Perceptual assimilation of French oral vowels in consonantal contexts by naïve Korean listeners*

Eunjin Oh

(Ewha Womans University)

Oh, Eunjin. 2023. Perceptual assimilation of French oral vowels in consonantal contexts by naïve Korean listeners. *Linguistic Research* 40(1), 93-118. This study investigates perceptual assimilation of French vowels by native Korean listeners without knowledge of French to estimate perceptual similarity between vowels of the two languages (Best 1995). French vowels /i, e, ɛ, a, y, ø, œ, u, o, ɔ/ in non-coronal and coronal contexts were perceptually assimilated to Korean vowels /i, e, ɯ, ʌ, ɑ, u, o/. As a measure of perceptual similarity, fit indices were calculated by weighting a response percentage of the most frequently assimilated Korean vowel with its mean goodness-rating score (Sun and van Heuven 2007). French high front rounded /y/ was assimilated to Korean high back rounded /u/, suggesting that acoustic features reflecting lip rounding affect the identification of the front rounded vowel. French vowels were assimilated to the same Korean vowels in the two consonantal contexts except /ø/ and /œ/. It was not always the case that the assimilation patterns were explained in terms of acoustic distances between the vowels of French and Korean. The patterns where two French vowels were assimilated to a single Korean vowel showed one category-goodness (CG) type (/i/-/e/ to /i/) and two uncategorized-categorized (UC) types (/œ/-/ɔ/ to /ʌ/; /y/-/u/ to /u/) in the non-coronal contexts, and two CG types (/ɛ/-/œ/ to /e/; /u/-/y/ to /u/), one single-category type (/y/-/ø/ to /u/), and one UC type (/e/-/i/ to /i/) in the coronal contexts. The ability to identify and discriminate French vowels by Korean listeners was expected to be predicted based on the perceptual assimilation patterns found in the present study. **(Ewha Womans University)**

Keywords   perceptual assimilation, goodness rating, fit index, assimilation set, French vowels, Korean vowels

---

1. Introduction

1.1 Perceptual assimilation of foreign-language vowels

The Perceptual Assimilation Model (PAM) for the perception of foreign language (FL) speech sounds assumes that naïve listeners perceive FL sounds or sound contrasts based on their similarity with their native (i.e., first-language; L1) sound categories (Best 1995; Best and Tyler 2007). According to the PAM, listeners *perceptually assimilate* an FL sound to an L1 category, and perceptual assimilation patterns of FL sounds to L1 categories provide a measure of perceptual similarity between FL and L1 sounds. It is further assumed that the perceptual similarity between FL and L1 categories predicts the difficulty of discriminating the FL sound contrasts. The main aim of this study is to investigate the perceptual assimilation patterns of French vowels by native Korean listeners without knowledge of French (i.e., naïve listeners) and to estimate the perceptual similarity between the vowels of the two languages.

The PAM proposes several perceptual assimilation patterns of FL sounds into L1 categories and argues that difficulty discriminating FL sound contrasts can be predicted according to patterns in which FL contrasts are assimilated to L1 categories (e.g., Best 1995; Best and Tyler 2007; Sun and van Heuven 2007; Levy 2009a; Levy 2009b; Holliday 2014; Colantoni, Steele, and Escudero 2015). For example, in a case where two FL sounds are assimilated to two different L1 categories, it is classified as a two-category (TC) type and it is assumed that the FL contrast can be discriminated without difficulty. In a case where two FL sounds are assimilated to a single L1 category and are judged to be equally good or equally bad exemplars of the L1 sound, then it is classified as a single-category (SC) type and it is assumed to be difficult to identify the FL contrast. If two FL sounds are assimilated to a single L1 category but one is a better exemplar of that category than the other, it is classified as a category-goodness (CG) type and the perceptual difficulty is assumed to vary according to the difference in the category goodness between the two FL sounds. It is predicted that the larger the difference in the category goodness, the easier it is to discriminate the FL contrast. In an uncategorized-categorized (UC) type, one FL sound is not categorized as any L1 sound and another is categorized as an L1 sound, while in an uncategorized-uncategorized (UU) type, both FL sounds are not categorized as any L1 sound. It is predicted that the UC type is well discriminated whereas the perceptual difficulty of the UU type is determined

according to the phonetic similarity of the FL sounds. It is predicted that the more similar the two FL sounds, the more difficult it is to discriminate the contrast.

A direct way to estimate the perceptual similarity between FL and L1 sounds is to perform a perceptual assimilation task where listeners listen to FL sounds and select the one they judge to be the most similar among the given L1 sounds. The perceptual assimilation task is usually accompanied by a goodness-of-fit task, a task evaluating the *category goodness* of how good a given FL sound is as an exemplar of the selected L1 sound. A Likert scale is used to select from the smallest value for the poorest exemplar of the selected L1 sound to the largest for the best exemplar of it (e.g., Strange, Akahane-Yamada, Kubo, Trent, Nishi, and Jenkins 1998; Sun and van Heuven 2007; Levy 2009a; Mayr and Escudero 2010; Holliday 2014).

1.2 Vowel systems of French and Korean

The vowel systems of French and Korean are outlined in this section. Table 1 presents the monophthong oral vowel system of standard French (ref., Park 2011; Kim 2020; Kim, Park, and Kim 2022). According to tongue height, the vowels are classified as high, mid, and low, and mid is sub-classified as higher-mid and lower-mid. According to tongue frontness, the vowels are classified into front and back, and the back vowels (/u, o, ɔ/) are all rounded. French contrasts the front vowels depending on lip rounding; high /i/-/y/, higher-mid /e/-/ø/, and lower-mid vowels /ɛ/-/œ/ are categorized with the feature values [-round] (i.e., unrounded vowels) vs. [+round] (i.e., rounded vowels), respectively. The vowel /a/ is the only low vowel, which is front-unrounded. French also contrasts oral vs. nasal vowels (/ɛ̃, ɑ̃, ɔ̃/), but only oral vowels are considered in the present study.

Table 1. The oral vowel system of standard French.

	Front		Back
	Unrounded	Rounded	Rounded
High	i	y	u
Higher-Mid	e	ø	o
Lower-Mid	ɛ	œ	ɔ
Low	a		

The vowel system of standard Korean is presented in Table 2 (e.g., Kang and Kong

2016). The Korean vowels are categorized as high, mid, and low according to the tongue height, and as front and back according to the tongue frontness. The front vowels are all unrounded (/i, e/), and the back vowels are either unrounded (/ɯ, ʌ, ɑ/) or rounded (/u, o/).

Table 2. The vowel system of standard Korean.

	Front	Back	
	Unrounded	Unrounded	Rounded
High	i (이)	ɯ (으)	u (우)
Mid	e (에)	ʌ (어)	o (오)
Low		ɑ (아)	

The main differences between the French and Korean vowel systems are that French has four levels of vowel height but Korean has three levels, and that only in French, but not in Korean, are the front vowels contrasted with or without lip rounding.

1.3 Perceptual assimilation of French and German vowels by native English listeners

Several studies have examined how native English listeners perceive French vowels differentiated by [round], a vowel feature that is not used contrastively in English (e.g., Gottfried 1984; Levy and Strange 2008; Levy 2009a; Levy 2009b). For example, /i/ and /u/ in English are differentiated by [+front] vs. [+back] features, respectively. The vowel /u/ is rounded, but the roundedness is not a phonemic property in English. On the other hand, [round] is a phonemic feature in the French vowel system. For example, French /i/ and /y/ are both [+high, +front], and are differentiated by [-round] vs. [+round], respectively.

Levy (2009a) examined the perceptual assimilation of French vowels /i, ɛ, a, y, œ, u, o/ by native American English listeners and reported that French front rounded /y/ and /œ/ were largely assimilated to English back vowels, not to front vowels. Levy (2009b) performed a discrimination task of French vowels by native English listeners and compared the results with those of the Levy's (2009a) perceptual assimilation task. Learners who assimilated French /y/ and /u/ to a single English category showed more errors in the French vowel discrimination task, which indicate that perceptual assimilation data predict learners' FL vowel discrimination capability. Similarly in Mayr and Escudero

(2010), a perceptual assimilation task was performed for six rounded German vowels by native English listeners. Listeners assimilated German /y/ and /u/ into a single English vowel category /u/ and had difficulties in identifying the two vowels in the German vowel identification task.

Several studies have reported that consonantal contexts in which French vowels /y/ and /u/ are produced affect the perception of the vowels as an FL. That is, the difficulty differentiating the FL vowels differed depending on the contexts of the vowels. Gottfried (1984) compared the FL perception of vowels produced in isolation with that of vowels produced in a /tVt/ context (V=vowel). The amount of French experience only affected the perception of vowels produced in the /tVt/ context; experienced learners discriminated French /y/ and /u/ more accurately in the alveolar context, but there was no difference between experienced and inexperienced learners in discriminating vowels produced in isolation. Levy (2009a) reported that native English listeners distinguished French vowels /y/ and /u/ more accurately when produced in the bilabial context (/rabVp/) than when produced in the alveolar context (/radVt/). These differences in the FL vowel perception as a function of the consonantal contexts were interpreted as taking place because American English /u/ is produced more similarly to French front rounded /y/ in the alveolar context due to its fronting phenomenon in the context (e.g., Ash 1996; Fought 1999). Accordingly, French /y/ might have sounded like American English /u/ in the alveolar context, causing difficulty discriminating French /y/ and /u/ in the context. It is thus suggested that, when predicting the difficulty of FL vowel perception, it is necessary to consider the consonantal contexts in which FL vowels are produced (see also Strange, Akahane-Yamada, Kubo, Trent, and Nishi 2001 regarding the effects of consonantal contexts on the perceptual assimilation of American English vowels by native Japanese listeners).

1.4 Research questions

Based on the differences in the vowel systems of French and Korean (Section 1.2) and the results on the perceptual assimilation of French or German vowels by native English listeners (Section 1.3), the following research questions are formulated regarding how native Korean listeners would perceptually assimilate French to Korean vowels. (I) In French, but not in Korean, high front vowels are contrasted with lip rounding (i.e.,

unrounded /i/ vs. rounded /y/). Will French high front rounded /y/ be perceived as Korean high front unrounded /i/ or high back rounded /u/? (II) In the mid-front-vowel region, Korean has one /e/ but French contrasts higher-mid /e/ vs. lower-mid /ɛ/. To which Korean vowels are French /e/ and /ɛ/ to be assimilated? (III) Will perceptual assimilation patterns of French to Korean vowels differ as a function of consonantal contexts (non-coronal vs. coronal contexts) in which French vowels are produced? (IV) In cases where two French vowels are assimilated to a single Korean vowel, in which PAM patterns are they to be classified among the SC, CG, UC, and UU types (Section 1.1)? In addition, through acoustic analyses of Korean vowels produced by native Korean participants and of vowels in French listening materials (Sections 2.2 and 2.3), it will be examined whether perceptual assimilation patterns of French to Korean vowels are related to acoustic distances among the vowels of the two languages.

2. Experimental methods

2.1 Participants

Eighteen native Korean speakers (mean age 21.4; age range 19-24) participated in a perceptual assimilation task, a goodness-of-fit task, and a production experiment. They were all female undergraduate students at a university located in Seoul, Korea. They were all born and raised in Seoul or Gyeonggi Province and spoke standard Korean. Only one was born in Seoul and raised in Seoul and Daejeon. No participants had experience residing in a foreign country, with an exception of one participant who had lived in the Philippines for two months at the age of 15. The main language that all participants used at the time of the experiment was Korean. They had never learned French. Participants who had learned German with the front-rounded vowel system were also excluded. Except for one participant who had obtained the Chinese HSK level 5, none of them could speak any foreign language other than English at the intermediate level or higher. None of the participants had problems with hearing or articulation.

Pronunciation files of French words provided in the dictionary of an internet search site (Naver) were downloaded and used as listening materials. The words were produced by a female native French speaker. One native French speaker (male; 42 years old) confirmed that the vowels in the pronunciation files were native exemplars of the target

vowels. He was born and raised in France, and lived in Seoul for about 16 years. At the time of the experiment, he was working as a professor in the Department of French Language and Literature at a university located in Seoul. He spoke English at an advanced level and Korean at a beginner level. The native Korean participants and the native French speaker were given a participation fee after the experiment.

2.2 Materials

As listening materials for the perceptual assimilation task, CV(C) real words were used with non-coronal (1a) and coronal onsets (1b). Due to the distributional characteristics of the vowels /œ/ and /ɔ/ in French, which appear only in closed syllables in monosyllabic words, words with coda consonants were selected for the two vowels.

(1) a. Non-coronal contexts: 'qui' /ki/; 'fée' /fe/; 'fait' /fɛ/; 'fa' /fa/; 'pu' /py/; 'veut' /vø/; 'veulent' /vœl/; 'cou' /ku/; 'beau' /bo/; 'bosse' /bɔs/

   b. Coronal contexts: 'si' /si/; 'thé' /te/; 'taie' /tɛ/; 'ta' /ta/; 'du' /dy/; 'jeu' /ʒø/, 'jeune' /ʒœn/; 'sous' /su/; 'dos' /do/; 'sol' /sɔl/

A production experiment was also conducted to compare the acoustic values of Korean vowels with the French vowels used in the perceptual assimilation task (e.g., Levy 2009a). Production materials included the CV syllables /pi/ ('비'), /pe/ ('베'), /pɯ/ ('브'), /pʌ/ ('버'), /pɑ/ ('바'), /pu/ ('부'), and /po/ ('보'), using a bilabial stop for the non-coronal contexts, and /ti/ ('디'), /te/ ('데'), /tɯ/ ('드'), /tʌ/ ('더'), /tɑ/ ('다'), /tu/ ('두'), and /to/ ('도'), using a denti-alveolar stop for the coronal contexts. To check whether there are differences in acoustic values between vowels /e/ and /ɛ/ in Korean, which have been assumed to be merged (e.g., Yoon and Kang 2014), /pɛ/ ('배') and /tɛ/ ('대') were also included in the production materials. The raw acoustic data of the Korean vowels are presented in the Appendix, and their average acoustic values for displaying perceptual assimilation patterns of French to Korean vowels are presented in Figure 1 of Section 3.3.

2.3 Procedure

Before the start of the experiments, each participant filled out a questionnaire regarding their language background. The perceptual assimilation task was undertaken first, followed by the production experiment. Before proceeding with the perceptual assimilation task, the experimental procedure was explained to each participant, who then practiced with three words to gain familiarity with the task. Each stimulus was played twice in succession. The first was to listen to a French word and select the most similar one among the seven Korean vowels written in Korean orthography. Listening to words composed of a consonant and a vowel, they were asked to ignore the consonant part and focus on the vowel. At the second listening, the goodness-of-fit task was performed to evaluate perceptual similarity between a French vowel and a selected Korean vowel. The words 'veulent' and 'bosse' were produced as two syllables, and the participants were instructed to judge with the first vowel of the two. The similarity of a selected Korean vowel with a French vowel was evaluated on a scale of 0 (completely different) to 10 (exactly the same). The tasks with the words in the coronal contexts were performed first, followed by the tasks with the words in the non-coronal contexts.

After the perceptual assimilation task and the goodness-of-fit task, the production experiment was conducted. The Korean syllables were each presented for two seconds in isolation in random order on a computer screen. Participants read the entire word set twice. Recordings were made on Praat (Boersma and Weenink 2016), using a TAKSTAR GX6 USB condenser microphone. Data were digitized at a sampling rate of 44,100 Hz and saved as WAV files. The first (F1) and the second formant (F2) values were measured at the midpoint of vowel duration.

3. Results

3.1 Perceptual assimilation in non-coronal contexts

This section reports experimental results regarding the perceptual assimilation of French to Korean vowels in the non-coronal contexts. Table 3 presents the perceptual assimilation patterns of ten French vowels (horizontal axis) to Korean vowels (vertical axis). The response percentage refers to the ratio of the number of responses in which

a French vowel is assimilated to a Korean vowel. The numbers in parentheses are the average values of the goodness-rating scores for the corresponding responses. Shaded cells indicate the response with the highest percentage (i.e., the most frequently selected response) for each French vowel. The response percentages and the average values of the goodness-rating scores are rounded to one decimal place. A higher response percentage means that listeners more consistently responded to the corresponding Korean vowel. The higher the average value of the goodness-rating score, the more a French vowel is judged as a good exemplar of the selected Korean vowel.

Table 3. Response percentages (%) and mean goodness-rating scores (in parentheses) of Korean vowels assimilated for French vowels in non-coronal contexts. Shaded cells indicate the Korean vowel showing the highest response percentage for each French vowel.

		French (FL) vowels									
		/i/ 'qui'	/e/ 'fée'	/ɛ/ 'fait'	/a/ 'fa'	/y/ 'pu'	/ø/ 'veut'	/œ/ 'veulent'	/u/ 'cou'	/o/ 'beau'	/ɔ/ 'bosse'
Korean (L1) vowels	/i/ (이)	**94.4** **(7.7)**	**91.7** **(5.3)**			5.6 (1.5)					
	/e/ (에)		8.3 (5.3)	**94.4** **(7.0)**				25.0 (4.8)			
	/ɯ/ (으)	5.6 (2.0)		5.6 (4.5)		38.9 (2.4)	**91.7** **(5.5)**	27.8 (3.4)	2.8 (2.0)		
	/ʌ/ (어)				22.2 (7.6)		5.6 (6.5)	**47.2** **(4.9)**		5.6 (3.0)	**94.4** **(7.3)**
	/ɑ/ (아)				**77.8** **(5.9)**						5.6 (7.5)
	/u/ (우)					**55.6** **(2.8)**	2.8 (5.0)		**91.7** **(7.0)**	11.1 (2.0)	
	/o/ (오)								5.6 (5.5)	**83.3** **(6.4)**	

    Four French vowels (/i/, /ɛ/, /u/, and /ɔ/) were assimilated to Korean vowels with the highest response percentage (henceforth, response percentage) of 80% or more and the mean goodness-rating score of 7.0 or more. French /i/ was assimilated to Korean /i/ 94.4% with a goodness rating of 7.7, and French /ɛ/ was assimilated to Korean /e/ 94.4% with a goodness rating of 7.0. French /u/ was assimilated to Korean /u/ 91.7% with a goodness rating of 7.0, and French /ɔ/ was assimilated to Korean /ʌ/ 94.4% with a goodness rating of 7.3. These results suggest that the French vowels were consistently assimilated to the corresponding Korean vowels and were judged as relatively good

exemplars thereof.

Three French vowels (/e/, /ø/, and /o/) were assimilated to Korean vowels with the highest response percentage of 80% or more, but their goodness-rating scores were less than 7.0. French /e/ was assimilated to Korean /i/ 91.7% with a goodness rating of 5.3, French /ø/ was assimilated to Korean /ɯ/ 91.7% with a goodness rating of 5.5, and French /o/ was assimilated to Korean /o/ 83.3% with a goodness rating of 6.4. These results indicate that the vowels were consistently assimilated to the corresponding Korean vowels, but were not judged as good exemplars thereof.

Three French vowels (/a/, /y/, and /œ/) were assimilated to Korean vowels with the response percentages less than 80% and the goodness-rating scores less than 7.0. French /a/ was assimilated to Korean /ɑ/ 77.8% with a goodness rating of 5.9, and French /y/ was assimilated to Korean /u/ 55.6% with a very low goodness rating of 2.8. French /œ/ was assimilated to Korean /ʌ/ 47.2%, the response percentage being the lowest less than 50%, and its goodness rating was also low at 4.9. These results indicate that the vowels were not consistently assimilated to the corresponding Korean vowels and were not judged as good exemplars thereof.

3.2 Perceptual assimilation in coronal contexts

This section reports experimental results regarding the perceptual assimilation of French to Korean vowels in the coronal contexts. Table 4 presents the perceptual assimilation patterns of ten French vowels to Korean vowels (see Section 3.1 for table-related explanations).

Table 4. Response percentages (%) and mean goodness-rating scores (in parentheses) of Korean vowels assimilated for French vowels in coronal contexts. Shaded cells indicate the Korean vowel showing the highest response percentage for each French vowel.

		French (FL) vowels									
		/i/ 'si'	/e/ 'thé'	/ɛ/ 'taie'	/a/ 'ta'	/y/ 'du'	/ø/ 'jeu'	/œ/ 'jeune'	/u/ 'sous'	/o/ 'dos'	/ɔ/ 'sol'
Korean (L1) vowels	/i/ (이)	**94.4 (7.3)**	**55.6 (4.6)**								
	/e/ (에)		27.8 (5.5)	**100 (7.6)**				**91.7 (5.8)**			
	/ɯ/ (으)	5.6 (5.5)	16.7 (4.0)		2.8 (6.0)		11.1 (4.3)	2.8 (0)		2.8 (6.0)	
	/ʌ/ (어)				16.7 (5.7)		8.3 (3.7)			27.8 (5.4)	**100 (7.9)**
	/ɑ/ (아)				**80.6 (6.9)**			5.6 (0)		2.8 (2.0)	
	/u/ (우)					**100 (5.0)**	**80.6 (4.1)**		**75.0 (7.4)**	25.0 (6.2)	
	/o/ (오)								25.0 (5.3)	**41.7 (5.5)**	

Three French vowels (/i/, /ɛ/, and /ɔ/) were assimilated to Korean vowels with the response percentages of 80% or more and the mean goodness-rating scores of 7.0 or more. French /i/ was assimilated to Korean /i/ 94.4% with a goodness rating of 7.3, French /ɛ/ was assimilated to Korean /e/ 100% with a goodness rating of 7.6, and French /ɔ/ was assimilated to Korean /ʌ/ 100% with a goodness rating of 7.9, suggesting that these French vowels were consistently assimilated to the corresponding Korean vowels and were judged as relatively good exemplars thereof. In another case, French /u/ was assimilated to Korean /u/ 75.0% (less than 80%) with a goodness-rating score of 7.4.

Four French vowels (/y/, /œ/, /a/, and /ø/) were assimilated to Korean vowels with the response percentages of 80% or more, but their goodness-rating scores were less than 7.0. French /y/ was assimilated to Korean /u/ 100% with a goodness rating of 5.0, and French /œ/ was assimilated to Korean /e/ 91.7% with a goodness rating of 5.8. French /a/ was assimilated to Korean /ɑ/ 80.6% with a goodness rating of 6.9, and French /ø/ was assimilated to Korean /u/ 80.6% with a low goodness rating of 4.1. These results indicate that the vowels were consistently assimilated to the corresponding Korean vowels, but were not judged as good exemplars thereof.

Two French vowels (/e/ and /o/) were assimilated to Korean vowels with the response

percentages less than 80% and the goodness-rating scores less than 7.0. French /e/ was assimilated to Korean /i/ 55.6% with a low goodness rating of 4.6, and French /o/ was assimilated to Korean /o/ 41.7% with a goodness rating of 5.5. This indicates that the French vowels were not consistently assimilated to the corresponding Korean vowels and were not judged as good exemplars thereof.

3.3 Perceptual assimilation patterns in non-coronal and coronal contexts

Figure 1 presents the perceptual assimilation pairs of French (orange circles) to Korean vowels (blue triangles) in the F1-F2 acoustic dimension.[1] French vowels were assimilated to the corresponding Korean vowels in the direction of arrows. Except for /ø/ and /œ/, all French vowels were assimilated to the same Korean vowels with the highest response percentages in both non-coronal and coronal contexts. That is, in both contexts, French /i/ was assimilated to Korean /i/, French /e/ to Korean /i/, French /ɛ/ to Korean /e/, French /a/ to Korean /ɑ/, French /y/ to Korean /u/, French /u/ to Korean /u/, French /o/ to Korean /o/, and French /ɔ/ to Korean /ʌ/.
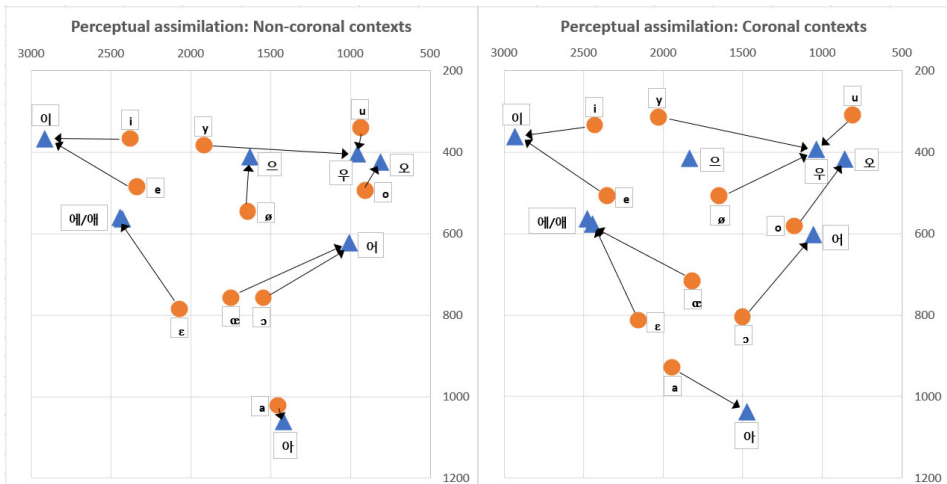

Figure 1. Perceptual assimilation of French (orange circles) to Korean vowels (blue triangles) in the F1 (vertical axis; Hz) and F2 (horizontal axis; Hz) dimension: Non-coronal (left) and coronal contexts (right).

---

1   Appendix 1 presents the scatterplots of the F1 and F2 values of Korean vowels in the two consonantal contexts to overview the distributions of their raw acoustic values.

Even if a French vowel was assimilated to the same Korean vowel in the two consonantal contexts, differences in the response percentages could be as large as 30% or more, depending on the contexts. French /e/ was assimilated to Korean /i/ in both contexts, with the response percentage of 91.7% in the non-coronal context but only of 55.6% in the coronal context. French /y/ was assimilated to Korean /u/ with the response percentage of 55.6% in the non-coronal context vs. 100% in the coronal context. French /o/ was assimilated to Korean /o/ with the response percentage of 83.3% in the non-coronal context vs. 41.7% in the coronal context (see discussion in Section 4).

As described earlier, two French vowels were assimilated to different Korean vowels as a function of the consonantal contexts. French /ø/ was assimilated to Korean /ɯ/ in the non-coronal context (response percentage 91.7%; goodness rating 5.5) but to Korean /u/ in the coronal context (80.6%; 4.1). French /œ/ was assimilated to Korean /ʌ/ in the non-coronal context (47.2%; 4.9) but to Korean /e/ in the coronal context (91.7%; 5.8). In these cases where a French vowel is assimilated to different Korean vowels depending on the consonantal contexts, the mean goodness-rating scores showed a relatively low tendency of 4.1 to 5.8 (see discussion in Section 4).

In summary, French vowels were assimilated to the same Korean vowel in the non-coronal and the coronal contexts in most cases. Two French vowels were assimilated to different Korean vowels as a function of the consonantal contexts. Some French vowels were assimilated to the same Korean vowels in both contexts, but their response percentages differed considerably according to the consonantal contexts.

3.4 Assimilation sets and PAM patterns

There were cases in which two or more French vowels are perceptually assimilated to a single Korean vowel. Sun and van Heuven (2007) called *assimilation sets* for FL vowels classified as one L1 vowel. Table 5 presents French and Korean assimilation pairs, and their response percentages and goodness-rating scores, in the non-coronal (above) and the coronal contexts (below). There were three assimilation sets in the non-coronal contexts (/i/-/e/, /œ/-/ɔ/, /y/-/u/) and three assimilation sets in the coronal contexts (/i/-/e/, /ɛ/-/œ/, /u/-/y/-/ø/). Among the assimilation sets, /i/-/e/ and /y/-/ø/ are distinguished by vowel height (i.e., high vs. higher-mid), /y/-/u/ and /œ/-/ɔ/ by vowel frontness (i.e., front vs. back), and /ɛ/-/œ/ by lip rounding (i.e., unrounded vs. rounded).

Sun and van Heuven (2007) integrated perceptual assimilation and goodness-of-fit data into one measure, *fit index*, because of the necessity to reflect the goodness-of-fit scores in the response percentages. In cases where response percentages of two FL vowels were equally high, the FL vowel could be a good exemplar of the corresponding L1 vowel (i.e., with a high goodness-of-fit score) or the L1 vowel could have been selected because there was no better option to choose from (i.e., with a low goodness-of-fit score). In the present study, for example, French /ɛ/ in the coronal context was 100% assimilated to Korean /e/ with a mean goodness rating of 7.6. On the other hand, French /y/ in the coronal context was 100% assimilated to Korean /u/, but the mean goodness-rating score was lower as 5.0. In the latter case, the Korean vowel may have been selected because there was no better option for the listeners to choose from. To differentiate between such cases, it is necessary to *weight* (i.e., adjust) the response percentages to reflect the goodness-of-fit scores.

The fit index was calculated for each French vowel with the formula in (2) (Sun and van Heuven 2007). The response percentage of an L1 (Korean) vowel that was most frequently responded to (i.e., the highest response percentage) was weighted with its mean goodness-of-fit score.

(2) Fit index = (Response percentage of an L1 vowel that was most frequently
    responded ÷ 100) × Mean goodness-of-fit score of the identification

Table 5 presents the fit indices for each French-Korean assimilation pair in the fifth columns. Sun and van Heuven (2007) classified FL vowels with the mean value of fit indices for all FL vowels and their standard deviation (SD). As presented in (3), an FL vowel with a fit index larger than the 'mean index plus one SD' is classified as a "good" instance of a corresponding L1 vowel category (3a). An FL vowel with a fit index between the 'mean index' and the 'mean index plus one SD' is classified as a "fair" exemplar of an L1 category (3b). An FL vowel with a fit index between the 'mean index minus one SD' and the 'mean index' is classified as a "poor" instance of a corresponding L1 category (3c). An FL vowel with a fit index smaller than the 'mean index minus one SD' is classified as "uncategorized" (3d).

(3) Classifications of perceptually assimilated FL vowels
    a. Mean fit index + One SD ≤ "Good"

b. Mean fit index ≤ "Fair" < Mean fit index + One SD

c. Mean fit index − One SD ≤ "Poor" < Mean fit index

d. Mean fit index − One SD > "Uncategorized"

Table 5. Assimilation sets and fit indices for French vowels: Non-coronal (above) and coronal contexts (below). 'Percent' refers to response percentages of Korean vowels and 'Rating' to their goodness-rating scores. PAM patterns are presented for each assimilation set.

Non-coronal contexts					
French	Korean	Percent	Rating	Fit index / Classification	PAM pattern
/i/	/i/	94.4	7.7	7.3 / Good	CG
/e/		91.7	5.3	4.9 / Poor	
/ɔ/	/ʌ/	94.4	7.3	6.9 / Fair	UC
/œ/		47.2	4.9	2.3 / UnC	
/u/	/u/	91.7	7.0	6.4 / Fair	UC
/y/		55.6	2.8	1.6 / UnC	
/ɛ/	/e/	94.4	7.0	6.6 / Fair	
/a/	/ɑ/	77.8	5.9	4.6 / Poor	
/ø/	/ɯ/	91.7	5.5	5.0 / Poor	
/o/	/o/	83.3	6.4	5.3 / Fair	

Coronal contexts					
French	Korean	Percent	Rating	Fit index / Classification	PAM pattern
/i/	/i/	94.4	7.3	6.9 / Fair	UC
/e/		55.6	4.6	2.6 / UnC	
/ɛ/	/e/	100	7.6	7.6 / Good	CG
/œ/		91.7	5.8	5.3 / Fair	
/u/	/u/	75.0	7.4	5.6 / Fair	/u/-/y/ CG /y/-/ø/ SC
/y/		100	5.0	5.0 / Poor	
/ø/		80.6	4.1	3.3 / Poor	
/a/	/ɑ/	80.6	6.9	5.6 / Fair	
/o/	/o/	41.7	5.5	2.3 / UnC	
/ɔ/	/ʌ/	100	7.9	7.9 / Good	

Following the method used by Sun and van Heuven (2007) as presented in (3), French vowels were classified based on their mean fit index and the SD. In the non-coronal contexts, the mean fit index for French vowels was 5.1 with the SD of 1.9. Therefore, a French vowel with a fit index larger than the 'mean index plus one SD' (i.e., 7.0 or higher) was classified as a "good" instance of a corresponding Korean vowel

category. French /i/ (fit index 7.3) was classified as a good exemplar of Korean /i/. A French vowel with a fit index between the 'mean index' (i.e., 5.1 or higher) and the 'mean index plus one SD' (i.e., smaller than 7.0) was classified as a "fair" instance of a Korean category. French /ɔ/ (6.9), /u/ (6.4), /ɛ/ (6.6), and /o/ (5.3) were classified as fair exemplars of Korean /ʌ/, /u/, /e/, and /o/, respectively. A French vowel with a fit index between the 'mean index minus one SD' (i.e., 3.2 or higher) and the 'mean index' (i.e., smaller than 5.1) was classified as a "poor" instance of a Korean category. French /e/ (4.9), /a/ (4.6), and /ø/ (5.0) were classified as poor exemplars of Korean /i/, /ɑ/, and /ɯ/, respectively. A French vowel with a fit index smaller than the 'mean index minus one SD' (i.e., smaller than 3.2) was classified as "uncategorized" (UnC). French /œ/ (2.3) and /y/ (1.6) were not categorized as any Korean vowel.

In the coronal contexts, the mean fit index for French vowels was 5.2 with the SD of 2.0. Therefore, a French vowel with a fit index larger than the 'mean index plus one SD' (i.e., 7.2 or higher) was classified as a "good" instance of a corresponding Korean vowel category. French /ɛ/ (7.6) and /ɔ/ (7.9) were classified as good exemplars of Korean /e/ and /ʌ/, respectively. A French vowel with a fit index between the 'mean index' (i.e., 5.2 or higher) and the 'mean index plus one SD' (i.e., smaller than 7.2) was classified as a "fair" instance of a Korean category. French /i/ (6.9), /œ/ (5.3), /u/ (5.6), and /a/ (5.6) were classified as fair exemplars of Korean /i/, /e/, /u/, and /ɑ/, respectively. A French vowel with a fit index between the 'mean index minus one SD' (i.e., 3.2 or higher) and the 'mean index' (i.e., smaller than 5.2) was classified as a "poor" instance of a Korean category. French /y/ (5.0) and /ø/ (3.3) were both classified as poor exemplars of Korean /u/. A French vowel with a fit index smaller than the 'mean index minus one SD' (i.e., smaller than 3.2) was classified as "uncategorized." French /e/ (2.6) and /o/ (2.3) were not categorized as any Korean vowel.

As described in Section 1.1, the PAM proposes several perceptual assimilation patterns for the assimilation sets in which two FL (French) categories are perceptually assimilated to a single L1 (Korean) category (e.g., Best 1995; Best and Tyler 2007; Sun and van Heuven 2007; Levy 2009a; Levy 2009b). Among the SC, CG, UC, and UU types, three assimilation sets belong to the CG type, in which two French vowels were assimilated to a single Korean vowel but one is a better exemplar of the Korean category than the other. In the non-coronal contexts, French /i/ and /e/ were both assimilated to Korean /i/; French /i/ was classified as a good exemplar of Korean /i/ (fit index 7.3) and French /e/ as its poor exemplar (4.9). Since French /i/ is a better exemplar of Korean

/i/ than French /e/, the assimilation set is assumed to belong to the CG type. In the coronal contexts, French vowels /ɛ/ and /œ/ were assimilated to Korean /e/; French /ɛ/ was classified as a good exemplar of Korean /e/ (7.6) and French /œ/ as its fair exemplar (5.3). Since French /ɛ/ is a better exemplar of Korean /e/ than French /œ/, the assimilation set belongs to the CG type. Also in the coronal contexts, French vowels /u/ and /y/ were both assimilated to Korean /u/; French /u/ was classified as a fair exemplar of Korean /u/ (5.6) and French /y/ as its poor exemplar (5.0). Since French /u/ is a better exemplar of Korean /u/ than French /y/, the assimilation set belongs to the CG type.

One assimilation set belongs to the SC type, in which two French vowels were assimilated to a single Korean vowel and were judged to be equally good or equally bad instances of the Korean vowel. In the coronal contexts, French vowels /y/ and /ø/ were both assimilated to Korean /u/; both /y/ (fit index 5.0) and /ø/ (3.3) were classified as poor exemplars of Korean /u/. Since French /y/ and /ø/ are both poor exemplars of Korean /u/, the assimilation set belongs to the SC type.

Three assimilation sets belong to the UC type, in which two French vowels were assimilated to a single Korean vowel but one French vowel was categorized as a Korean vowel and another was not categorized as any Korean vowel. In the non-coronal contexts, French /ɔ/ and /œ/ were both assimilated to Korean /ʌ/; French /ɔ/ was a fair exemplar of Korean /ʌ/ (fit index 6.9) and French /œ/ was not categorized as any Korean vowel (2.3). In the non-coronal contexts, French /u/ and /y/ were assimilated to Korean /u/; French /u/ was a fair exemplar of Korean /u/ (6.4) and French /y/ was not categorized as any Korean vowel (1.6). In the coronal contexts, French /i/ and /e/ were assimilated to Korean /i/; French /i/ was a fair exemplar of Korean /i/ (6.9), but /e/ was not categorized as any Korean vowel (2.6). In each of these cases, since the former French vowel is categorized as a Korean vowel but the latter is not categorized as any Korean vowel, the assimilation sets are assumed to belong to the UC type.

4. Summary and discussion

The purpose of this study was to examine the perceptual assimilation patterns of French vowels to Korean vowels by native Korean listeners without knowledge of French to estimate the perceptual similarity between the vowels of the two languages. The vowel systems of French and Korean differ in terms of the vowel height, the phonemic use of

the [round] feature in the front vowel system, and the distinction between /e/ and /ɛ/ in the mid-front vowel region. Through the perceptual assimilation data, which were quantified by the fit indices of the response percentages weighted by the goodness-of-fit scores, French vowel contrasts in the assimilation sets were classified into several PAM patterns.

4.1 The perceptual assimilation of French high front rounded /y/

Regarding whether French high front rounded /y/ would be perceived as Korean high front unrounded /i/ or high back rounded /u/, French /y/ was assimilated to Korean /u/ in both consonantal contexts. The response percentage was 100% in the coronal context, but only 55.6% in the non-coronal context. The mean goodness-rating score was low in both contexts (2.8 in the coronal and 5.0 in the non-coronal), suggesting that French /y/ was not judged as a good exemplar of Korean /u/. These results are consistent with Levy and Strange (2008), in which beginning learners of French whose native language is American English perceptually assimilated French front rounded vowels to the corresponding back vowels of English and did so more in alveolar contexts than in bilabial contexts (Section 1).

It is known that lip rounding in producing vowels exhibits an acoustic effect that lowers the third-formant (F3) value. The rounder shape of the lips, the lower of the F3, mainly because lip rounding during vowel articulation increases the length of the oral cavity (e.g., Levy 2009a). The F3 value is a useful acoustic feature for languages like French or German which contrast front unrounded vs. front rounded vowels: The F3 values of front rounded vowels are generally lower than those of corresponding front unrounded vowels. Ladefoged (2003) stated that it is necessary to plot F1 vs. F3, not only F1 vs. F2, to show the front rounded vowels. Figure 2 presents the F1-F3 (measured at the midpoint of vowel duration) dimension for French and Korean high vowels in the non-coronal contexts used in the present study. The F3 value of French /y/ (in 'pu' /py/) was 2410 Hz, that of /i/ (in 'qui' /ki/) 3535 Hz, and that of /u/ (in 'cou' /ku/) 2373 Hz. The mean F3 value of Korean /i/ (in '비' /pi/) was 3724 Hz (SD 145 Hz), that of /ɯ/ (in '브' /pɯ/) 2914 Hz (SD 177 Hz), and that of /u/ (in '부' /pu/) 2571 Hz (SD 142 Hz). In the F1 vs. F3 dimension, French /y/ is closest to Korean /u/ among the Korean high vowels. The perceptual assimilation of French /y/ to Korean /u/ instead of Korean

/i/ or /ɯ/ might have been because listeners focused on the acoustic feature reflecting lip rounding of the front rounded vowel in the French vowel perception.
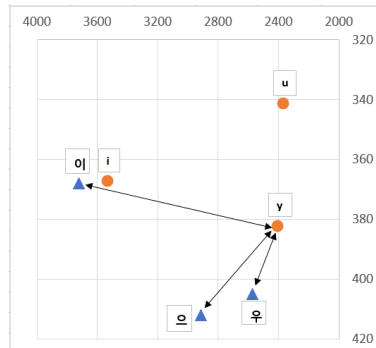

Figure 2. The F1 (vertical axis; Hz) vs. F3 (horizontal axis; Hz) dimension for French (orange circles) and Korean (blue triangles) high vowels produced in non-coronal contexts.

Mayr and Escudero (2010), through a perceptual assimilation task, found that native English learners of German assimilated German /y/ to English /u/ 98% of the time and German /u/ to English vowels other than /u/ 20% of the time. This may be interpreted as having occurred due to the fronting process of English /u/, a sound change in which the vowel /u/ is produced at a more front part of the mouth (e.g., Ash 1996; Fought 1999). As a result of this process, English /u/ became phonetically closer to German /y/. German /u/ is more of a back vowel, so some listeners may have assimilated German /u/ to English vowels other than the fronted /u/. However, Korean does not have an /u/-fronting process and so the same interpretation with the English listeners' perceiving the FL /y/ does not apply to the results of the present study. It appears more plausible to interpret the perceptual assimilation of French /y/ to Korean /u/ as the acoustic cue related to lip rounding of the front rounded vowel is prominent in the FL vowel perception.

4.2 The perceptual assimilation of French mid front unrounded /e/ and /ɛ/

In the mid-front vowel region, Korean has one vowel /e/, whereas French higher-mid /e/ contrasts with lower-mid /ɛ/. In both consonantal contexts, French /e/ was assimilated to Korean /i/ (response percentage 91.7%, goodness rating 5.3 in the non-coronal; 55.6%,

4.6 in the coronal), and French /ɛ/ was assimilated to Korean /e/ (94.4%, 7.0 in the non-coronal; 100%, 7.6 in the coronal). As seen in Figure 1 and the Appendix, French /e/ is closer to Korean /e/ than Korean /i/ in the F1-F2 dimension, and the pattern is interesting in that French /e/ was assimilated to Korean /i/ instead of /e/. The acoustic differences between French /e/ and Korean /i/ in the non-coronal contexts are 117 Hz for F1 (= |485 Hz − 368 Hz|) and 581 Hz for F2 (= |2337 Hz − 2918 Hz|), and the differences between French /e/ and Korean /e/ are 79 Hz for F1 (= |485 Hz − 564 Hz|) and 92 Hz for F2 (= |2337 Hz − 2429 Hz|). The acoustic differences between French /e/ and Korean /i/ in the coronal contexts are 144 Hz for F1 (= |507 Hz − 363 Hz|) and 578 Hz for F2 (= |2353 Hz − 2931 Hz|), and the differences between French /e/ and Korean /e/ are 57 Hz for F1 (= |507 Hz − 564 Hz|) and 124 Hz for F2 (= |2353 Hz − 2477 Hz|). That is, although French /e/ and Korean /e/ were more similar than French /e/ and Korean /i/ in both F1 and F2 values, French /e/ was assimilated to Korean /i/. It is difficult to explain this perceptual assimilation pattern using only the acoustic distances between the FL and L1 vowels (cf., Strange, Bohn, Trent, and Nishi 2004).

4.3 The perceptual assimilation as a function of consonantal contexts

The perceptual assimilation patterns of French to Korean vowels did not differ depending on the consonantal contexts except the two French vowels (/ø/ and /œ/), which were assimilated to different Korean vowels in the non-coronal vs. coronal contexts (Section 3.3). These vowels are in the front rounded vowel series in French that do not exist in Korean. French higher-mid front rounded /ø/ was assimilated to Korean high back unrounded /ɯ/ in the non-coronal context (response percentage 91.7%; goodness rating 5.5) and to Korean high back rounded /u/ in the coronal context (80.6%; 4.1). French lower-mid front /œ/, which does not have a corresponding vowel height in Korean, was assimilated to Korean mid back unrounded /ʌ/ in the non-coronal context (47.2%; 4.9) and Korean mid front unrounded /e/ in the coronal context (91.7%; 5.8). A slight /œ/ fronting occurred in the coronal context (F2 1746 Hz in the non-coronal vs. 1816 Hz in the coronal). This coarticulatory variation in the coronal context might have caused the different perceptual assimilation patterns, the vowel being perceived as the L1 front /e/, rather than the back /ʌ/, in the corresponding context (cf., Ash 1996; Fought 1999). As such, while there were cases in which the contextual variations in acoustic values

seemed to affect the assimilation patterns in the L2 vowel perception, not all cases can be explained by the contextual changes in the vowels. In the case of French /ø/, vowel fronting did not occur in the coronal context (F2 1648 Hz) compared to the non-coronal context (F2 1646 Hz). It is difficult to explain why French /ø/ was assimilated to Korean /ɯ/ in the non-coronal context, and yet to Korean /u/, which is a back vowel, in the coronal context.

Some French vowels were assimilated to the same Korean vowel in both consonantal contexts, but their response percentages differed considerably as a function of the contexts. There were three cases in which the differences in the response percentages were at least as large as 30% (Section 3.3). The response percentages of French /e/ to Korean /i/ (91.7% in the non-coronal vs. 55.6% in the coronal) and of French /o/ to Korean /o/ (83.3% vs. 41.7%) were lower in the coronal contexts than in the non-coronal contexts. The response percentage of French /y/ to Korean /u/ (55.6% vs. 100%) was lower in the non-coronal contexts than in the coronal contexts.

The difference in F1 between French /e/ and Korean /i/ is 117 Hz (= |485 Hz – 368 Hz|) in the non-coronal contexts and 144 Hz (= |507 Hz – 363 Hz|) in the coronal contexts. Their difference in F2 is 581 Hz (= |2337 Hz – 2918 Hz|) in the non-coronal contexts and 578 Hz (= |2353 Hz – 2931 Hz|) in the coronal contexts. That is, the difference in F1 between French /e/ and Korean /i/ is considerably larger in the coronal contexts than in the non-coronal contexts. Furthermore, the difference in F1 between French /o/ and Korean /o/ is 69 Hz (= |494 Hz – 425 Hz|) in the non-coronal contexts and 163 Hz (= |581 Hz – 418 Hz|) in the coronal contexts. Their difference in F2 is 97 Hz (= |910 Hz – 813 Hz|) in the non-coronal contexts and 311 Hz (= |1173 Hz – 862 Hz|) in the coronal contexts. That is, the acoustic distances in both F1 and F2 between French /o/ and Korean /o/ are farther in the coronal contexts than in the non-coronal contexts. The reason for the lower response percentages in the coronal contexts for these assimilation pairs may be the larger acoustic differences in the corresponding contexts.

However, the acoustic distances between French /y/ and Korean /u/ cannot explain the difference in the response percentages as a function of the consonantal contexts. The difference in F1 between French /y/ and Korean /u/ is 23 Hz (= |382 Hz – 405 Hz|) in the non-coronal contexts and 79 Hz (= |315 Hz – 394 Hz|) in the coronal contexts. Their difference in F2 is 959 Hz (= |1914 Hz – 955 Hz|) in the non-coronal contexts and 992 Hz (= |2031 Hz – 1039 Hz|) in the coronal contexts. The differences between

French /y/ and Korean /u/ in both F1 and F2 were rather larger in the coronal contexts, but the response percentage was higher in the coronal contexts than in the non-coronal contexts. It is difficult to explain this perceptual assimilation pattern depending on the consonantal contexts in terms of the acoustic distances between the FL and L1 vowels (cf., Strange, Bohn, Trent, and Nishi 2004).

4.4 The PAM patterns of assimilation sets

For the assimilation sets in which two French vowels were assimilated into a single Korean vowel, the PAM patterns appeared as the CG, UC, and SC types (Section 3.4). Three assimilation sets were classified as the CG type in which one French vowel offers a better exemplar of a Korean category than the other [i.e., French /i/ ("Good") and /e/ ("Poor") to Korean /i/ in the non-coronal; French /ɛ/ ("Good") and /œ/ ("Fair") to Korean /e/ in the coronal; French /u/ ("Fair") and /y/ ("Poor") to Korean /u/ in the coronal]. Three assimilation sets were classified as the UC type in which one French vowel was categorized as a Korean vowel and another was not categorized as any Korean vowel [i.e., French /ɔ/ ("Fair") and /œ/ ("Uncategorized") to Korean /ʌ/ in the non-coronal; French /u/ ("Fair") and /y/ ("Uncategorized") to Korean /u/ in the non-coronal; French /i/ ("Fair") and /e/ ("Uncategorized") to Korean /i/ in the coronal]. One assimilation set was classified as the SC type in which two French vowels were judged to be equally bad instances of a Korean vowel [i.e., French /y/ ("Poor") and /ø/ ("Poor") to Korean /u/ in the coronal].

As described in Section 1.1, the PAM argues that difficulty perceiving FL contrasts can be predicted using the PAM patterns in which the FL contrasts are assimilated to L1 categories (e.g., Best 1995; Best and Tyler 2007; Sun and van Heuven 2007; Levy 2009a; Levy 2009b; Suh 2020). Levy (2009b) performed a discrimination task of French vowels by native English listeners and compared the results with those of the Levy (2009a)'s perceptual assimilation task. Learners who perceptually assimilated French /y/ and /u/ as a single English category showed more errors in the French vowel discrimination task, indicating that the perceptual assimilation data could predict learners' discrimination ability (Section 1.3; see also Mayr and Escudero (2010) for similar results regarding the perceptual assimilation of German vowels by native English listeners).

Based on the PAM patterns of the French assimilation sets classified in this study,

it is expected to predict the ability that Korean listeners can discriminate French vowel contrasts. The CG-type vowel contrasts in which one French vowel was a better exemplar of a Korean category than the other (i.e., French /i/-/e/ in the non-coronal; /ɛ/-/œ/ in the coronal; /u/-/y/ in the coronal) are predicted to show "moderate" discrimination. Discriminating the SC-type contrast in which two French vowels were judged to be equally poor instances of a Korean vowel (i.e., /y/-/ø/ in the coronal) is predicted as "difficult." For the UC-type contrasts in which one French vowel was categorized as a Korean vowel and another was not categorized as any Korean vowel (i.e., /ɔ/-/œ/ in the non-coronal; /u/-/y/ in the non-coronal; /i/-/e/ in the coronal), L2 discrimination is predicted as "good." A future study should test whether the perceptual assimilation patterns of French to Korean vowels found in this study can predict Korean listeners' ability to identify and discriminate French vowel contrasts.[2] Although the perceptual assimilation task of FL sounds was designed to target participants without knowledge of the FL, it has sometimes been implemented by including experienced learners in order to examine whether the perception of FL sounds depends on the level of FL experience (e.g., Levy 2009a; Levy 2009b). Therefore, it can also be considered whether there are differences in the perceptual assimilation patterns of French vowel contrasts and their discrimination ability by native Korean listeners as a function of the level of French experience.

References

Ash, Sharon. 1996. Freedom of movement: /uw/-fronting in the Midwest. In Jennifer Arnold, Renée Blake, Brad Davidson, Scott Schwenter, and Julie Solomon (eds.), *Sociolinguistic variation: data, theory and analysis: Selected papers from NWAV 23 at Stanford*, 3-25. Stanford, CA: CSLI Publications.

Best, Catherine T. 1995. A direct realist perspective on cross-language speech perception. In

---

2   Kim (2020) conducted perception experiments in which native Korean listeners perceive 14 minimal pairs of French vowels. A discrimination test (a task of listening to two French vowels and determining whether they sound the same or different) and an identification test (a task of listening to one French vowel and selecting a perceived vowel from various options) were conducted. Participants were students who had studied French for more than four years and scored high for accuracy in the perception tests. Since the study reported the results of the perception tests for each vowel contrast group, it is not possible to determine the perception ability of each vowel contrast. For example, the perceptual accuracy was calculated by grouping the minimal pairs /ɛ/-/œ/, /œ/-/ɔ/, and /ɛ/-/ɔ/ together into the lower-mid vowel group.

Winifred Strange (ed.), *Speech perception and linguistic experience: Issues in cross-language research*, 171-204. Baltimore, MD: York Press.

Best, Catherine T. and Michael Douglas Tyler. 2007. Nonnative and second-language speech perception: Commonalities and complementarities. In Ocke-Schwen Bohn and Murray J. Munro (eds.), *Language experience in second language speech learning: In honor of James Emil Flege*, 13-34. Amsterdam: John Benjamins.

Boersma, Paul and David J. M. Weenink. 2016. Praat: Doing phonetics by computer (version 6.0.10) [Computer program]. Retrieved from http://www.praat.org/.

Colantoni, Laura, Jeffrey Steele, and Paola Escudero. 2015. *Second language speech: Theory and practice*. Cambridge: Cambridge University Press.

Fought, Carmen. 1999. A majority sound change in a minority community: /u/-fronting in Chicano English. *Journal of Sociolinguistics* 3(1): 5-23.

Gottfried, Terry L. 1984. Effect of consonant context on the perception of French vowels. *Journal of Phonetics* 12(2): 91-114.

Holliday, Jeffrey J. 2014. The perceptual assimilation of Korean obstruents by native Mandarin listeners. *Journal of the Acoustical Society of America* 135(3): 1585-1595.

Kang, Jieun and Eun Jong Kong. 2016. Static and dynamic spectral properties of the monophthong vowels in Seoul Korean: Implication on sound change [in Korean]. *Phonetics and Speech Sciences* 8(4): 39-47.

Kim, Sunhee. 2020. Une étude sur la perception des voyelles françaises par les apprenants coréens à l'aide de paires minimales [in Korean]. *Enseignement de Langue et Littérature Françaises* 69: 7-29.

Kim, Sunhee, Hye-Sook Park, and Dohee Kim. 2022. Une méthode pour enseigner la prononciation des voyelles orales en français [in Korean]. *Enseignement de Langue et Littérature Françaises* 77: 7-40.

Ladefoged, Peter. 2003. *Phonetic data analysis: An introduction to fieldwork and instrumental techniques*. Malden: Blackwell Publishing.

Levy, Erika S. 2009a. Language experience and consonantal context effects on perceptual assimilation of French vowels by American-English learners of French. *Journal of the Acoustical Society of America* 125(2): 1138-1152.

Levy, Erika S. 2009b. On the assimilation-discrimination relationship in American English adults' French vowel learning. *Journal of the Acoustical Society of America* 126(5): 2670-2682.

Levy, Erika S. and Winifred Strange. 2008. Perception of French vowels by American English adults with and without French language experience. *Journal of Phonetics* 36(1): 141-157.

Mayr, Robert and Paola Escudero. 2010. Explaining individual variation in L2 perception: Rounded vowels in English learners of German. *Bilingualism: Language and Cognition* 13(3): 279-297.

Park, Eun-Mee. 2011. Le système vocalique du français standard: Structure et variation en voyelles moyennes [in Korean]. *Enseignement de Langue et Littérature Françaises* 36: 185-204.

Strange, Winifred, Reiko Akahane-Yamada, Rieko Kubo, Sonja A. Trent, Kanae Nishi, and James

J. Jenkins. 1998. Perceptual assimilation of American English vowels by Japanese listeners. *Journal of Phonetics* 26(4): 311-344.

Strange, Winifred, Reiko Akahane-Yamada, Rieko Kubo, Sonja A. Trent, and Kanae Nishi. 2001. Effects of consonantal context on perceptual assimilation of American English vowels by Japanese listeners. *Journal of the Acoustical Society of America* 109(4): 1691-1704.

Strange, Winifred, Ocke-Schwen Bohn, Sonja A. Trent, and Kanae Nishi. 2004. Acoustic and perceptual similarity of North German and American English vowels. *Journal of the Acoustical Society of America* 115(4): 1791-1807.

Suh, Heajin. 2020. A study on Korean students' perception of English short vowels [in Korean]. *Studies in Linguistics* 55: 265-286.

Sun, Lei and Vincent J. van Heuven. 2007. Perceptual assimilation of English vowels by Chinese listeners: Can native-language interference be predicted? Bettelou Los and Marjo van Koppen (eds.), *Linguistics in the Netherlands 2007*, 150-161.

Yoon, Tae-Jin and Yoonjung Kang. 2014. Monophthong analysis on a large-scale speech corpus of read-style Korean. *Phonetics and Speech Sciences* 6(3): 139-145.

Appendix

Scatterplots of the F1 (vertical axis; Hz) and F2 (horizontal axis; Hz) values of Korean vowels in the non-coronal (left) and coronal contexts (right). The acoustic values of French vowels used in the perceptual assimilation task are superimposed for comparison.
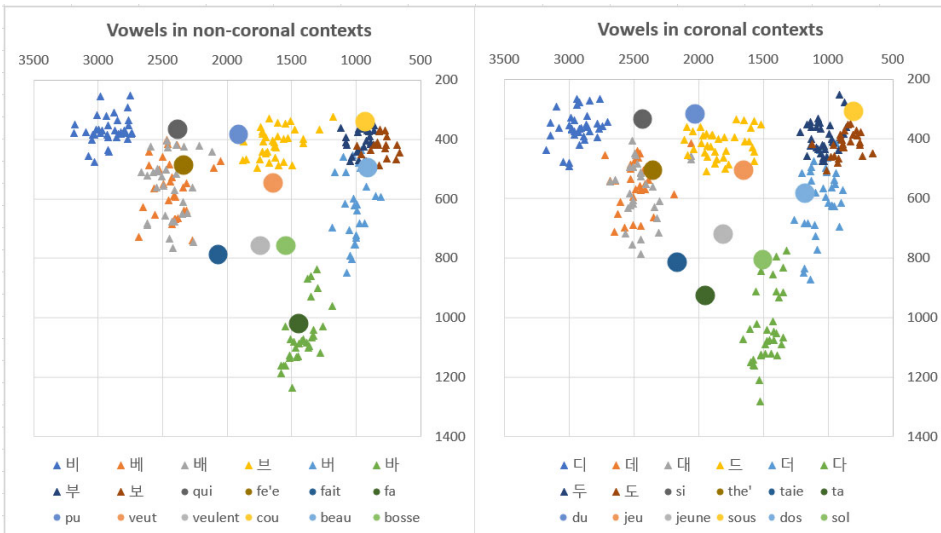
Eunjin Oh
Professor
Division of English Language and Literature
Ewha Womans University
52 Ewhayeodae-gil, Seodaemun-gu
Seoul, 03760 Korea
E-mail: ejoh@ewha.ac.kr