The influence of speech perception on French nasal vowel adaptation in Korean and English[*]

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Seo, Misun, and Park, Ye-Seul. 2011. The influence of speech perception on French nasal vowel adaptation in Korean and English. *Studies in Phonetics, Phonlogy and Morphology* 17.3. 385-404. When a French nasal vowel is borrowed into Korean and English, it is adapted as an oral vowel followed by a nasal consonant. When this process called 'unpacking' occurs, the nasal consonant following an oral vowel is realized as /ŋ/ in Korean and as /n/, /m/ or /ŋ/ in English. In this study we examine the role of speech perception on such different place realization patterns of a nasal consonant in Korean and English during the unpacking of a French nasal vowel. Results of a categorization experiment with Korean and English listeners conducted in this study indicate that the influence of speech perception plays a role but that speech perception is not the only factor affecting French nasal vowel adaptation. In addition to speech perception, other factors such as orthography and phonemic uniformity are found to be in play in the adaptation of a French nasal vowel in Korean and English. **(Hannam University)**

1. Introduction

When a French nasal vowel is borrowed into a language disallowing nasal vowels, it is systematically adapted as an oral vowel followed by a nasal consonant (i.e., ṽ → V + N), not as a single segment. According to Paradis and Prunet (2000), this process called 'unpacking' occurs as long as it results in allowed syllable structures within a language. Loss of nasality (i.e., ṽ → V) rather than unpacking occurs if the unpacking process would generate a disallowed syllable structure. The examples in (1) illustrate the unpacking of French nasal vowels in different languages.

(1) Unpacking of French Nasal Vowels (Paradis and Prunet 2000)
    a. *French*   *Moroccan Arabic*
       comptant   [kɔ̃tɑ̃]   [kʊnta]   'cash'
       assurance   [asyrɑ̃s]   [laṣɪrans, laṣʊrans, laṣɪranṣ]
                                                  'insurance'
    b. *French*   *Fula*
       continent   [kɔ̃tinɑ̃]   [kɔntinan]   'continent'

ingénieur	[ɛ̃ʒenjœr]	[ɛnsɛnjɔr]	'engineer'

c. *French*   *Kinyarwanda*

industrie	[ɛ̃dystri]	[iⁿdisitiri]	'industry'
consul	[kɔ̃syl]	[kʷooⁿsiiri]	'consul'

The unpacking of French nasal vowels is also observed within Korean and English where only oral vowels exist phonemically and there is no contrast between oral and nasal vowels. Both in Korean and English, a French nasal vowel is adapted as an oral vowel followed by a nasal consonant. However, when unpacking a French nasal vowel, Korean and English show different patterns in the place realization of a nasal consonant following an oral vowel. The nasal consonant is consistently realized as /ŋ/ in Korean and as /n/, /m/ or /ŋ/ in English, as illustrated in (2). For the French borrowings in (2), the Korean pronunciations are from Kim (2000) and the English pronunciations from the online Merriam-Webster dictionary (www.merriam-webster.com/dictionary).

(2) Unpacking of French Nasal Vowels in Korean and English
    a. in word-final position

French		*Korean*	*English*
Cancan	[kɑ̃kɑ̃]	[kʰaŋkʰaŋ]	[kǽnkæn]
salon	[salɔ̃]	[salloŋ]	[səlán]
Gobelin	[goblɛ̃]	[kobllɛŋ]	[góʊbələn]

    b. before a coronal consonant

French		*Korean*	*English*	
Dilettante	[diletɑ̃t]	[tillɛt'ant'ɨ]	[dílətànt]	or
			[dɪlətánt]	
Fiancé	[fjɑ̃se]	[pʰiaŋsɛ]	[fiɑnséɪ]	

    c. before a bilabial consonant

French		*Korean*	*English*
Ensemble	[ɑ̃sɑ̃bl]	[aŋsaŋbɨl]	[ansámbəl]
Bombardon	[bɔ̃baʀdɔ̃]	[poŋbarɨdoŋ]	[bámbərdɔn]
Bonbon	[bɔ̃bɔ̃]	[poŋboŋ]	[bánban]

    d. before a velar consonant

French		*Korean*	*English*
Concours	[kɔ̃kuʀ]	[kʰoŋkʰuɾi] or [kʰoŋkʰul]	[kaŋkúər]
Encore	[ɑ̃kɔʀ]	[aŋkʰoɾi] or [ɛŋkʰol]	[áŋkɔr] or [ánkɔr]

As can be seen from the examples in (2), when a French nasal vowel is unpacked in Korean, a nasal consonant following an oral vowel is consistently realized as a velar nasal /ŋ/ regardless of the context in which it occurs. On the other hand, a nasal consonant following an oral vowel is realized as /n/, /m/ or /ŋ/ in English. As can be seen from (2a), a word-final

French nasal vowel is unpacked as an oral vowel plus a coronal nasal /n/ in English. This pattern can be due to the influence of orthography. Examples in (2b)-(2c) confirm that the place realization of a nasal consonant following an oral vowel is affected by orthography. Specifically, the French /ɔ̃b/ sequence is realized as [amb] in [bámbərdɔn] ('bombardon') and as [anb] in [bánban] ('bonbon'). However, examples in (2d) illustrate that orthography is not the only factor determining the place realization of a nasal consonant. The examples in (2d) show that a French nasal vowel can be realized as an oral vowel plus /ŋ/ before a velar consonant.

A goal of this study is to investigate why different place realization patterns of a nasal consonant are attested in Korean and English during the unpacking of French nasal vowels. In doing so, following Silverman (1992), Peperkamp and Dupoux (2003), Peperkamp, Vendelin, and Nakamura (2008), Boersma and Hamann (2009), Calabrese (2009), we explore the influence of speech perception. According to the previous studies mentioned, the adaptation of the loanwords is determined by the perception of foreign sounds. Thus, for example, loanwords with word-final [n] from English and French show different adaptation patterns in Japanese due to the perceptual differences of English and French word-final [n], as discussed in Peperkamp et al. (2008). According to them, different perception patterns of English and French word-final [n] by Japanese listeners result in a following epenthetic vowel for French loanwords and no epenthetic vowel for English loanwords.

To examine the influence of speech perception on the adaptation of French nasal vowels in Korean and English, we tested how French nasal vowels are perceived by Korean and English listeners. That is, by conducting a categorization experiment, we investigated the place realization pattern of a nasal consonant following an oral vowel when the unpacking of French nasal vowels occurs in Korean and English.

This paper is organized as follows. The methodology and the results of the perception experiment are provided in section 2 and 3, respectively. Discussion and conclusion of the present study is provided in section 4.

2. Methodology

2.1 Stimuli

For the categorization experiment, three French nasal vowels /ɑ̃, ɛ̃, ɔ̃/ were recorded in the contexts of #_#, #_da, #_ba and #_ga[1]. A total of 12 non-sense words (3 vowels x 4 positions) were recorded ten times by a female French from Grenoble near Lyon in the Alps. She was in her thirties and

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[1] According to Malécot and Lindsay (1976), Maddieson (1984), and Rogers (2000), there are three nasal vowels /ɑ̃, ɛ̃, ɔ̃/ in modern French as the result of merger between /ɛ̃/ and /œ̃/. Thus, /œ̃/ was excluded from our stimuli.

had lived in Korea for 3 years at the time of the recording. The non-sense words to record were presented in IPA symbols and there was a training session before the recording in order to familiarize the speaker with the IPA symbols. Stimuli recording was made in a sound-attenuated room using a SHURE SM58 microphone and a TASCAM HD-P2 recorder with the setting of 44100 Hz and 16 bit samples. For each stimulus type, five repetitions were taken and presented in the categorization experiment. Thus, each participant was presented with 60 non-sense words in the experiment.

Acoustic analyses of the stimuli presented in the categorization experiment were made to ensure the appropriateness of the stimuli. Nasal vowels illustrate complicated acoustic characteristics due to the interplay of oral formants, nasal formants and nasal anti-formants (Johnson 2003). In the present study, to see whether or not the three types of French nasal vowels were distinctively produced by the French female speaker, F1 and F2 values of French nasal vowels used in the experiment were measured at the point where the amplitude of F1 is reduced with concomitant broadening of its bandwidth. Figure 1 below illustrates F1 and F2 of five repetitions of the perceptual stimuli /ɑ̃, ɛ̃, ɔ̃/.
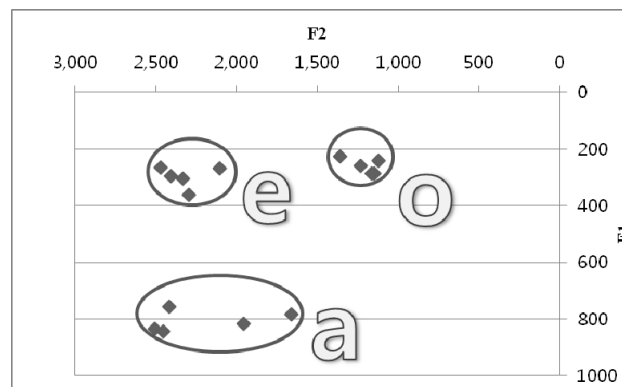
Figure 1. F2 and F1 of five repetitions of the perceptual stimuli /ɑ̃, ɛ̃, ɔ̃/

In Figure 1 above, F2 is plotted on the horizontal axis and F1 on the vertical axis. In addition, scatter plots labeled as 'o' are for /ɔ̃/, those labeled as 'e' are for /ɛ̃/, and those labeled as 'a' are for /ɑ̃/. As shown in Figure 1, our French speaker distinguished /ɔ̃/ and /ɛ̃/ in terms of F2, /ɛ̃/ and /ɑ̃/ in terms of F1, and /ɔ̃/ and /ɑ̃/ in terms of both F1 and F2. To see if these findings are statistically significant, a multivariate analysis of variance (MANOVA) was performed with F1 and F2 as dependent variables and the nasal vowel type (/ɑ̃/, /ɛ̃/ or /ɔ̃/) as an independent variable. According to the analysis, there was a significant main effect for the nasal vowel type regarding F1 (df = 2, F = 388.828, p < .05) and F2 (df

= 2, F = 33.573, p < .05). According to a post-hoc analysis of LSD, F1 was significantly higher with /ɑ̃/ than with /ɛ̃/ or /ɔ̃/ (p < .05) and there was no significant difference between /ɛ̃/ and /ɔ̃/. In addition, F2 was significantly higher with /ɛ̃/ than with /ɔ̃/ and also with /ɑ̃/ than with /ɔ̃/ (p < .05). There was no significant difference between /ɛ̃/ and /ɑ̃/. Thus, it can be said that the French nasal vowel stimuli /ɑ̃, ɛ̃, ɔ̃/ used in our categorization experiment were acoustically distinctive ones.

To see whether or not the places of the consonants /b, d, g/ following a nasal vowel were distinctively pronounced for the /ṽCa/ stimuli by the French speaker, F2 at the boundary of each of the consonants and /a/ was examined. Figure 2 illustrates the F2 values of five repetitions of the perceptual stimuli /ɑ̃ba, ɑ̃da, ɑ̃ga/.
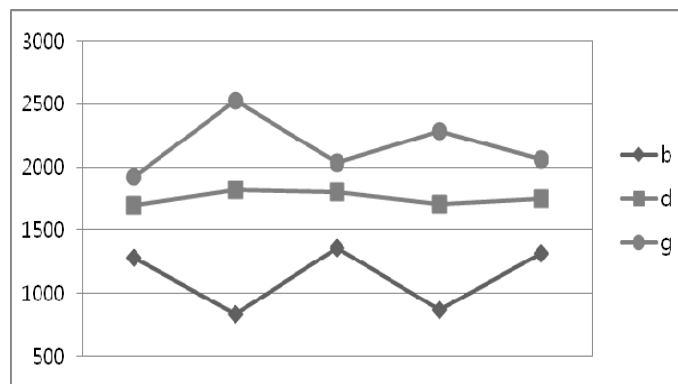
Figure 2. F2 of five repetitions of the perceptual stimuli /ɑ̃ba, ɑ̃da, ɑ̃ga/

As can be seen from Figure 2, /g/ has a high F2, /d/ a middle-level F2 and /b/ a low F2 which is the pattern reported in previous studies (Delattre et al. 1955; Johnson 2003). An analysis of variance (ANOVA) was run with F2 as a dependent variable and the places of consonants (/b/, /d/ or /g/) as an independent variable. According to the analysis, there was a significant main effect of the places of consonants (df = 2, F = 32.097, p < .05). In addition, a post-hoc analysis of LSD showed that there were significant differences between /b/ and /d/, between /d/ and /g/, and between /b/ and /g/ with regard to F2. Thus, it can be said that the places of /b/, /d/ and /g/ following /ɑ̃/ were distinctively produced by our French speaker.

Figure 3 below illustrates the F2 values of five repetitions of the perceptual stimuli /ɛ̃ba, ɛ̃da, ɛ̃ga/.
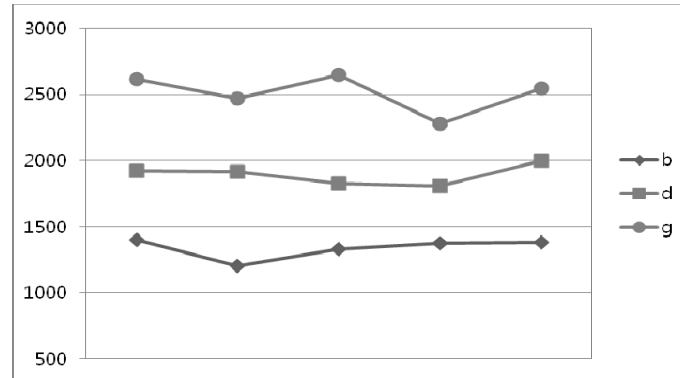
Figure 3. F2 of five repetitions of the perceptual stimuli /ɛ̃ba, ɛ̃da, ɛ̃ga/

As shown in Figure 3, the pattern of the F2 for /b/, /d/ and /g/ following /ɛ̃/ are the same as the consonants following /ɑ̃/. According to an ANOVA, there was a significant main effect of the places of consonants (df =2, F = 150.947, p < .05). In addition, a post-hoc analysis of LSD illustrated that there were significant differences between /b/ and /d/, between /d/ and /g/, and between /b/ and /g/ with respect to F2. This ensures that the places of /b/, /d/ and /g/ were distinctively pronounced by our French speaker.

The F2 values of five repetitions of the perceptual stimuli /ɔ̃ba, ɔ̃da, ɔ̃ga/ are shown in Figure 4.

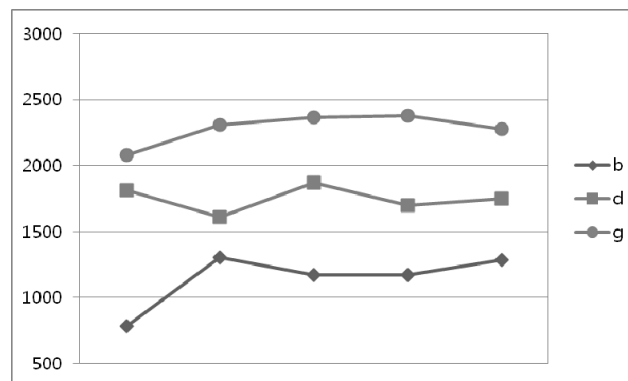**Figure 4. F2 of five repetitions of the perceptual stimuli /ɔ̃ba, ɔ̃da, ɔ̃ga/**

As in the contexts of ɑ̃_ and ɛ̃_, F2 was the highest for /g/, followed by /d/ and /b/ in the context of ɔ̃_. According to an ANOVA, there was a significant main effect of the places of consonants (df = 2, F = 71.486, p < .05). Additionally, a post-hoc analysis of LSD showed that there were

significant differences between /b/ and /d/, between /d/ and /g/, and between /b/ and /g/ with respect to the F2 values. Thus, the F2 values of /b, d, g/ shows that the places of the consonants used in our categorization experiment were acoustically distinctive ones in each of the contexts.

2.2 Participants

Fifteen native speakers of Korean (9 males, 6 females) participated in the categorization experiment. They were all students at a university in the Daejeon area. None of the Korean participants had studied French except one who had studied French for 6 months as an adult and rated her proficiency in French as poor. For the proficiency in English, 4 participants rated it as low medium, 9 as medium and 2 as high medium. In addition, fifteen native speakers of English (10 males, 5 females) from North America participated in the categorization experiment. The English listeners were visiting students at a university or English teachers in the Dajeon area. Of the 15 English listeners, 4 were in their twenties, 6 in their thirties, 3 in their forties and 2 in their fifties. According to English-speaking participants' self-assessment of their knowledge of French, 14 rated their knowledge as poor and 1 as medium. For the knowledge of Korean, 13 rated as poor, 1 as medium and 1 as high medium. None of the participants reported any past or present speech or hearing disorders. All of the participants were paid for their participation in the experiment.

2.3 Procedure

With the stimuli produced by a female French speaker, 15 native speakers of Korean and 15 native speakers of English performed a forced-choice categorization task. In this task, the participants were instructed to choose a nasal consonant they thought they heard. For instance, upon hearing the stimulus [ɑ̃], the three choices [am], [an] and [aŋ] provided in the alphabets of participants' language were given on a computer screen and the participants were asked to choose one of them they heard by pressing a relevant button on a keyboard. For the familiarization with the test, before starting the main session, each participant was trained with a trial session consisting of 3 English words.

Each participant was asked to perform the categorization task one at a time in a quiet room. In the task, each participant heard 60 stimuli played through headphones (SONY MDR 7505) using the E-prime program installed on a laptop computer. The stimuli were presented to each participant in a randomized order and at a constant volume level.

3. Results

In presenting the result of the categorization experiment according to a

context, the responses by each vowel type will be merged together since similar patterns were observed within each context of '_#', '_d', '_b' and '_g' in all the vowel types. For the responses for each type of the vowels, see Appendix.

Figure 5 below shows the percentage of responses for the word-final French nasal vowels (i.e. /ɑ̃, ɛ̃, ɔ̃/) by Korean and English listeners.
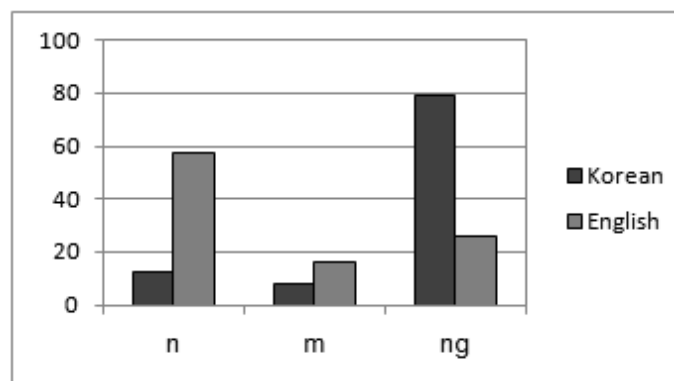

Figure 5. Percentage of responses in categorizing word-final nasal vowels

As can be seen from Figure 5, Korean listeners categorized a word-final French nasal vowel as an oral vowel plus a velar nasal /ŋ/ (79.1%) most frequently, followed by an oral vowel plus an alveolar nasal (12.9%) and an oral vowel plus a bilabial nasal (8.0%). On the other hand, English listeners showed a tendency to categorize a word-final French nasal vowel as an oral vowel followed by an alveolar nasal /n/ (57.8%) most frequently. The percentage of the categorization as an oral vowel followed by /m/ or /ŋ/ was 16.4 % and 25.4 %, respectively. The crosstabulation in Table 1 shows the relationship for the two variables of groups and responses in the categorization of word-final French nasal vowels by Korean and English listeners. In Table 1, "observed" refers to the observed number of tokens and "expected" the expected number of tokens.

Table 1. Groups * responses crosstabulation for the word-final nasal vowel (ṽ) stimuli (percentage in parentheses)

Stimuli	Group		Responses			Total
			Vn	Vm	Vŋ	
ṽ	Korean	Observed	29 (12.9)	18 (8.0)	**178 (79.1)**	225
		Expected	79.5	27.5	118	225
	English	Observed	**130 (57.8)**	37 (16.4)	58 (25.8)	225
		Expected	79.5	27.5	118	225
	Total	Observed	159	55	236	450
		Expected	159	55	236	450

In order to examine whether or not there is a relationship between the two variables in the above table, a chi-square test was conducted. According to the test, there was a strong relationship between the two variables, groups and responses [χ^2 (2) = 131.738, p < .05]. This result indicates that the two variables are not independent of each other.

As can be seen from the crosstabulation in Table 1, Korean listeners categorized /ṽ/ as /Vŋ/ in 178 trials out of the total of 225. To see whether or not Korean listeners' categorization of /ṽ/ as /Vŋ/ in 178 trials out of 225 occurred by chance, the binomial probability was calculated. In our categorization experiment, listeners were asked to choose one out of the three possible response options (i.e. /Vn/, /Vm/ or /Vŋ/). Thus, each response option has about 33% of probability being chosen. The binomial probability that one such response occurs 178 times out of 225 trials is smaller than 0.01%. This suggests Korean listeners' categorization of /ṽ/ as /Vŋ/ in 178 times out of 225 trials did not occur by chance. English listeners categorized /ṽ/ as /Vn/ in 130 trials out of 225. The binomial probability of getting the response option /Vn/ (which has the probability of 33%) in 130 trials out of 225 is smaller than 0.01%. Thus, it can be said that English listeners' categorization of /ṽ/ as /Vn/ in 130 trials out of 225 did not occur by chance.

Figure 6 below illustrates the percentage of responses for the stimuli containing the nasal vowel (ṽ) plus /d/ sequence (i.e., /ãda, ɛ̃da, ɔ̃da/) by Korean and English listeners. Both Korean and English listeners tended to categorize /ṽd/ as /Vnd/ (75.6 % and 90.2 %, respectively) most frequently. The percentage of categorizing /ṽd/ as /Vmd/ was 5.8 % for Korean listeners and 4.4 % for English listeners. In addition, /ṽd/ was categorized as /Vŋd/ in 18.7 % of the trials by Korean listeners and in 5.3 % of the trials by English listeners.
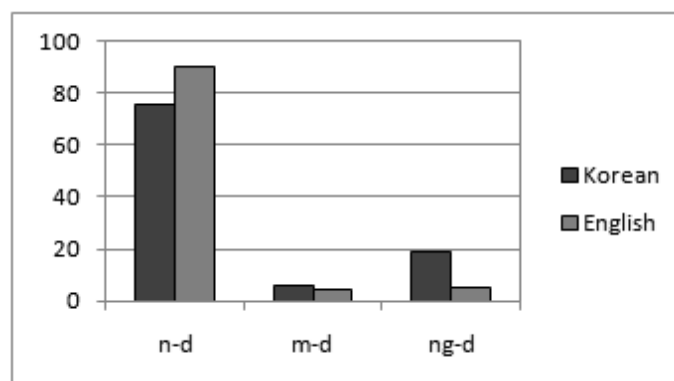
Figure 6. Percentage of responses in categorizing French nasal vowel plus /d/ sequences

The crosstabulation in Table 2 illustrates the relationship for the two variables of group and responses in the categorization of /ṽd/ by Korean and English listeners. According to a chi-square test, there was a strong relationship between the two variables, groups and responses in Table 2 [χ^2 (2) = 19.978, p < .05].

Table 2. Groups * responses crosstabulation for the /ṽd/ stimuli
(percentage in parentheses)

Stimuli	Group		Responses			Total
			Vnd	Vmd	Vŋd	
ṽd	Korean	Observed	**170 (75.6)**	13 (5.8)	42 (18.7)	225
		Expected	186.5	11.5	27	225
	English	Observed	**203 (90.2)**	10 (4.4)	12 (5.3)	225
		Expected	186.5	11.5	27	225
	Total	Observed	373	23	54	450
		Expected	373	23	54	450

For the /ṽd/ stimuli, as shown in Table 2 above, Korean listeners categorized them as /Vnd/ in 170 trials out of 225. The binomial probability of getting the response option /Vnd/ (which has about 33% of probability being chosen) in 170 trials out of 225 is smaller than 0.01%. Thus, it cannot be said that Korean listeners' categorization of /ṽ/ as /Vnd/ in 170 trials out of 225 occurred by chance. English listeners categorized /ṽd/ as /Vnd/ in 203 trials out of 225. The binomial probability of getting

the response option /Vnd/ with about 33% of probability being chosen in 203 trials out of 225 is smaller than 0.01%. Therefore, this result could not occur by chance.

Figure 7 illustrates the percentage of responses for the stimuli containing the nasal vowel (ṽ) plus /b/ sequence (i.e., /ɑ̃ba, ɛ̃ba, ɔ̃ba/) by Korean and English listeners. The /ṽb/ stimuli tended to be categorized as /Vmb/ by both Korean and English listeners (65.3 % and 76.9 %, respectively) most frequently. The percentage of categorizing /ṽb/ as /Vnb/ was 24.0 % for Korean listeners and 20.4 % for English listeners. The categorization of /ṽb/ as /Vŋb/ showed the least response rate. It was 10.7 % for Korean listeners and 2.7 % for English listeners.

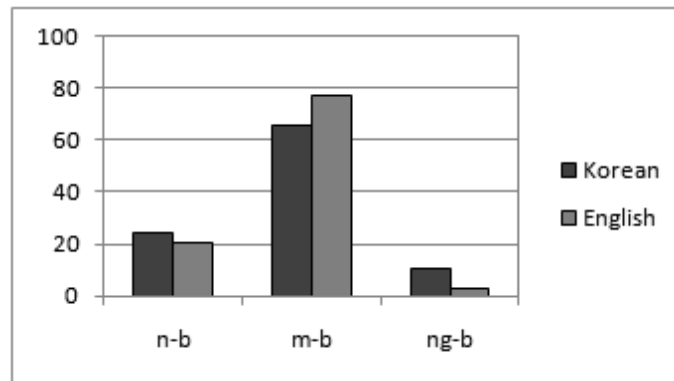**Figure 7. Percentage of responses in categorizing French nasal vowel plus /b/ sequences**

The crosstabulation in Table 3 illustrates the relationship for the two variables of group and responses in the categorization of /ṽb/ by Korean and English listeners. According to a chi-square test, there was a strong relationship between the two variables in the table above [$\chi^2 (2) = 13.553$, $p < .05$].

Table 3. Groups * responses crosstabulation for the /ṽb/ stimuli
(percentage in parentheses)

Stimuli	Group		Responses			Total
			Vnb	Vmb	Vŋb	
ṽb	Korean	Observed	54 (24.0)	**147 (65.3)**	24 (10.7)	225
		Expected	50	160	15	225
	English	Observed	46 (20.4)	**173 (76.9)**	6 (2.7)	225
		Expected	50	160	15	225
	Total	Observed	100	320	30	450
		Expected	100	320	30	450

As can be seen from Table 3 above, Korean listeners categorized /ṽb/ as /Vmb/ in 147 trials out of 225. According to the binomial probability calculation, the chance of getting the response option /Vnd/ (which has about 33% of probability being chosen) in 147 trials out of 225 is smaller than 0.01%, suggesting that the result did not occur by chance. English listeners categorized /ṽd/ as /Vnd/ in 173 trials out of 225 and the binomial probability of this event is smaller than 0.01%. Therefore, this result could not occur by chance.

The percentage of responses for the stimuli containing the nasal vowel (ṽ) plus /g/ sequence (i.e., /ɑ̃ga, ɛ̃ga, ɔ̃ga/) by Korean and English listeners is illustrated in Figure 8. The /ṽg/ stimuli tended to be categorized as /Vŋg/ most frequently by both Korean and English listeners (66.7 % and 59.6 %, respectively), followed by as /Vng/ (28.0 % and 38.2 %) and /Vmg/ (5.3 % and 2.2 %).
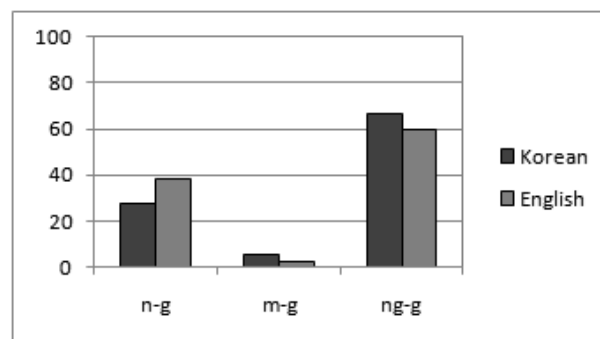
Figure 8. Percentage of responses in categorizing French nasal vowel plus /g/ sequences

The groups * responses crosstabuli for the /ṽg/ stimuli is given in Table 4 below. According to a chi-square test, there was a strong relationship between the two variables in Table 4 [χ^2 (2) = 7.334, p < .05].

Table 4. Groups * responses crosstabulation for the /ṽg/ stimuli
(percentage in parentheses)

Stimuli	Group		Responses			Total
			Vng	Vmg	Vŋg	
ṽg	Korean	Observed	63 (28.0)	12 (5.3)	**150 (66.7)**	225
		Expected	74.5	8.5	142	225
	English	Observed	86 (38.2)	5 (2.2)	**134 (59.6)**	225
		Expected	74.5	8.5	142	225
	Total	Observed	149	17	284	450
		Expected	149	17	284	450

As can be seen from Table 2 above, Korean listeners categorized /ṽg/ as /Vŋg/ in 150 trials out of 225. The binomial probability of getting the response option /Vŋg/ (which has about 33% of probability being chosen) in 150 trials out of 225 is smaller than 0.01%. Thus, it can be said that Korean listeners' categorization of /ṽg/ as /Vŋg/ in 150 trials out of 225 did not occur by chance. English listeners categorized /ṽg/ as /Vŋg/ in 134 trials out of 225. The binomial probability of getting this result is smaller than 0.01%, thereby suggesting that this result did not occur by chance.

4. General discussion and conclusion

From the categorization experiment, it was found that French nasal vowels in word final position were more likely to be categorized as /Vŋ/ rather than /Vn/ or /Vm/ by Korean listeners. Thus, it can be said that speech perception plays a major role in the adaptation of a word-final French nasal vowel in Korean. As mentioned in section 1, a word-final French nasal vowel is adapted as an oral vowel followed by /ŋ/ in Korean. The unpacking of a word-final French nasal vowel as /Vn/ rather than as /Vm/ or /Vŋ/ in English can also be said to be influenced by speech perception.[2] According to our categorization experiment, word-final French nasal

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[2] As pointed out by a reviewer, in categorizing /ɔ̃/, English listeners exhibited similar rates for the responses /ɔn/ (33.3%), /ɔm/ (41.3%) and /ɔŋ/ (25.3%), as shown in Appendix A. Despite such perceptual variations according to a vowel, a consistent pattern is observed in the adaptation of the French nasal vowels. We leave this to a future study.

vowels were more likely to be perceived as /Vn/ than /Vm/ or /Vŋ/ by English listeners.

These results of our categorization experiment illustrate that the same foreign input can be perceived differently by listeners with different L1 backgrounds. In a substantial number of previous studies, this has been reported and attributed to different phonological (i.e. segmental and structural) properties of languages (Massaro and Cohen 1983; Werker and Tees 1984; Dupoux et al. 1997; Dupoux et al. 1999; Sebastián-Gallés and Bosch 2002). The results of the present study are interesting considering the same phonological properties of nasal consonants in Korean and English. Both Korean and English have the same inventory of nasal consonants /m, n, ŋ/ and the three nasals can occur word-finally in both languages. Despite the same phonological properties of nasal consonants in their native languages, it was found that Korean and English listeners perceived different nasal consonants during the unpacking of French nasal vowels in the present study. It is possible that such results were obtained in our study since perceptual similarity between the French input and its correspondence in L1 is different in Korean and English. Drawing on Steriade (2001)'s P-map hypothesis, according to which speakers possess knowledge of perceptual similarity between strings of sound, Yip (2002, 2006), Kang (2003), Kenstowicz (2003, 2007), Fleischhacker (2005), Kawahara (2006), Miao (2006), Shinohara (2006) and Kang et al. (2008) propose that a foreign input is adapted as the native form which is perceptually closest to the foreign input. Thus, it is possible that a word-final French nasal vowel was categorized as /Vŋ/ by Korean listeners and as /Vn/ by English listeners since a French nasal vowel was perceived as being closest to /Vŋ/ by Korean listeners and to /Vn/ by English listeners.

As for French nasal vowels occurring before /b/, /d/ or /g/, both Korean and English listeners were more likely to categorize them as /Vm/, /Vn/ and /Vŋ/, respectively. In English, as mentioned in section 1, French nasal vowels before /d/ or /g/ (i.e. /d/ or /g/) are adapted as /Vn/ and /Vŋ/, respectively. Thus, it can be said that the adaptation of French /d/ and /g/ in English is the result of the influence of speech perception. As for the adaptation of French nasal vowels occurring before /b/ (i.e. /ṽb/), if speech perception played a role, /Vm/ would be the adapted form in English. However, as discussed in section 1 by referring to the examples in (2c), orthography influences the adaptation and thus /ṽb/ is adapted as /Vmb/ or /Vnb/ depending on the orthography of a word. This result shows that speech perception is not the only factor influencing the adaptations of loanwords. In addition to speech perception, orthography can be a factor affecting loanword adaptation and the role of orthography of the source language in loanword adaptation was previously noted by Dohlus (2005), Smith (2006), Vendelin and Peperkamp (2006), and Detey and Nespoulous (2008).

Unlike in English, a French nasal vowel is adapted as /Vŋ/ whether it

occurs before /b/, /d/ or /g/ in Korean. Contrary to this adaptation pattern, according to our experiment, Korean listeners were more likely to categorize a French nasal vowel as /Vm/ before /b/, /Vn/ before /d/ and /Vŋ/ before /g/ just like English listeners. The adaptation of French nasal vowels as /Vŋ/ in Korean across different contexts can be due to phonemic uniformity (or leveling). Phonemic uniformity is a force driving segmental adaptations to become phonemically uniform. Thus, if phonemic uniformity plays a role in the adaptation of French nasal vowels, the contextual variation of nasal consonants would not be allowed when the unpacking of French nasal vowels occurs in Korean. Instead, a uniform nasal consonant would be preferred. The role of phonemic uniformity in loanword adaptation was mentioned in previous studies such as Peperkamp et al. (2008) and Kang (2010). According to them, despite the variable perception data in laboratory experiments, established adaptation patterns are more systematic and regular since a process of standardization takes place as established loanwords develop.

Attributing the adaptation of French nasal vowels as /Vŋ/ in Korean to phonemic uniformity raises a question: what makes /ŋ/ (rather than /n/ or /m/) be selected as the nasal consonant following an oral vowel in French nasal vowel adaptation? The selection of /ŋ/ could be related to the higher frequency rate of perceiving French nasal vowels as /Vŋ/. According to our experiment, Korean listeners' perception of French nasal vowels as /Vŋ/ was attested more frequently, that is, both in word final position and before /g/. On the other hand, perceiving nasal vowels as /Vn/ or /Vm/ were observed only before /d/ and /b/, respectively. Thus, such a perception pattern could have affected the selection of /ŋ/ as a uniform nasal consonant following an oral vowel in loanword adaptation.

Although the present study suggests that phonemic uniformity plays a role in French nasal vowel adaptation in Korean, there are plenty of cases showing that not all segmental adaptations become phonemically uniform. For example, English /s/ is adapted as /s'/ in prevocalic or word-final position and as /s/ elsewhere in Korean (Kim and Curtis 2002; Ahn and Iverson 2004; Davis and Cho 2006; Kang 2008). In addition, according to Kenstowicz and Suchato (2006), English /v/ is adapted as /w/ in onset position and as /p/ in coda position in Thai. As for the issue of when phonemic uniformity is in play and when not, we leave it to a future study.

The present study explored the influence of speech perception on the adaption of French nasal vowels in Korean and English and it was found that speech perception is not the only factor affecting loanword adaptation. As discussed, it can be said that loanword adaptation is a much more complex phenomenon, which is affected by other factors such as orthography and phonemic uniformity as well.

Appendix A. Percentage and frequency of responses in categorizing /ɑ̃, ɛ̃, ɔ̃/ (percentage in parentheses)

Group	Vowel	Responses			Total
		/n/	/m/	/ŋ/	
Korean	/ɑ̃/	7 (9.3)	4 (5.3)	64 (85.3)	75 (100)
	/ɛ̃/	18 (24.0)	6 (8.0)	51 (68.0)	75 (100)
	/ɔ̃/	4 (5.3)	8 (10.7)	63 (84.0)	75 (100)
English	/ɑ̃/	50 (66.7)	1 (1.3)	24 (32.0)	75 (100)
	/ɛ̃/	55 (73.3)	5 (6.7)	15 (20.0)	75 (100)
	/ɔ̃/	25 (33.3)	31 (41.3)	19 (25.3)	75 (100)

Appendix B. Percentage and Frequency of Responses in Categorizing /ɑ̃d, ɛ̃d, ɔ̃d/ (percentage in parentheses)

Group	Vowel	Responses			Total
		/n/	/m/	/ŋ/	
Korean	/ɑ̃/	48 (64.0)	4 (5.3)	23 (30.7)	75 (100)
	/ɛ̃/	64 (85.3)	2 (2.7)	9 (12.0)	75 (100)
	/ɔ̃/	58 (77.3)	7 (9.3)	10 (13.3)	75 (100)
English	/ɑ̃/	65 (86.7)	4 (5.3)	6 (8.0)	75 (100)
	/ɛ̃/	72 (96.0)	0 (0)	3 (4.0)	75 (100)
	/ɔ̃/	66 (88.0)	6 (8.0)	3 (4.0)	75 (100)

Appendix C. Percentage and Frequency of Responses in Categorizing /ɑ̃b, ɛ̃b, ɔ̃b/ (percentage in parentheses)

Group	Vowel	Responses			Total
		/n/	/m/	/ŋ/	
Korean	/ɑ̃/	17 (22.7)	48 (64.0)	10 (13.3)	75 (100)
	/ɛ̃/	19 (25.3)	53 (70.7)	3 (4.0)	75 (100)
	/ɔ̃/	18 (24.0)	46 (61.3)	11 (14.7)	75 (100)
English	/ɑ̃/	14 (18.7)	59 (78.7)	2 (2.7)	75 (100)
	/ɛ̃/	22 (29.3)	52 (69.3)	1 (1.3)	75 (100)
	/ɔ̃/	10 (13.3)	62 (82.7)	3 (4.0)	75 (100)

Appendix D. Percentage and Frequency of Responses in Categorizing /ɑ̃g, ɛ̃g, ɔ̃g/ (percentage in parentheses)

Group	Vowel	Responses			Total
		/n/	/m/	/ŋ/	
Korean	/ɑ̃/	15 (20.0)	5 (6.7)	55 (73.3)	75 (100)
	/ɛ̃/	29 (38.7)	5 (6.7)	41 (54.7)	75 (100)
	/ɔ̃/	19 (25.3)	2 (2.7)	54 (72.0)	75 (100)
English	/ɑ̃/	23 (30.7)	3 (4.0)	49 (65.3)	75 (100)
	/ɛ̃/	32 (42.7)	1 (1.3)	42 (56.0)	75 (100)
	/ɔ̃/	31 (41.3)	1 (1.3)	43 (57.3)	75 (100)

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