An acoustic Analysis of English Vowels produced by Korean University Students

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Hwang, Injah. (2015). An acoustic Analysis of English Vowels produced by Korean University Students. *The Linguistic Association of Korea Journal, 23*(1), 65-90. This paper investigated Korean university students' production of English /ɪ/, /ɛ/, /æ/, /ʌ/, and /ɔ/ vowels in minimal pair settings of /ɪ/ & /ɛ/, /ɛ/ & /æ/, and /ʌ/ & /ɔ/. Thirty female freshmen (15 higher- and 15 lower-proficiency group) were recruited and their production was analyzed in terms of acoustic values such as F1, F2, and duration. The results indicated that both groups differentiated the vowel contrast between /ɪ/ and /ɛ/, but they did not produce the vowel /ɪ/ accurately. Also, most of the participants had a great difficulty differentiating between /ɛ/ & /æ/, and /ʌ/ & /ɔ/ in terms of F1 and F2 values although higher-proficiency group outperformed lower-proficiency group. In particular, all of the subjects had the most difficulty producing /ɔ/ accurately. As for duration, the length of /æ/ and /ɔ/ vowels produced by both groups was much shorter compared to native norms whereas the duration of /ɪ/, /ɛ/ and /ʌ/ vowels was similar to native talkers.

Key Words: L2 phonological acquisition, L1 transfer, acoustic analysis

1. Introduction

There has been a lot of research on second language/foreign language (hereafter L2) phonological acquisition and it has been widely accepted that a great number of ESL/EFL learners have difficulty in correctly acquiring English sound categories. Many factors related to this matter are reported such as native language (hereafter L1) transfer (Weinreich, 1953; Flege & Hillenbrand, 1984; Munro, & Bohn 2007), age of L2 acquisition (Lenneberg, 1967; Oyama, 1979;

Scovel, 1988; Bronstein, 1989; Flege, Yeni-Komshian, and Liu, 1999), extent of L1 and L2 use (Flege, Frieda, & Nozawa 1997; Moyer, 2004), L2 learning environment (Flege & Liu, 2001) and so on.

Ausubel (1963) asserted that all learning involves some type of transfer and there should be necessary conditions needed for transfer to occur. With regard to L1 transfer in L2 acquisition, Trubetzkoy (1939/1958) claimed, requoted by Major (2008), that the "sieve" of the L1 "filters" one's perception in an L2. In the 1960s, Contrastive Analysis (hereafter CA) on L2 acquisition is the most dominant in language teaching. Based on CA, it was believed that predicted all L2 errors can be explained within L1 transfer. After some criticism of CA in that a lot of L2 learners did not make the anticipated errors, the weak version of CA was introduced. Oller and Ziahosseiny (1970) contended that similar patterns in L1 and L2 lead to more difficulty than dissimilar patterns. In spite of the weak version, CA lost its popularity of the peak period, and later it was considered one of interlanguage factors by Selinker (1972).

In L2 phonology, L1 transfer was described with a variety of types of sound transfer such as sound substitution, under- differentiation, over-differentiation, reinterpretation of distinctions, phonotactic interference, and prosodic interference (Weinreich, 1953; Haugen, 1956). Sound substitution takes place when L2 learners use the closest L1 equivalent in the L2. For example, native French speakers tend to use /ʒ/ for English /ð/ (Swan & Smith, 2001) because the system of consonants in French does not have /ð/. In case of underdifferentiation, it occurs when the L2 has more phonemic categories than the L1. L1 French does not have distinctions between /ɪ/ and /i/ since these two sounds are allophones in French. However, /ɪ/ and /i/ are separate phonemes in English, so native French speakers are inclined to use /i/ for both /ɪ/ and /i/ in English. As for overdifferentiation, there are distinctive phonemes in the L1 while the L2 does not have this distinction as it is also applied in /d/ and /ð/ in L1 English/L2 Spanish. The German language does not have English tense/lax distinctions and German speakers interpret these tense/lax distinctions as long and short distinctions. This phenomenon is called reinterpretation of distinctions. Phonotactic interference is a type of strategy which is used for changing the syllable structure in the L2 in order to conform to the L1 syllable structure. For instance, L1 Korean learners tend to insert the vowel /ɨ/ when

they produce L2 English consonant clusters since Korean does not allow consonant clusters in either onsets or codas. Thus, they produce 'pretty' /pɨ.rɪ.ti/ instead of 'pretty /prɪ.ti/'. When L1 and L2 do not share the same intonation system, prosodic interference occurs. For example, L1 English speakers produces falling intonation in utterance final words when they speak Mandarin, regardless of the tone in Mandarin.

In connection with L1 transfer in L2 phonology, Flege probably has done more research than any other researcher. He proposed Speech Learning Model (hereafter, SLM, 1992, 1995); this SLM classifies L2 sounds based on their similarity to sounds in L1. According to this model, 'identical' sounds do not cause learning problems. However, it was claimed that 'similar' sounds are hard to learn. In SLM, similar sounds are close to each other between an L1 and an L2 but they are slightly different from a phonetic/acoustic perspective. The L2 speakers accept similar sounds as equivalent to those in the L1, while 'new' sounds are easier to learn because there are definite authentic differences between the native language and the target language. For example, Flege (1987) proved that the French /y/ is more successfully articulated by English speakers because this vowel is 'new' or 'dissimilar' sound to native speakers of English, whereas French /u/, which is similar to English /u/ phone, is not produced with distinction by native speakers of English. Specifically, Flege (1995, 2009) contended that phonological systems of L1 filter out L2 specific phones and hence these phones are not well-categorized in L2 speakers' inventory. Further, this inadequate perception impedes the production of accurate L2 sounds. Perceptual Assimilation Model (Best et al., 1995, 1997, 2007) also supported Flege's SLM in that similar L2 sounds are more interrelated with L1 sounds and they are categorized as L1 sounds while dissimilar sounds are categorized as instances of L2 sounds.

In addition to L1 transfer, age of L2 acquisition is another important factor as to L2 phonological acquisition. Usually, age factor is recognized with Lenneberg's Critical Period Hypothesis (hereafter CPH 1967). It is said that L2 foreign accent is closely related to brain plasticity during sensitive or critical period. In support of CPH, 60 Italian-born immigrants to the US, whose ages of arrival are varied, were studied. The results showed that late L1 Italian immigrants produced heavier foreign accent than early L1 Italian immigrants

and that length of residence was not a strong indicator of foreign accent (Oyama, 1976). Scovel (1988) also asserted that it is not easy for L2 learners after the age of 12 to acquire L2 sounds without an accent due to lack of "plasticity" in their brain. There is another experiment related to CPH. The English production of 240 L1 Korean immigrants' to U.S. was rated by English native-speaking judges. The participants were varied according to ages of arrival and the findings revealed that the degrees of accent are extremely dependent on ages of arrival (Flege, Yeni-Komshian, and Liu, 1999).

Extent of L1 and L2 use (Flege, Frieda, & Nozawa, 1997; Moyer, 2004), in addition to L1 transfer and age of L2 acquisition, is also an important element with regard to L2 phonological acquisition. According to the research by Flege, Frieda, and Nozawa among L1 Italian immigrants to Canada, those who spoke Italian more frequently had a stronger foreign accent in English than those who spoke Italian less frequently. Also, Moyer (2004) studied 25 immigrants from the US, Britain, France, Russia, Poland, Slovakia, and Turkey to Berlin, whose L2 German proficiency was an advanced level but their lengths of stay and ages of arrival were varied. One of his suggestions was that the L2 learners utilize available linguistic resources very effectively and consistently, which might be a deciding factor in constraints on phonological attainment. Moyer asserted that the subjects' level of German proficiency is heavily correlated with the interactions to native speakers of German.

Also, as for L2 learning environment (Flege & Liu, 2001), another interesting findings were drawn. In order to assess L2 learning input, Flege and Liu investigated adult Chinese immigrants living in the US. The results suggested if these adult Chinese immigrants receive a considerable amount of L2 input, their performance in the L2 may improve measurably over time regardless of their lengths of residence (2001).

As for Korean learners' acquisition of English vowel sound categories, Yun (2005) presented some interesting suggestions. With respect to L1 transfer, he reported that Korean learners' experience with the English language did not have a lot of influences on the acquisition of English front vowels. He experimented the perception of English front vowels by using synthesized English /i-ɪ/ (beat-bit) and /ɪ-ɛ/ (bit-bet) continua. There were three groups; native English speakers as a control group, an experienced group whose mean

length of residence is from 6 to 13 years in the US as one experimental group, and an inexperienced group whose mean length of residence is from 1 month to 12 months as another experimental group. The results revealed that both experienced and inexperienced Korean subjects used vowel durational cues when they identified the /i-ɪ/ continuum while the native English control group depended more on vowel spectral cues. However, unlike the /i-ɪ/ continuum, both groups of Korean subjects relied on spectral cues when identifying /ɛ/ in the /ɪ-ɛ/ continuum. Yun asserted that the existence of the vowel /ɛ/ in Korean contributed to the categorization of English /ɛ/. Lee (2009) also presented similar findings on the acquisition of English high tense and lax vowels (/i, ɪ, u, ʊ/) in /hVd/ context by Korean learners in the US. She claimed that unlike native English speakers Korean speakers heavily relied on vowel durational cues when they discriminated synthesized English high tense and lax vowels. The lengths of residence of the Korean subjects were quite varied, which is from 10 months to 5 years in the US.

There is another study on Korean learners' acquisition of English vowel sounds with respect to L1 sound transfer. Kim (2010) investigated perception and production of English front vowels by Korean speakers with the concept of "reinterpretation of distinction" and "under-differentiation." In this experiment, Korean speakers discriminate /i/ and /ɪ/ relatively well while many of the subjects were not able to discriminate /ɛ/ and /æ/. She contended that Korean speakers reinterpreted the distinction between /i/ and /ɪ/ by duration as in Korean instead of other acoustic features such as degrees of height, fronting or rounding. Also, she concluded that Korean speakers have trouble producing /i/ and /ɪ/ distinctively as well as /ɛ/ and /æ/ because they under-differentiated English front vowels.

A lot of research examined above, especially studies on the acquisition of English vowels by Korean learners indicated that Korean learners' perception or/and production of English vowels was not the same as that of native English speakers due to the influence of Korean speakers' L1 phonological system. However, most experiments in above studies used synthesized vowel stimuli or words in /hVd/ context rather than frequently used real words. Moreover, most previous studies focused on the acquisition of front vowels or high tense and lax vowel pairs without exploring another problematic vowel pairs like /ʌ/ and

/ɔ/ (Hwang & Lee, 2012). Thus, it would be of great interest to investigate which vowels or vowel contrasts cause the hardest difficulty in producing English vowels or vowel contrasts. Further, most existing studies examined the acquisition of English vowels by ESL immigrants living in the US. Accordingly, it is important to study the production of English vowels by Korean learners of English in the EFL settings. Moreover, whether learners' different English proficiency level has an impact on the production of English vowels will be investigated.

The present study aims to explore the production of English vowels by Korean EFL learners taking into consideration the effect of L1 transfer in L2 vowel production with several perspectives. Research questions are as follows: (1) What is the most plausible reason for causing confusion of English vowel contrasts to Korean EFL learners when they produce the English vowel sounds? Is it a L1 transfer or any other reasons?; (2) What is the most problematic vowel pair to Korean EFL learners when they produce the sounds?; (3) Are Korean students' productions of English vowels influenced by their English proficiency? Namely, do higher-proficiency level learners produce English vowel sounds better than lower-proficiency level students?; (4) What kind of pedagogical implications can be drawn based on the results of the study?

2. Experiment

The present study investigates the production of the following English vowel contrasts in minimal pair settings of /ɪ/ vs. /ɛ/, /ɛ/ vs. /æ/, and /ʌ/ vs /ɔ/, which pose to challenge to Korean university students. First, the Korean phonemic inventory does not have English /ɪ/ and there have not been many experiments on the distinction between /ɪ/ and /ɛ/ while /i/ and /ɪ/ pair has been studied more frequently. Secondly, the pair /ɛ/ and /æ/ in Korean has been neutralized and the merger is prevailed especially in Korean younger generations. The impact of this merger was found to influence the production and perception of the matching English vowels by Korean speakers of English (Flege et. al., 1997). Moreover, the vowel /ɔ/ in English cause acquisition difficulty for Korean learners since Korean does not have /ɔ/ in their vowel

inventory (Nilsen & Nilsen, 1973). Thus, it is meaningful to examine which vowels or vowel contrasts cause the most difficulty to the Korean learners of English relative to other vowels or vowel contrasts.

2.1. Participants

Thirty female university students at two different levels of English proficiency (15 in the higher and lower proficiency group each) were selected for the experiment. Three different majors (English, Fashion Design, and Broadcasting) attending the same women's university in Seoul participated in the study. There were 25, 28, and 23 students in each class. Their age is between 19 and 21 and all participants are taking the Freshman English I class, which is a required course. Their English proficiency level was evaluated on the basis of the listening comprehension and speaking test from the textbook of Freshman English I. 40 listening comprehension questions were excerpted from the textbook with a maximum score of 40 points and one speaking passage was chosen from the same book with a maximum score of 10 points. The listening test questions in the textbook were very similar to the official TOEIC test, whereas the speaking test consisted of reading diverse passages. Based on the results of the listening and speaking performance, the higher five students from each major were categorized as a higher-proficiency group and the lower five students were classified as a lower-proficiency group.[1)] Out of 40 points in the listening comprehension test, 36.67 was the average score of the higher group and 24.8 was the average score of the lower-level students. The mean score of the speaking fluency test for the higher group was 8.93, whereas it was 4.87 for the lower group. The *t*-test using SPSS 12.0 indicated that the mean difference between the two groups was significant ($t(28)=15.744$, $p<.001$).

All of the participants began to learn English as one of the elementary school courses at the age of 9. This regular school course lasted 10 years on average throughout the secondary school. Even though English was introduced as a preschool course to some participants, the effect was very marginal based on the students' self-check questionnaire. Moreover, none of them had lived in an

1) The thirty subjects in this research are the same as those who participated in the study conducted by Hwang & Lee (2012).

English speaking country more than six months. Clearly, all thirty students did not show any evidence of speech disorder or a current respiratory infection.

2.2. Speech Materials and Procedures

In order to investigate the production of English /ɪ/ & /ɛ/, /ɛ/ & /æ/, and /ʌ/ & /ɔ/ contrasts, six minimal pairs for each pair, all real one-syllable words, were selected in which only the vowels were different. The stimuli were excerpted from the book *Pronunciation Contrasts in English* (Nilsen & Nilsen, 1973). Care was taken to select basic English words that were likely to be familiar to all of the participants. Meanwhile, in order to verify any correlation between participants' production accuracy and their familiarity with the words, a word familiarity test was also conducted right after the production test. Students were asked to mark from 1 to 5 scale on the familiarity test sheet; 1 is the least familiar and 5 is the most familiar. The total average score of all 30 students was 3.7, which indicates that most participants assessed that most of the target stimuli in the production were quite familiar to them. Table 1 lists all thirty six stimuli used in the experiment. The produced vowels were embedded in a CVC word, where the preceding and following consonants' places of articulation spread from bilabial to glottal sounds, and the manners of articulation also ranged from stop to liquid consonants.

Table 1. The words used in the production experiment

/ɪ/ & /ɛ/		/ɛ/ & /æ/		/ʌ/ & /ɔ/	
hid	head	said	sad	dub	daub
pick	peck	peck	pack	sung	song
big	beg	leg	lag	tuck	talk
him	hem	hem	ham	flood	flawed
pin	pen	ten	tan	sun	sawn
bit	bet	pet	pat	cut	caught

In an actual production procedure, in order for subjects not to figure out which target materials are tested, all the minimal pairs were randomly mixed. The stimuli in the production test were offered with a written form in which each target word was printed within a carrier sentence "I say _____, again.

Speech recordings were conducted one-on-one in a sound-attenuated room. Before recording, each participant was given 3 minutes to look through 36 stimuli in the production test sheet in order to produce each sentence smoothly without any hesitation. The participants were given some time to practice several sample words before recording the target stimuli. When some of the participants asked about less familiar words, brief explanations were given by using other words including identical vowel sounds. Thus, there was no direct demonstration of the stimuli themselves. When in an actual recording, the participants were asked to read each sentence twice at a normal speed. Their production was recorded to a note-book computer using Audacity 2.0 version and a microphone (INTEGRATE PRO-22Q).

2.3. Measurements and analysis

First of all, participants' sound files were converted to MP3 files in order to be analyzed using Praat (version v5. 3.56) since the participants' production was recorded by using Audacity program as mentioned above. In order to judge acoustic values, the first and second formant frequencies (in Hz) of each subject's were measured from the vowel tokens in the 2160 words (30 participants x 6 target vowels x 6 words x 2 times). The formant values were both automatically computed by a spectral analysis tool and visually verified using waveform and spectrogram displays. Also, phonetically well-trained researchers double-checked formant values by listening to and comparing the spectrograms of all the tokens. As described earlier, the target vowels were produced in diverse phonetic contexts, so the token vowels were examined at their acoustic midpoint during steady state in order to minimize the effect of the differing consonantal contexts.

It is said that gender-related difference in vocal tract size can affect the formant frequencies of vowels (Peterson & Barney, 1952). Thus, acoustic values of native criteria are also from female American English speakers in the US taken from Hillenbrand et al.'s experiment (1995). This might be more appropriate comparison between two experimental groups and the existing standard group.

With regard to duration (in ms.) measurements, far fewer tokens were

measured for two reasons. First, recorded tokens with nasal codas were excluded since it is hard to demarcate the border between the vowel and the coda. Second, tokens with voiceless codas were not included because all comparative native criteria tokens end with voiced codas, i.e. "hid" for /ɪ/ phoneme, "head" for /ɛ/, "had" for/æ/, "hud" for /ʌ/ and "hawed" for /ɔ/ were used (Hillenbrand et al., 1995). It has been reported that there is a distinctive vowel duration difference on the following consonants' voicing quality. Thus, 720 tokens (30 participants x 6 target vowels x 2 words x 2 times) were selected and waveforms and spectrograms of the tokens were checked in the same manner as F1 and F2 values. In order to estimate duration as accurate as possible, normal conservative method was used, that is, vowel duration was measured from the second positive peak to the end of vowel formant with the aid of pitch signals and formant tracking.

3. Results

F1 and F2 values of three pairs of vowel contrast produced by thirty Korean subjects will be described respectively and then vowel duration of three pairs of vowels will be reported. Both formant frequency values and vowel duration will be compared to native criteria values, which were taken from the Hillenbrand et al.' experiment (1995). Table 2 shows native criteria values.

Table 2. Average values of F1, F2 and durations produced by 48 American female talkers. Formant frequencies are in Hz; duration measurements are in ms; standard deviation in parenthesis.

Vowel type	/ɪ/	/ɛ/	/æ/	/ʌ/	/ɔ/
F1	483 (34)	731 (74)	669 (69)	753 (58)	781 (75)
F2	2365 (149)	2058 (143)	2349 (159)	1426 (115)	1136 (129)
Duration	237 (53)	254 (54)	332 (50)	226 (48)	353 (48)

3.1. Formant Frequencies

3.1.1. /ɪ/ & /ɛ/

The mean F1 and F2 measurements of English /ɪ/ and /ɛ/[2] produced by 15

higher- and lower-proficiency level students are represented on the F1-F2 vowel space in Figure 1 and 2. The graph in Figure 1 shows F1 and F2 average values produced by 15 higher-proficiency level students.

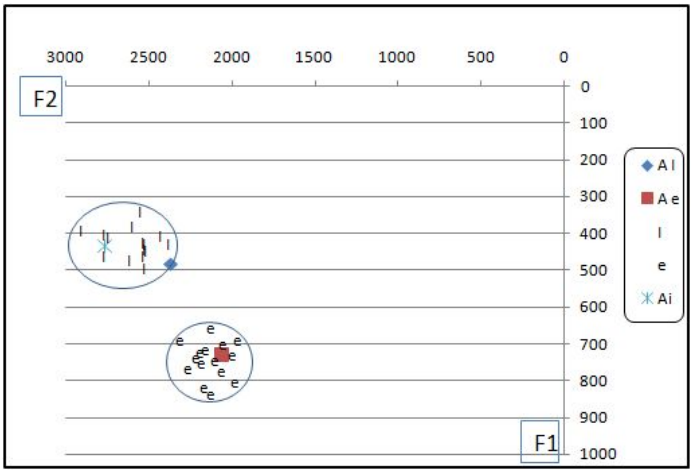

Figure 1. Average values of /ɪ/ & /ɛ/ F1 and F2 produced by 15 higher-proficiency level subjects. "AI" = native talkers'/ɪ/, "Ae"= native talkers'/ɛ/, "I" = /ɪ/, "e" = /ɛ/ and "Ai"= native talkers'/i/.

As shown in Figure 1, higher-proficiency level students were able to produce /ɪ/ & /ɛ/ sounds distinctively. Two separate circle areas of production /ɪ/ and /ɛ/ by 15 higher-proficiency talkers were placed in the graph with a clear contrast. It is obvious that 15 higher-proficiency subjects were not confused when they pronounced English /ɪ/ and /ɛ/ vowels. However, their F1-F2 vowel space of the production of /ɪ/ was well overlapped with the F1-F2 vowel space of native /i/ criteria rather than /ɪ/.

Table 3. Average values of F1 and F2 measurement of English /ɪ/ produced by 15 higher-proficiency group (KH) and lower-proficiency group (KL). Average values of F1, F2 measurement of English /i/ and /ɪ/ by 48 American female talkers (AE) (Unit; Hz); standard deviation in parenthesis

	/i/		/ɪ/	
	F1	F2	F1	F2
KH	n.a.	n.a.	426 (39)	2598 (142)
KL	n.a.	n.a.	442 (49)	2697 (141)
AE	437(41)	2761 (149)	483 (34)	2365 (149)

2) Each individual's average mean values were shown in appendix (A)

Specifically, as represented in Table 3, formant differences between natives' /ɪ/ and Korean higher-proficiency /ɪ/ were 57 Hz in F1 and 233 Hz in F2, while 11 Hz in F1 and 163 Hz in F2 between natives' /i/ and Korean higher-proficiency /ɪ/. Thus, it seems that the production /ɪ/ by Korean subjects is much similar to English /i/ rather than English /ɪ/ with a F1 and F2 value perspective. In other words, Korean higher-proficiency speakers produced English /ɪ/ with the tongue placed in a higher and more frontal place, which is closer to English /i/.

Figure 2 also reveals similar findings. Lower-proficiency level students could produce /ɪ/ & /ɛ/ sounds distinctively, too. However, their /ɪ/ productions were much more superimposed on natives' /i/ compared with higher-proficiency level students. In addition, with larger circle area of F1-F2 vowel space of /ɛ/, their production of /ɛ/ was far more wide-spreading than higher-proficiency level students.

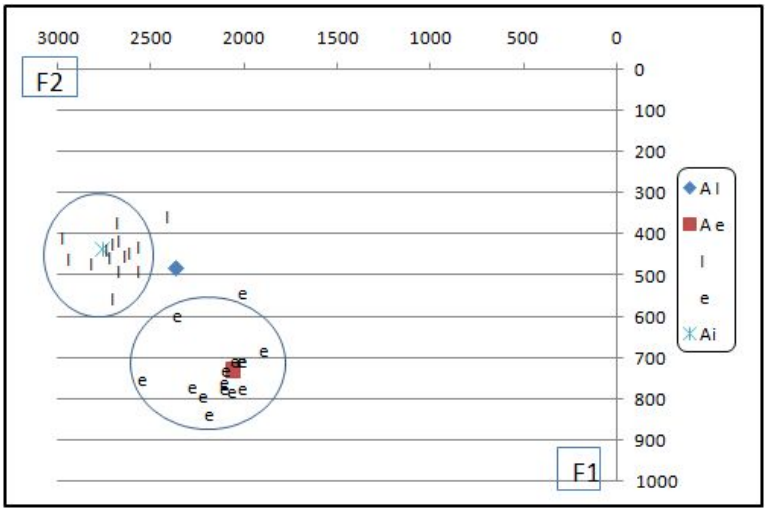

Figure 2. Average values of /ɪ/ & /ɛ/ F1 and F2 produced by 15 lower-proficiency level subjects. "AI" = native talkers' /ɪ/, "Ae"= native talkers'/ɛ/, "I" = /ɪ/, "e" = /ɛ/ and "Ai"= native talkers' /i/.

In summary, both higher- and lower-proficiency groups did not have any difficulty differentiating the vowel contrast between /ɪ/ and /ɛ/, but both groups did not produce the sound /ɪ/ accurately. They pronounced /ɪ/ in a

more frontal and higher position than natives did. In other words, Korean speakers tend to produce English /i/ sound when they try to pronounce English /ɪ/ since the acoustic values of F1 and F2 by both higher- and lower-proficiency groups were much closer to /i/ rather than /ɪ/.

3.1.2. /ɛ/ & /æ/

The mean F1 and F2 measurements of English /ɛ/ and /æ/[3] produced by 15 higher- and lower-proficiency level learners are represented on the F1-F2 vowel space in Figure 3 and 4.

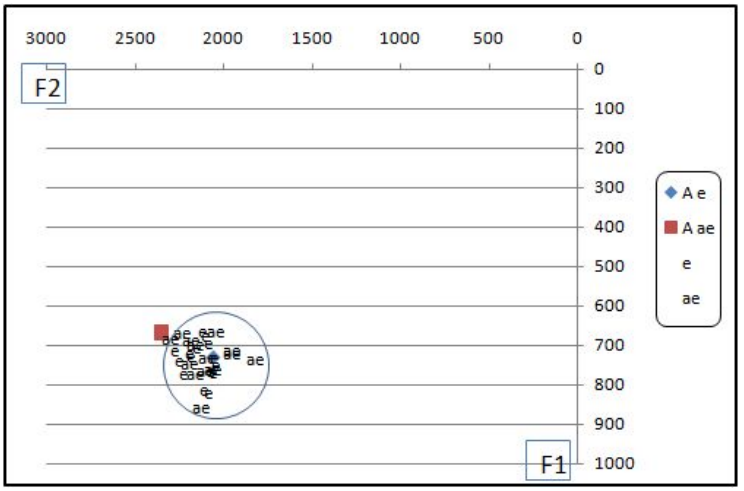

Figure 3. Average values of /ɛ/ & /æ/ F1 and F2 produced by 15 higher-proficiency level subjects. "Ae" = native talkers' /ɛ/, "Aae"= native talkers'/æ/,"e" = /ɛ/", and "ae"= /æ/.

Table 4. Average values of F1 and F2 measurement of English /ɛ/ & /æ/ produced by 15 higher-proficiency group (KH) and lower-proficiency group (KL) and by 48 American female talkers(AE) (Unit; Hz); standard deviation in parenthesis

	/ɛ/		/æ/	
	F1	F2	F1	F2
KH	735 (45)	2126 (76)	728 (49)	2094 (122)
KL	718 (84)	2145 (183)	766 (56)	2061 (145)
AE	731 (74)	2058 (143)	669 (69)	2349 (159)

3) Each individual's average mean values were shown in appendix (A)

The F1-F2 vowel space of the production of /ɛ/ and /æ/ was overlapped unlike native criteria. It indicates that both higher- and lower-proficiency level subjects had a great difficulty differentiating /ɛ/ and /æ/.

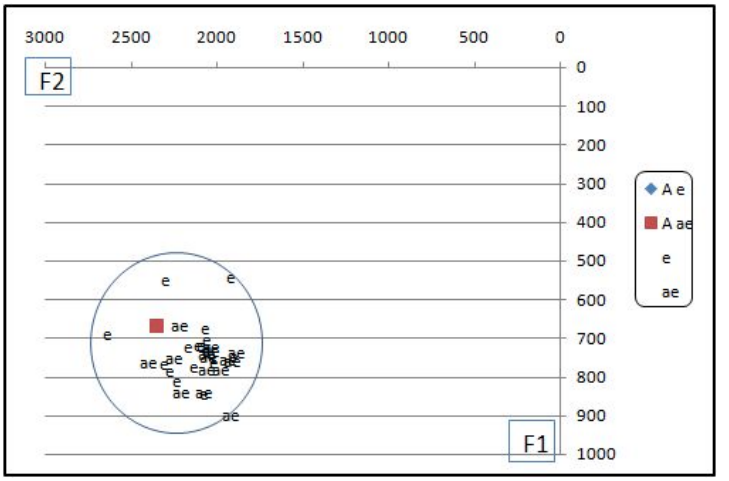

Figure 4. Average values of /ɛ/ & /æ/ F1 and F2 produced by 15 lower-proficiency level subjects. "Ae" = native talkers' /ɛ/, "Aae"= native talkers'/æ/,"e" = /ɛ/", and "ae"= /æ/.

Specifically, as represented in Table 4 above, AE's F2 differences between /ɛ/ and /æ/ is 291 Hz, while KH's was only 32 Hz and KL's was 84 Hz. Thus, it seems that Korean subjects could not recognize different degrees of frontness between English /ɛ/ and /æ/. Unfortunately, AE's /ɛ/ and /æ/ F1 values representing place of highness taken from Hillenbrand et al.'s experiment (1995) are different compared with usually accepted F1 values among phoneticians. Unlike Hillenbrand et al.'s results, it has been reported that /ɛ/ is usually produced in a higher place than /æ/, so the author avoids mentioning degrees of highness between /ɛ/ and /æ/ in the present study.[4)]

Athough both groups failed to produce English /ɛ/ and /æ/ distinctively, there is a difference between two levels of students. As the graphs reveal in Figure 3 and 4, lower-proficiency subjects' /ɛ/ and /æ/ vowel space occupied larger area. The production circle area of the higher-proficiency level students

4) In Hillenbrand et al.'s experiment, /ɛ/ and /æ/ F1 values of 45 male subjects are normal. Here /ɛ/ was produced in a higher position than /æ/.

was relatively smaller. It means that lower-proficiency group's production of /ɛ/ and /æ/ was more deviant than that of higher-proficiency group's since /ɛ/ and /æ/ production spots of lower-proficiency level subjects were much more wide-spreading. This phenomenon is also proved from the standard deviation digits in Table 4.

It is noticed that the F1 and F2 values of the vowel /æ/ by both groups are similar to those of the vowel /ɛ/ as shown in Table 4. Thus, we can tell most participants had difficulty distinguishing these two separate vowels. Both groups of the subjects seemed to be unaware of different acoustic properties of the vowel /ɛ/ and /æ/. The vowel system of Korean used to have two non-high front vowels: a mid-high /e/ and a mid-low front vowel /ɛ/ (Lee, 2005). Recently, these two vowels have been merged to one intermediate vowel sound and Yang (1996) suggested that this Korean intermediate vowel sound is closer to English /ɛ/. The difficulty of distinguishing English /ɛ/ and /æ/ by Korean talkers may be caused by the phonetic merger of Korean /e/ and /ɛ/ because Korean talkers were unable to find a direct counterpart of English /æ/ in their L1. Further discussion will be followed in the next section.

In sum, in the production of the English vowel /ɛ/ and /æ/ by both higher- and lower-proficiency groups, the F1 and F2 values of those tokens were totally superimposed. The Korean subjects had a great difficulty producing the English vowel /ɛ/ & /æ/ distinctively although there was a level of difference between two groups.

3.1.3. /ʌ/ & /ɔ/

Unlike front vowels of /ɪ/, /ɛ/ and /æ/, /ʌ/ is a central vowel and /ɔ/ is a back vowel and the vertical position of both /ʌ/ and /ɔ/ are the same as mid vowels. The mean F1 and F2 measurements of English /ʌ/ and /ɔ/[5] produced by 15 higher- and lower-proficiency level learners are represented on the F1-F2 vowel space in Figure 5 and 6. Higher-proficiency level subjects as shown in Figure 5 experienced a great difficulty pronouncing /ʌ/ and /ɔ/ distinctively. Their F1-F2 vowel spaces of /ʌ/ and /ɔ/ seemed really mixed even though the circle is smaller compared to the vowel space circle in Figure 6.

5) Each individual's average mean values were shown in appendix (A)

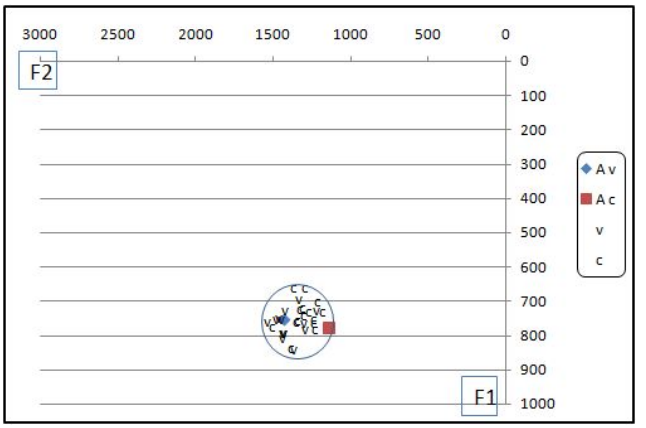

Figure 5. Average values of /ʌ/ & /ɔ/ F1 and F2 produced by 15 higher-proficiency level subjects. "Av" = native talkers' /ʌ/, "Ac"= native talkers'/ɔ/, "v" =/ʌ/, and "c"=/ɔ/.

Figure 6 below reveals that lower-proficiency level subjects also had a great difficulty distinguishing the target vowels of /ʌ/ & /ɔ/ appropriately. Again, the formants were all 'mingled' and a lot of tokens in the F1-F2 vowel circle seemed to be more deviated than higher-level talkers in Figure 5. More specifically, the standard deviation of /ɔ/ formants by lower-proficiency level subjects is almost double comapared to that of higher-proficiency level subjects. This fact proves that lower-proficiency level subjects experienced much more difficulty producing /ɔ/ accurately.

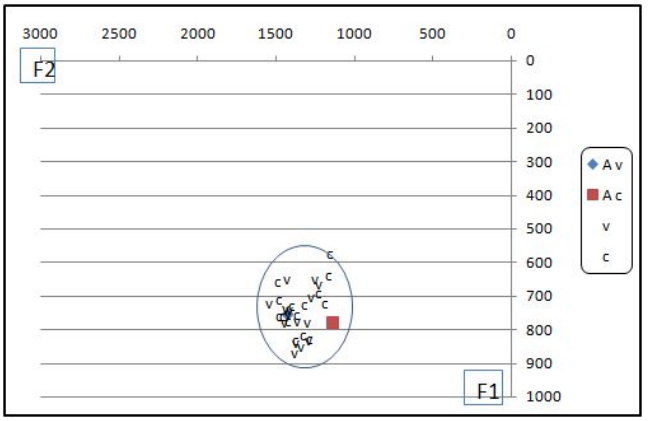

Figure 6. Average values of /ʌ/ & /ɔ/ F1 and F2 produced by 15 lower-proficiency level subjects. "Av" = native talkers' /ʌ/, "Ac"= native talkers'/ɔ/, "v" =/ʌ/, and "c"=/ɔ/.

There is a distinctive frontness difference between /ʌ/ and /ɔ/ since /ʌ/ is a central vowel and /ɔ/ is a back vowel. Thus, as represented in Table 5, F2 value difference between /ʌ/ and /ɔ/ by native speakers is notable 290 Hz. However, Korean higher level group's difference was 98 Hz and lower level group's only 25 Hz represented in Table 5. More specifically, 18 Korean participants produced English /ɔ/ with F2 values of around 1300 Hz[6]. It indicates that a lot of Korean subjects did not recognize correct degrees of frontness in English /ɔ/.

Table 5. Average values of F1 and F2 measurement of English /ʌ/ nd /ɔ/ produced by 15 higher-proficiency group (KH) and lower-proficiency group (KL) and by 48 American female talkers(AE) (Unit; Hz); standard deviation in parenthesis

	/ʌ/		/ɔ/	
	F1	F2	F1	F2
KH	763 (37)	1400 (82)	737 (46)	1302 (81)
KL	754 (71)	1367 (87)	730 (72)	1342 (116)
AE	753 (58)	1426 (115)	781 (75)	1136 (129)

Thus, the results clearly demonstrate that the participants of both groups had a difficulty producing /ɔ/ accurately. Koreans have a mid central vowel /ə/ in the Korean vowel system, which is similar to English /ʌ/, but there is an acoustic difference between them (Swan and Smith, 2001). Also, Korean mid back vowel /o/ is not quite the same as the English /ɔ/ vowel (Swan and Smith, 2001). The difference of the Korean vowels of /ə/ and /o/ have influenced the production of English vowel /ʌ/ and /ɔ/ by Korean subjects. Further discussion will be provided in the next section.

3.2. Vowel Durations

Although most of the research on vowel durations investigates differences between tense-lax contrasts, five English vowels of /ɪ/, /ɛ/, /æ/, /ʌ/ and /ɔ/ examined in the present study are all lax vowels. Still, the comparison of these five lax vowels between L1 and L2 speakers would be meaningful even though vowel durations are very much subject to change depending on individuals and

6) Each individual's average mean values were shown in appendix (A)

speech rates.

Table 6. Average values of durations produced by 15 higher-proficiency level students (KH) and 48 American female talkers (AE) (unit: ms)

	/ɪ/	/ɛ/	/ɛ/	/æ/	/ʌ/	/ɔ/
KH1	176	220	185	187	190	217
KH2	146	193	213	275	227	236
KH3	223	238	280	268	240	249
KH4	196	230	222	241	235	261
KH5	137	273	236	205	253	263
KH6	130	171	179	139	178	206
KH7	164	265	226	242	248	434
KH8	193	231	252	247	267	294
KH9	249	224	248	239	235	238
KH10	211	263	292	276	227	260
KH11	151	185	219	231	198	206
KH12	140	171	226	213	205	250
KH13	215	286	298	303	294	307
KH14	211	234	331	268	244	330
KH15	187	222	234	241	215	216
Average KH	182 (36)	227 (36)	243 (42)	238 (41)	230 (30)	264 (59)
AE	237 (53)	254 (54)	254 (54)	332 (50)	226 (48)	353 (48)

The average vowel durations of English /ɪ/-/ɛ/, /ɛ/-/æ/, and /ʌ/ -/ɔ/ produced by higher- and lower- proficiency level students are represented in Table 6 and 7 and average values of durations produced by 48 American female talkers are also offered in Table 8.

Table 7. Average values of durations produced by 15 lower-proficiency level students (KL) and 48 American female talkers (AE) (unit: ms)

	/ɪ/	/ɛ/	/ɛ/	/æ/	/ʌ/	/ɔ/
KL1	236	267	266	284	288	307
KL2	158	222	193	195	288	213
KL3	180	208	260	227	219	246
KL4	201	199	244	250	223	269
KL5	193	213	223	226	202	203
KL6	164	216	211	201	204	218
KL7	169	196	216	198	194	221
KL8	153	187	215	168	200	263
KL9	199	198	234	211	224	228
KL10	155	171	172	169	173	222
KL11	228	288	262	298	286	268
KL12	190	239	208	229	233	279
KL13	132	201	180	185	212	196
KL14	177	225	229	227	220	271
KL15	152	178	198	215	200	256
Average KL	179 (29)	214 (32)	220 (29)	219 (37)	224 (36)	244 (32)
AE	237 (53)	254 (54)	254 (54)	332 (50)	226 (48)	353 (48)

As for the first pair /ɪ/ and /ɛ/, native speakers' length difference between /ɪ/ and /ɛ/ durations was extremely small, which was 17 ms but KH's was 45 ms and KL's 35 ms. The /ɪ/-/ɛ/ pair's length difference between native speakers and Korean subjects was caused by relatively shorter production of /ɪ/ vowel by both higher- and lower-proficiency level students. The average duration of /ɪ/ vowel produced by native speakers was 237 ms while KH's was 182 and KL's 152 ms.

As for a /ɛ/ and /æ/ pair, native speakers' produced a vowel /ɛ/ more shortly than /æ/ and the length difference between /ɛ/ and /æ/ durations was 78 ms, which is more than 5 times compared with the difference between /ɪ/ and /ɛ/. It indicates that native speakers' /æ/ is produced distinctively longer than /ɛ/. However, 7 speakers of 15 higher level group produced a vowel /æ/ more shortly than /ɛ/ and the rest of 8 speakers' the length difference between

/ɛ/ and /æ/ was much smaller than 78 ms. The result of the lower level speakers was exactly the same. 7 speakers of 15 lower level group produced a vowel /æ/ more shortly than /ɛ/ and the rest of 8 speakers' the length difference between /ɛ/ and /æ/ was much smaller than 78 ms. In other words, most of the Korean subjects produced /æ/ far more shortly than native speakers. Namely, the average duration of KH was 238 ms and the average duration of KL was 219 ms while the average duration of AE was 332 ms.

As for the last pair /ʌ/ and /ɔ/, the average duration of a vowel /ɔ/ produced by native speakers was distinctively longer than the vowel /ʌ/. Actually, as represented in Table 9, the length difference between the /ʌ/ and /ɔ/ contrast is the biggest, which is 127 ms among three pairs of /ɪ/-/ɛ/, /ɛ/-/æ/, and /ʌ/ -/ɔ/. It means normally native speakers produce /ɔ/ longer than /ʌ/. However, the length difference of Korean talkers was very marginal, which was 2 ms although 28 Korean talkers except 2 lower-proficiency level talkers did produce /ɔ/ a little bit longer than /ʌ/. It means that both groups of Korean talkers did not recognize the length difference between /ʌ/ and /ɔ/. By and large, Korean speakers produced /ɔ/ much shorter than native speakers.

In sum, generally both higher and lower proficiency groups had similar mean durations of /ɪ/, /ɛ/ and /ʌ/ compared to native criteria, but mean durations of /æ/ and /ɔ/ were much shorter than those of the native norms.

Table 8. Length difference of /ɪ/–/ɛ/, /ɛ/–/æ/ and /ʌ/– /ɔ/ (unit: ms)

	/ɪ/ - /ɛ/	/ɛ/ - /æ/	/ʌ/ - /ɔ/
AE	17	94	127
KH	45	5	34
KL	35	1	20

4. Discussion

This research investigated the production of English /ɪ/, /ɛ/, /æ/, /ʌ/, and /ɔ/ vowels by thirty Korean female university students in the EFL settings focusing on the three sets of vowel contrasts /ɪ/ vs. /ɛ/, /ɛ/ vs. /æ/ and /ʌ/ vs. /ɔ/. The subjects were divided by two different groups according to their English proficiency level. The experiment employed minimal pairs as stimuli

consisting of authentic basic English words. The aims of the study was the impact of L1 transfer in L2 production. The results demonstrated that most subjects' L1 did have an influence on the production of English vowels even though there is a degree of difference between two groups.

First, Korean subjects in this experiment articulated English vowel /ɪ/ with the tongue placed in a higher and more frontal place, which is closer to English /i/. This phenomenon is attributed to the influence of L1 since Korean vowel inventory has only one high front vowel in Korean. Even though most participants were able to produce English /ɪ/ and /ɛ/ distinctively, they could not recognize accurate highness and frontness of English /ɪ/, so they had the tendency to pronounce /ɪ/ mainly depending on short duration. Seemingly, Korean subjects wanted to secure correct production of /ɪ/ by on-purpose shortened pronunciation of /ɪ/. Yun's experiment (2005) supported this phenomenon since he asserted that Korean subjects used vowel durational cues when they identified the /i-ɪ/ continuum, whereas they relied upon spectral cues when identifying /ɛ/ in the /ɪ-ɛ/ continuum. In sum, it seems that Korean subjects were aware that there is a durational difference in the vowel /ɪ/ compared with /i/ since their actual production of duration /ɪ/ is even shorter than that of native speakers. Thus, it is obvious that most participants did apprehend distinctiveness /ɪ/ and /ɛ/ but they did not have good knowledge of acoustic properties of vowel /ɪ/. As Flege, Bohn, and Jang (1997) investigated, Korean speakers failed to perceive a meaningful height difference between English /i/ and /ɪ/ due to their phonetic similarity between Korean /i/ and English /ɪ/, which is the effect of L1 interference in L2 production. This is the reason that most participants produced /ɪ/ inappropriately even though they succeeded in differentiating /ɪ/ and /ɛ/.

For the second pair /ɛ/ and /æ/, another L1 sound transfer was witnessed due to failure of distinctive production of /ɛ/ and /æ/ by most Korean speakers in the experiment. The result clearly revealed that both higher- and lower-proficiency level subjects had a great difficulty differentiating /ɛ/ and /æ/. More specifically, the experiment showed that the F1-F2 vowel space of the production of /ɛ/ and /æ/ was extensively superimposed and durational difference between /ɛ/ and /æ/ was almost undetectable. The current Korean vowel system no longer has two non-high front vowels since recently a

mid-high front Korean vowel /e/ and a mid-low front Korean vowel /ɛ/ have been neutralized. The merger of these two different mid front vowels in Korean might lead to unstable establishment of English /ɛ/ and /æ/. Namely, the absence of vowel category /æ/ in Korean phonemic inventory might be the reason that Korean speakers failed to produce /ɛ/ and /æ/ distinctively since the formant values and duration measurements of /ɛ/ and /æ/ seemed severely confusing among both levels of Korean speakers. As Flege (1995, 2009) postulated, fine-phonetic features of L2 sounds are hard to be attained in L2 learners' phonetic category because their L1 sound system tends to filter out these phonetic details. For example, almost all of Korean participants were not aware of durational difference between /ɛ/ and /æ/, so many of them produced /ɛ/ longer than /æ/ unlike native criteria. In sum, the merger of Korean mid front vowels was attributed to confused articulation of English /ɛ/ and /æ/ by Korean learners of English.

The final set of /ʌ/ and /ɔ/ was another problematic pair in the present study according to formant and duration measurements by the subjects. Most participants did not recognize a distinctive frontness difference between /ʌ/ and /ɔ/ and they also did not identify a perceptible duration difference between /ʌ/ and /ɔ/. More specific, lower-proficiency level students' productions were severely mixed up since their formant values of /ʌ/ were very similar to those formant values of /ɔ/. In sum, most participants did not perceive the proper articulatory gestures of /ʌ/ and /ɔ/ distinctively. According to Swan and Smith (2001), Korean learners of English relied upon Korean /o/ in order to acquire English /ɔ/. However, this one-to-one substitution misled inaccurate production of English /ɔ/. Koreans have a mid central vowel /ə/ and a mid back vowel /o/ in the Korean vowel system and these two mid vowels are clearly distinctive to native speakers of Korean. The problem seems to arise when they differentiate English /ʌ/ and /ɔ/ by using the same phonetic strategy of distinguishing Korean /ə/ and /o/. Korean learners did not contemplate other articulatory property like durational cues when they produce English /ʌ/ and /ɔ/. Again, L1 sound system filtered out L2 phonetic features. It is obvious that the production result of /ʌ/ and /ɔ/ revealed the effect of L1 sound transfer in L2 production.

Importantly, the results of the present study arouse pedagogical implications under the situation that most of the stimuli were frequently uttered basic words.

In other words, inaccurate vowel productions of the basic words can lead to communication difficulty although segmental level accuracy has been assumed to be less serious than prosodic level accuracy in communication (Celce-Murcia, Brinton, & Goodwin, 2010). In order to improve Korean learners' vowel production accuracy, detailed description about acoustic features of English vowels would be advised during English class. For example, if Korean learners are introduced different degrees of highness/frontness and/or lip rounding and duration of English vowels and they recognize subtle differences between L1 and L2 corresponding vowels, Korean speakers' better production can be expected. Presumably, Korean speakers will try to pronounce target vowels more accurately with acoustic awareness because they no longer rely upon unclear one-to-one mapping of each counterpart between L1 and L2.

There are some limitations in the present study in that only 3 pairs of English vowels were investigated and 30 female recruited subjects may not be considered as representatives of Korean EFL learners. However, the present study revealed that university-level Korean EFL speakers had difficulty in accurately producing English vowels and differentiating vowel contrasts even for basic English words. Hopefully, in the future, further comprehensive research on all English vowels and vowel contrasts produced by Korean EFL learners would be followed to enhance the effectiveness of this study.

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Appendix A

	/ɪ/		/ɛ/		/ɛ/		/æ/		/ʌ/		/ɔ/	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
H1	494	2526	742	2096	750	2038	760	2052	806	1437	833	1381
H2	471	2614	728	1993	730	2047	729	2082	792	1430	739	1303
H3	411	2749	687	2309	711	2268	745	2188	791	1434	754	1345
H4	429	2384	686	1960	693	2076	733	1813	724	1223	697	1212
H5	402	2774	816	2167	819	2080	763	2092	788	1435	773	1502
H6	429	2530	713	2154	725	2175	685	2180	759	1304	728	1271
H7	445	2522	734	2211	735	2239	696	2147	689	1334	657	1290
H8	381	2604	655	2120	663	2113	710	1942	746	1461	758	1349
H9	442	2531	721	2188	702	2147	668	2222	723	1422	720	1325
H10	338	2548	700	2046	672	2091	662	2039	749	1477	717	1310
H11	407	2433	801	1974	766	2054	718	1949	756	1536	656	1363
H12	425	2536	835	2124	811	2106	854	2122	780	1289	727	1178
H13	462	2769	764	2259	771	2218	769	2149	838	1367	749	1236
H14	393	2910	751	2178	716	2188	680	2293	750	1445	762	1240
H15	461	2536	773	2057	760	2045	746	2134	755	1411	780	1229
L1	487	2676	758	2105	762	2012	778	2049	739	1415	724	1318
L2	453	2721	772	2100	771	2123	746	2041	773	1366	754	1367
L3	453	2641	681	1895	745	1892	735	1880	733	1439	709	1480
L4	354	2416	780	2060	715	2087	781	1972	776	1447	726	1396
L5	444	2617	707	2015	722	2161	721	2030	649	1430	656	1484
L6	488	2567	704	2009	671	2057	737	2056	719	1547	758	1476
L7	429	2570	707	2047	702	2051	732	2027	664	1224	572	1159
L8	470	2823	772	2005	809	2227	896	1910	865	1383	759	1456
L9	413	2674	728	2093	718	2100	753	1928	751	1419	774	1425
L10	368	2679	539	2006	539	1908	758	1904	646	1251	636	1163
L11	555	2706	835	2185	841	2068	840	2073	849	1344	828	1370
L12	459	2941	790	2218	784	2270	838	2204	836	1377	815	1329
L13	406	2975	749	2547	689	2628	759	2389	829	1296	827	1287
L14	435	2743	769	2273	764	2297	748	2244	777	1297	721	1189
L15	421	2708	595	2355	547	2295	666	2211	702	1277	689	1225

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