out that the native speakers' assessment of Korean participants' production may be different from the assessment based on acoustic measurements and this may pose a potential problem. This production test, however, focuses on how accurately Korean participants produce English vowels and the production accuracy was based on the native speakers' judgment. From the perspective of the communicative approach to teaching English, the production evaluation by native speakers is as valid as any other evaluation methods. Further, as shown in Appendix B, the production scores had a less broad range of CI than the perception scores (e.g., 0.6274-0.7392 for [i] production vs. 0.4737-0.7406 for [i] perception), thus giving more validness for the native instructors' assessment. Nonetheless, it may be worthwhile to analyze the production data per se acoustically for future research.

[12] The Korean participants mis-produced the target [ɑ] as [ɔ] possibly because the stimulus word *pot* was presented as a written form, and thus causing spelling pronunciation.

the production of the English tense/lax pairs of high vowels, [i] and [ɪ] were produced target-appropriately at a rate of 68% and 50%, respectively. While [i] was mis-produced as [ɪ] in 27% of instances, [ɪ] was misarticulated as [i] in 50% of instances. Production accuracies were 64% for [u] and 56% for [ʊ]. Similar to the confusion pattern of [i] and [ɪ], [u] was mis-produced as [ʊ] 26% of the time whereas [ʊ] was mis-produced as [u] 24% of the time and as [ʌ] 13% of the time. While the accuracy rate was high for diphthong [eɪ] resulting in no prominent confusion pattern, the accuracy rate was low for diphthong [oʊ] only accounting for 59%. The participants mis-produced [oʊ] as [ɔ] in 34% of the cases and [ɔ] as [oʊ] in 34% of the cases. Likewise, the participants produced [ɔ] target-appropriately 57% of the time and misarticulated it as [oʊ] 34% of the time. The confusion for [ɛ] and [æ] occurred in production as well as in perception. Target-appropriate production of [ɛ] amounted to only 35% while target-inappropriate production of [ɛ] as [æ] amounted to 59%, which becomes the modal response. By contrast, target-appropriate production of [æ] amounted to 63% while target-inappropriate articulation of [æ] as [ɛ] amounted to 29%. For the target [ʌ], the accuracy rate only amounted to 34% and the modal response to [ʌ] was [ɔ] (46%), thus causing uni-directional confusion of [ʌ] as [ɔ]. The production of [ʌ] was also confused with [ɑ] in 11% of the cases.

To summarize the error patterns in production, 4 bi-directional confusion patterns were found: [i] and [ɪ], [u] and [ʊ], [æ] and [ɛ], [oʊ] and [ɔ]. Also, 4 uni-directional confusion were detected; the participants mis-produced [ɑ] and [ʊ] as [ɔ] and [ʌ], respectively, but not the reverse. Further, [ʌ] was mis-produced as [ɔ] and [ɑ], respectively, but [ɔ] and [ɑ] were not misarticulated as [ʌ].

The paired-samples *t*-tests were conducted for the same pairs in the perception test and the results are summarized in Table 9.

Table 9. T-tests for the production accuracy of each pair

Pairs of comparison	Mean	S.D.	*t*	df	*p*-value
[i] vs. [ɪ]	.18571	.24194	3.528	20	.002*
[u] vs. [ʊ]	.07857	.11464	3.141	20	.005*
[eɪ] vs. [ɛ]	.56190	.24541	10.498	20	.000*
[oʊ] vs. [ɔ]	.01667	.39823	.192	20	.850
[æ] vs. [ɛ]	.27857	.23957	5.329	20	.000*
[ɑ] vs. [ʌ]	.35714	.42258	3.873	20	.001*

*$p<.05$

The results revealed that the difference between production accuracies of each pair was significant except the pair [oʊ] and [ɔ]. Unlike the perception test, the participants produced tense vowels [i] and [u] more accurately than lax counterparts [ɪ] and [ʊ]. More accurate production of the tense vowels in relation to lax vowels is similar to the result of Flege et al. (1997) in that an

inexperienced Korean with 0.8 year of LOR produced English [i] target-appropriately at a rate of 75% whereas the rate for [ɪ] was 61%. However, an experienced Korean with 7.3 years of LOR showed a reverse pattern because [i] was target-appropriately produced at a rate of 60% while the rate for [ɪ] amounted to 92%. Then, the participants in the current study seem to resemble the inexperienced Korean speaker in Flege et al. (1997). More accurate production of lax vowels than tense vowels is also reported in Lee and Lee (2011) where 4 Korean primary school students produced lax [ɪ] and [ʊ] significantly better than tense [i] and [u].

While the production scores were significantly higher for diphthong [eɪ] than monophthong counterpart [ɛ], there was no significant difference between diphthong [oʊ] and monophthong counterpart [ɔ]. That is, the participants had more difficulty in producing diphthong [oʊ] in relation to [eɪ]. In addition, the participants had significant difficulty producing monophthongs [ɛ] and [ɔ]. The asymmetry in the production of English [eɪ] and [oʊ] is also attested in Cho (2008: 489) where the production scores of [eɪ] by Korean university students was 93.7% while those of [oʊ] was 69.1%.

The participants performed significantly poor in producing [ɛ] and [ʌ] in relation to [æ] and [ɑ], respectively. The poor performance of [ɛ] in production as well as in perception is worth mentioning (31% in perception and 35% in production). The cause for the poor performance of [ɛ] was the replacement of [ɛ] with [æ]. English [ɛ] was substituted with English [æ] in 59% of instances in production and in 66% of instance in perception. According to an acoustic measurement study of Yang (1996: 257), Korean [ɛ] is more similar to English [ɛ] than English [æ]. Then, the substitution of English [ɛ] with English [æ] is unexpected. Rather, it is expected that Korean learners would replace English [æ] with English [ɛ]. This case would be parallel to the case in which Korean learners unexpectedly replaced English [p] with English [f]. In particular, Lee et al. (2002: 457) report that English [p] was hyper-corrected as [f]. Thus, in the process of developing a new category like English [æ] or [f], Korean learners of English may over-generalize the new categories even through replacement errors.

The poor production accuracy of [ʌ] is surprising because English [ʌ] has not been reported as posing a serious problem in L2 literature. This is because [ʌ] is produced "when speech organs are relaxed and in a neutral position (Prator and Robinett 2007: 12)". It is also regarded as being easy to acquire by the native children. According to Edwards (2003: 248), 90% of native children masters [ʌ] at the relatively young age, 2 years. Then, the low production accuracy of [ʌ] may be related to the effect of interlanguage speech intelligibility benefit-listener (ISIB-L: Hayes-Harb et al. 2008) in that the Korean participants' non-native speech of [ʌ] was more confusing to native listeners than to non-native listeners. Since ISIB-L is beyond the scope of this paper, it needs future research whereby non-native listeners should evaluate Korean participants' non-native speech.

5. Conclusion

The main objective of this study is to investigate the relationship between perception and production of English vowels by Korean EFL learners. The results revealed that neither the precedence relationship of perception over production nor a significant correlation between perception and production were found. This is of theoretical importance because this finding runs counter to the traditional assumption that good perception is a prerequisite to good production. The results also did not support the previous studies like Flege et al. (1997). in which the accuracies of nonnative participants' perception and production are related, thus suggesting that perception in the auditory faculty is not on a par with production in the motoric/articulatory faculty, and accordingly perception and production may be developing independently. Further, the results showed that the acquisition path varies depending on vowels (e.g., Figure 1) and individuals (e.g., Figure 2).

The results of the perception test showed that the participants' perceptual ability was rather poor because the accuracy rates of the target vowels were just above the chance level or below the chance level except [æ, oʊ, ɑ]. One of the factors in perceiving English vowels is the duration of the target vowel because vowels with a short length (or less element) are more difficult to perceive in relation to their counterpart vowels with a long length (or more element). Similar to results of the perception test, the participants' production ability was poor except [eɪ, ɑ] in the production test. The participants produced tense vowel better than lax vowels. Also, an asymmetry that the participants' production of [oʊ] was worse than their production of [eɪ] was found.

Concerning confusion patterns, the students showed bi-directional confusions between [i] and [ɪ], [u] and [ʊ], [æ] and [ɛ], and [oʊ] and [ɔ] both in perception and production. The pair [ʌ] and [ɔ] showed a bi-directional confusion in perception, but a uni-directional confusion ([ʌ] was mis-produced as [ɔ] but not the reverse) in production. Further uni-directional confusions were attested; the confusion of [ʌ] with [ɑ] but not the reverse occurred both in perception and production. The uni-directional confusion of [eɪ] with [i]/[ɪ] was attested in perception while the uni-directional confusions of [ɑ] with [ɔ] and [ʊ] with [ʌ] were attested in production.

Appendix A

설문지 (Questionnaire)

이름(Name): _____

생년월일(Date of Birth): 년 월 일 (만 세) 성별(Sex): _____

학번(ID number): _____

전공(Major/Minor): _____
(복수전공이나 부전공을 할 경우 그 전공도 기재해주세요.)

출신고교(Name of the high school attended): _____

출신고교 소재지(Location of the high school): _____

1) 본인이 생각하는 영어 능숙도는 어느 정도인지 아래의 보기에 표시해 주세요(Self-evaluate English proficiency).

상(High) / 중상(High-intermediate) / 중(Intermediate) / 중하(Low-intermediate) / 하(Low)

2) TOEIC, TOEFL, TEPS 등의 공인영어성적이 있는 경우 기재해 주세요(Provide the scores of TOEIC, TOEFL, TEPS and etc., if you have one).

TOEIC: _____ 점 TOEFL: _____ 점 TEPS: _____ 점

기타: _____점

3) 발음훈련 또는 음성학적 훈련을 받은 경험이 있습니까(Have you ever had English pronunciation training and/or phonetic training)?

네(Yes) / 아니오(No)

4) 영어권 국가에서 1년 이상 해외 거주 경험이 있습니까(Have you ever lived in English-speaking countries for more than one year)?

네(Yes) / 아니오(No)

있다면 어느 국가에서 몇 년/몇 개월/몇 일 거주했는지 정확히 기입해 주십시오(If you have, how long?).

_____ 년 _____ 개월 _____ 일

Appendix B

	S.D.	Confidence	Mean	Confidence Interval	
				Lower	Upper
[i] perception	0.3120	0.1334	0.6071	0.4737	0.7406
[i] production	0.1307	0.0559	0.6833	0.6274	0.7392
[ɪ] perception	0.3314	0.1417	0.6429	0.5011	0.7846
[ɪ] production	0.1743	0.0745	0.4976	0.4231	0.5722
[eɪ] perception	0.2792	0.1194	0.6548	0.5353	0.7742
[eɪ] production	0.1955	0.0836	0.9119	0.8283	0.9955
[ɛ] perception	0.3250	0.1390	0.3095	0.1705	0.4485
[ɛ] production	0.1423	0.0609	0.3500	0.2891	0.4109
[æ] perception	0.2792	0.1194	0.7381	0.6187	0.8575
[æ] perception	0.1393	0.0596	0.6286	0.5690	0.6881
[ɑ] perception	0.1866	0.0798	0.8929	0.8130	0.9727
[ɑ] production	0.1516	0.0648	0.8048	0.7399	0.8696
[ɔ] perception	0.3076	0.1316	0.4286	0.2970	0.5601
[ɔ] production	0.2427	0.1038	0.5714	0.4676	0.6752
[oʊ] perception	0.2678	0.1145	0.7619	0.6474	0.8765
[oʊ] production	0.2318	0.0991	0.5881	0.4890	0.6872
[u] perception	0.2390	0.1022	0.4286	0.3263	0.5308
[u] production	0.1433	0.0613	0.6357	0.5744	0.6970
[ʊ] perception	0.3672	0.1570	0.6071	0.4501	0.7642
[ʊ] production	0.1607	0.0687	0.5571	0.4884	0.6259
[ʌ] perception	0.4053	0.1734	0.5357	0.3624	0.7091
[ʌ] production	0.2440	0.1044	0.3357	0.2314	0.4401

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