The effect of assimilation contexts in word detection*

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Lee, Shinsook. 2005. The effect of assimilation contexts in word detection. *Studies in Phonetics, Phonology and Morphology* 11.1. 105-124. This paper investigated whether compensation for phonological assimilation is brought on by language-specific mechanisms. To this end, this paper tested Korean obstruent nasalization, which exists in Korean, and English obstruent nasalization, which does not occur in English, by Korean speakers of English and English native speakers, using a word detection task. Overall, it has been shown that compensation for phonological variation is induced by language-specific mechanisms. This is because Korean participants compensated for both Korean and English obstruent nasalizations in a highly context-sensitive way, whereas English participants didn't show the same pattern. However, some universal mechanisms such as feature parsing and lexical compensation mechanisms may also contribute to compensation for phonological variation to some degree, as phonological viability was affected by lexical status even in the non-native process. Specifically, Korean participants showed a strong context effect for words for the native process and English participants showed a marginal effect for words for the non-native process. In addition, it has been shown that language-specific compensation for phonological assimilation is at work even in a compound noun structure without any higher-order of syntactic/semantic contextual information. **(Hoseo Universtiy)**

Keywords: assimilation contexts, compensation, speech perception, obstruent nasalization, language-specific, universal and lexical mechanisms

1. Introduction

The perception of words in continuous speech is complicated by phonological processes such as assimilation, deletion, and insertion, which cause the phonetic forms of words to be realized differently depending on the phonological context in which they occur. For example, the word *send* may be produced as [sɛm] in the context "Send me the file", where the final [d] is deleted and the [n] assimilates in place to the following labial segment. Similarly, it may emerge as [sɛndʒ] in the context "Did she send you the file", where the final [d] is palatalized (and spirantized) due to the following glide. It may also surface as [sɛn] in the context "Send Tom the file", where only the deletion of [d] occurs. These

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phonological processes are very productive in natural speech, but they do not appear to interfere with spoken word recognition. That is, [sɛm] is interpreted as *send* in the above context by English speakers, in spite of the changes brought by phonological processes. (Barry 1992; Marslen-Wilson, Nix and Gaskell 1995; Stevens 1998).

Then what are the mechanisms responsible for this phenomenon? Researchers have explored three approaches to this question. One is a language-specific compensation (or processing) mechanism, another is a universal compensation mechanism, and the third is a lexical compensation mechanism. Yet, up to now, not many studies have been conducted to test the validity of language-specific compensation mechanisms. Also, most research on language-specific compensation mechanisms has examined a native assimilation process by native speakers of a particular language and further it has usually investigated words but not nonce words. Moreover, studies on the perceptual effects of native-language phonological processes in foreign language learning are extremely rare.

This paper, thus, aims to investigate whether Korean speakers of English and English native speakers employ language-specific mechanisms to compensate for phonological assimilation. Specifically, the paper examines obstruent nasalization where a syllable-final obstruent assimilates in nasality to a following nasal segment, as it exists in Korean (e.g., /kuk+mul/ [kuŋ.mul] 'broth') but does not occur in English (e.g., *stock market* [stak.mar.kɪt] *[staŋ.mar.kɪt]). If compensation for assimilation is language-specific, it is expected that Korean speakers of English should compensate not only for the native Korean obstruent nasalization but also for the non-existing English obstruent nasalization. However, English native speakers should not compensate either for English or for Korean assimilation. Consequently, this paper explores the following research questions: 1. whether there is a language-specific effect of assimilation context in detecting target words; 2. whether the assimilation context effect is observed for both Korean and English; 3. whether there exists any difference in terms of words and nonce words as to detecting targets, in order to examine whether lexical and universal compensation mechanisms also play a role in the perception of obstruent nasalization. Additionally, the paper inquires into word detection in a compound noun structure instead of phoneme detection in a sentential context, as in Mitterer and Blomert (2003). This is because most studies have examined phonological context effects at the sentence level, since higher level of syntactic and semantic information has been assumed to be helpful in detecting the target phonemes or words (Marslen-Wilson, Nix and Gaskell 1995). Thus, the present study purports to examine

whether language-specific compensation mechanisms are working even without any higher-order contextual information, by using a compound noun structure.

The paper is structured as follows: Section 2 presents a brief overview on compensation mechanisms for phonological variation. Section 3 looks at obstruent nasalization, in particular, its different behavior with respect to Korean and English. Section 4 conducts an experiment on the perception of Korean and English obstruent nasalizations by Korean speakers of English and English native speakers. It also discusses the results, based on the research questions addressed above. Section 5 concludes the paper.

2. Mechanisms of compensation for phonological variation

Assimilation processes cause syllable-(or word-)final consonants to become more like a following syllable-(or word-)initial consonant in place, in manner, or in both. Yet, speakers of a language do not seem to have much difficulty detecting syllable-(or word-)final consonants in spite of the changes brought by assimilation processes. In order to account for this phenomenon, three classes of compensation mechanisms have been put forward in the literature: Language-specific compensation (or processing) mechanisms, universal compensation mechanisms, and lexical compensation mechanisms.

Proponents of language-specific compensation mechanisms claim that listeners have implicit knowledge of the phonological processes in their own language. Given such knowledge, in the process of speech perception, speakers of a native language may overcome assimilation by undoing the effect of assimilation rules in a given context, in particular, when the context is a legitimate one for assimilation (Lahiri and Marslen-Wilson 1992; Marslen-Wilson, Nix and Gaskell 1995; Gaskell and Marslen-Wilson 1998). For example, all vowels in English are underlyingly oral and a nasalized vowel occurs only when there is a neighboring nasal consonant, as in words like *man* or *ban*. Lahiri and Marslen-Wilson (1992) reported that English speakers associated assimilated nasality encountered in vowels with a neighboring nasal consonant, which implies that listeners have implicit knowledge of the phonological rules in their own language. Similarly, English has productive place assimilation, by which a syllable-final coronal consonant may assimilate in place to a following consonant. According to Gaskell and Marslen-Wilson (1998), English speakers tended to perceive consonants with labial or velar place as coronal when their following consonant had the same place of articulation, as shown in (1):

(1) Detection of coronal consonants in English place assimilation (Gaskell and Marslen-Wilson 1998: 390):
a. Luckily, the ship was only a freight [freɪp] bearer.
b. Luckily, the ship was only a freight [freɪp] carrier.

Gaskell and Marslen-Wilson reported that English speakers showed a high percentage of perceiving [freɪp] as *freight* before *bearer*, because the final segment [t] of *freight* can assimilate in place to its following syllable-initial segment (i.e., [b] of *bearer*). However, English speakers tended not to perceive [freɪp] as *freight* before *carrier*, since the final segment [t] of *freight* cannot become [p] before the initial segment [k] of *carrier* by assimilation. Moreover, according to Gaskell and Marslen-Wilson, the same tendency was observed with nonce words (e.g., *prayp bearer* vs. *prayp carrier*), which means that phonological viability occurred even in the absence of lexical cues, although the size of effect was bigger for the words than the nonce words.

Mitterer and Blomert (2003) also reported that phonological context effects were observed in Dutch speakers' word identification task. For instance, Dutch has a nasal place assimilation rule and Dutch speakers tended to perceive *tuim* as *tuin* 'garden' much more before *bank* 'bench' (i.e., in the viable context) than before *stoel* 'chair' (i.e., in the unviable context).

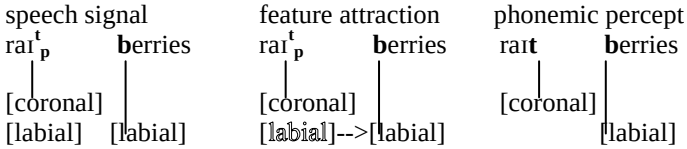
Thus, the language-specific processing theory predicts that the patterns of compensation for phonological variation should rely on the phonology of the listener's language. It also predicts that the same pattern of compensation should be possible for nonce words as well as real words.

The second class of compensation mechanisms is universal processing mechanisms, which argue that listeners compensate for phonological variation based on acoustic/phonetic processes or cues. In specific, Fowler (1996) and Pardo and Fowler (1997) suggested that speech sounds may vary depending on context, but the articulatory gestures that execute them are rather invariant. Further, humans have an innate faculty of catching the relationship between articulation and the acoustic cues of the speech signal. Thus, if assimilation is viewed as resulting from overlapping gestures, listeners should be able to detect the underlying form of assimilated sounds by retrieving the invariant gestures that produce them. However, Lotto and Kluender (1998) found that humans show a similar compensation for coarticulation in the perception of sine wave speech, although humans cannot produce sine wave speech. Consequently, Lotto and Kluender argue that articulation-based mechanisms cannot explain the result.

Gow (2001, 2003) provides an alternative account for assimilation

context effects. It is well established that the featural distinctions or acoustic cues, which mark the difference between any two segments, are temporally dispersed across the speech stream. Further, the perceptual apparatus of listeners involves the integration of multiple cues to the same feature. For instance, the voicing contrast between [k] and [g] can be encoded in voice onset time and the value of F1 at the onset of voicing. Specifically, in order to account for compensation effects for phonological variation, Gow (2001, 2003) contends that temporally distributed acoustic cues of features are grouped and integrated into segmentally aligned phonetic features on the basis of their similarity. In the case of place assimilation, for example, complex segments with two places of articulation are parsed onto two adjacent segmental positions, when a following segment attracts one of the place features, as illustrated in (2).

(2) Feature parsing schema in English place assimilation (Gow and Zoll 2002: 58)
e.g., *right berries*



In (2) the final segment of the word *right* is a complex segment with two places of articulation, but the following labial context pulls away the labiality of the complex place. As a result, the coronality of the complex place is mapped onto the final segment, and English speakers recover the final segment [t] of *right* (cf. Gow and Im 2004).

However, it has been noted that Gow's Feature Parsing theory would have difficulty with complete assimilation. This is because there may be no detectable acoustic traces of the underlying target phonemes when assimilation is complete. Yet, several studies have shown that compensation does occur even in complete assimilation (Gaskell and Marslen-Wilson 1998; Ellis and Hardcastle 2002). The Feature Parsing theory also has some limitations in accounting for cases, where several processes such as deletion and insertion are involved (cf. Snoeren and Sequi 2003).

The final class of compensation mechanisms for phonological variation uses lexical knowledge. Lexical compensation mechanisms claim that speakers of a particular language can match the input signal with their stored word list and select the closest or the most likely candidate available for the given input, based on lexical and higher-order contextual information (Samuel 2001). For example, when English speakers hear the word *send* produced as [sɛm] in the

context “Send me the file”, they know that the produced word should be a verb, as an object (i.e., *me*) follows, and further they know that there is no English verb pronounced as [sɛm]. Consequently, they are expected to choose the verb *send*, since it is the best fit for the given context. Thus, lexical compensation mechanisms work only for reconstructing the phonological shape of real words but not for nonce words, as they crucially rely on stored lexical items. Moreover, lexical compensation mechanisms do not use phonological context. That is, this mechanism treats phonetic variation as noise, based on the finding that listeners often fail to detect minor mispronunciations (Cole 1973). Thus, the selection process of the best-matching lexical item for a given input is done, based on the phonetic cues and the higher-order syntactic and semantic contextual information (e.g., sentential context information), not taking into account the phonological context where the changes occur. Thus, for instance, the fact that words like *send* can be produced as [sɛm] when the following segment is a labial does not contribute to recovering the word *send*.

However, Gaskell and Marslen-Wilson (1998) found compensation effects not only for words but also for nonce words, even though the size of effect was bigger for the former than the latter. Furthermore, several studies have shown that compensation for phonological variation is dependent upon phonological contexts. For instance, as given in (1) above, Gaskell and Marslen-Wilson (1998) reported more compensation for place assimilation in English when the phonological context was legitimate than when it was illegitimate (e.g., *freight*: *freight* [freɪp] *bearer* vs. *freight* [freɪp] *carrier*). Similar results were replicated, using an assimilation rule in Dutch by Mitterer and Blomert (2003), as discussed earlier. Moreover, according to Mitterer and Blomert, German speakers also showed a phonological context effect when they were tested with Dutch words.[1] Thus, they argued that phonological viability effects were not influenced by lexical top-down effects (i.e., lexical inference), since Dutch words were used as nonce words for German speakers.

Up to now, I have reviewed three compensation mechanisms for phonological assimilation. In the next section, I will look at obstruent nasalization, which behaves differently with respect to Korean and English.

3. Obstruent nasalization

In Korean, an obstruent nasalizes obligatorily before an adjacent nasal consonant over a syllable boundary, as given in (3).

[1] German also has a rule of nasal place assimilation.

(3) Obstruent nasalization in Korean

	Input	Output	Gloss
a.	/pap+mul/	[pam.mul]	"rice water"
	/ap^{h}+mosip/	[am.mo.sip]	"the front figure"
b.	/pat^{h}+noŋsa/	[pan.noŋ.sa]	"field farming"
	/os+noŋ/	[on.noŋ]	"a clothes chest"
c.	/kuk+mul/	[kuŋ.mul]	"broth"
	/hæk+muki/	[hæŋ.mu.ki]	"a nuclear weapon"

The data in (3) show that an obstruent, whether it is a labial, a coronal, or a velar consonant, undergoes nasalization before a neighboring nasal consonant. The data also show that the assimilation-triggering nasal should be either a labial or a coronal segment, as Korean does not allow a velar nasal to occur in syllable-initial position.

By contrast, obstruent nasalization does not exist in English. Consequently, an obstruent should remain intact concerning its obstruency even before an adjacent nasal consonant, as given in (4).

(4) Obstruent nasalization does not occur in English

a.	pop music	[pɑp.mju.zɪk]	*[pɑm.mju.zɪk]
b.	bread knife	[brɛd.naɪf]	*[brɛn.naɪf]
c.	stock market	[stak.mar.kɪt]	*[staŋ.mar.kɪt]

Thus, the word *pop*, for example, should be produced as [pɑp] instead of [pɑm] before the labial nasal consonant [m] of *music*, which is just the opposite of the Korean case. Yet like Korean, English prohibits a velar nasal to occur in syllable-initial position, and thus only a labial or a coronal nasal can occur in this position.

Obstruent nasalization, then, seems to be a good test case to examine some of the predictions of compensation mechanisms reviewed above, as it behaves differently with respect to Korean and English. Specifically, if compensation for assimilation is language-specific, Korean learners of English should compensate not only for the native Korean nasalization but also for the non-existing English nasalization.[2] Moreover, native speakers of English are expected not to compensate either for English or for Korean nasalization. In contrast, if phonological compensation relies on a universal mechanism, both Korean speakers of English and native speakers of

[2] This should be the case, even though Korean inputs are different from those of English, since the language-specific compensation mechanism claims that listeners' implicit knowledge of the phonological processes in their own language plays a crucial role in detecting target words in a given context. In addition, as the mechanism predicts that language-specific compensation effects should also occur even when listeners detect targets in other languages, language-specific effects observed in acquiring foreign language could be regarded as transfer effects.

English should show equal amounts of compensation for Korean and English obstruent nasalizations, as obstruent nasalization is a well-attested process, which occurs in several languages including Korean. The theory of lexical compensation predicts that compensation for obstruent nasalization should be possible only for real words but not for nonce words. In the next section, I will carry out an experiment, in order to investigate the validity of some of the assumptions laid out by theories of compensation mechanisms.

4. Experiment

The experiment purports to investigate whether Korean speakers of English and English native speakers employ language-specific compensation mechanisms with respect to obstruent nasalization. It also explores whether other compensation mechanisms are employed, in addition to language-specific processing mechanisms.

4.1 Method

4.1.1 Participants

4.1.1.1 Korean participants

The participants were 41 Korean learners of English drawn from the Metropolitan area. All of them were sophomores majoring in English and enrolled in an English phonology course. They could be classified as intermediate level learners of English, as they had been learning English for 8 years.

4.1.1.2 English participants

Eight native speakers of American and British English were drawn form the Metropolitan area; six were American and two were British. They ranged in age from 28 to 39 with a mean age of 33.8 years. They had been in Korea for more than two years, but they could not speak Korean.

4.1.2 Stimuli

Sixty target items, which were all monosyllabic nouns, were selected on the basis of checked word frequency.[3] In specific, 30 items with a

[3] English target items were checked for word frequency using the CELEX database. Most of the targets were matched in frequency (e.g., *ship* 34%, *stock* 32%) except a couple of items (e.g., *cake* 16%). For Korean target items, a word frequency survey with a 5 frequency scale was carried out with 20 native speakers of Korean. All of the target items except one (*kyəp* 'fold') were matched in average frequency in that they fit in one of the top 3 frequency scales, with 3 being "average in frequency".

(C)VC structure were selected for Korean obstruent nasalization; 15 of them were words and the other 15 were nonce words. Likewise, 30 items with a (C)(C)CVC structure (15 words and 15 nonce words) were chosen for English obstruent nasalization. All items ended in a coronal segment, a labial segment, or a velar segment; 10 were coronal, another 10 were labial, and the other 10 were velar in both Korean and English. Each of the target items was associated with three types of context words, which were always nouns, so that each target item was realized in a compound noun structure. The three context conditions were a no-change condition(nc), an unviable change condition(uc), and a viable change condition(vc). For the unviable change and no-change conditions, the initial consonant of a noun was an obstruent, which did not trigger nasalization. Specifically, when a target item ended in a coronal, the initial consonant of the context words was a coronal obstruent in order to avoid a potential confound from place assimilation, as coronals can assimilate in place to a following labial; when a target item terminated in a labial or a velar, the following consonant was either a coronal or a labial obstruent (also a labiodental consonant for English). For the viable change condition, the initial consonant of a noun was a coronal nasal for a coronal target, whereas it was either a coronal or a labial nasal for a labial or a velar target. Thus, in the viable change condition, the final obstruent of target words, which was produced as a nasal consonant, appeared in a legitimate context for nasalization. For instance, the final consonant [p] of *pap* 'rice' was produced as [m] in front of [mul] 'water', since the segment following [p] can trigger nasalization. In the unviable change condition, the final consonant of the target word surfaced as a nasal, as in the viable change condition (i.e., it underwent nasalization), but in a context which did not license nasalization. For example, the final consonant [p] of *pap* 'rice' was produced as [m] in front of [panc^{h}an] 'a side dish', even though [p] of [panc^{h}an] cannot trigger nasalization. Finally, in the no-change condition, the target word was produced without any change of the nasal feature in a context that did not authorize the assimilation process. Thus, the final consonant [p] of *pap* 'rice' was realized as [p] in front of [pyəŋsin] 'a cripple', because the following segment [p] was not a trigger of nasalization. Here the detection rates of target words in the no-change condition were measured, in order to test whether participants were able to identify the target stimuli correctly as in isolation. That is, if participants can detect target words higher than chance-level in the no-change condition, then it implies that participants are performing the task correctly and they can recognize the target stimuli themselves without difficulty. Thus, the no-change condition was used as a baseline for the task in the present study.

Combining 30 target items with the three conditions resulted in 90 compound noun structures for each assimilation. (See Appendices A and B.) Korean testing structures were recorded by an experimentally naive female who was a native speaker of Korean, and English testing structures by an experimentally naive female speaker of English. The Korean speaker was asked to read each target and context word in the carrier sentence of "Igəʃi _____ ida 'This is _____'" three times. Cross-splicing of target and context words was done so that each target word and each component of a compound noun were never spliced with a token from the same recording. The same holds true for English testing structures, with the exception that the carrier sentence was "I will say _____".[4] All tokens in assimilating contexts were checked by a researcher and a Canadian linguist to ensure that they were all completely assimilated. The testing structures were digitally recorded on a TASCAM CD-RW 700 recorder using a Mackie 1202-VLZ PRO microphone in a sound-attenuating lab.

4.1.3 Procedure

Before the experiment, participants were given auditory instructions about the experiment and they completed practice trials (8 trials for Korean and 6 trials for English) in order to familiarize themselves with the task. The task consisted in the presentation of the target item, followed by 1.5 second pause, which was in turn followed by a compound noun. Participants were asked to decide whether the target word and the first word of a compound noun were the same or different and to circle "Same" or "Different" on their answer sheet. All stimuli were presented auditorily over headphones. A sample procedure is illustrated in (5).

(5) A sample procedure
Korean obstruent nasalization
a. obstruent+nasal: the viable change condition
[pat^{h}] "field" 1.5 seconds [pan.noŋ.sa] "field farming"
b. obstruent+obstruent: the unviable change condition
[pat^{h}] "field" 1.5 seconds [pan.cak.mul] "field crops"

In order to check whether all participants were performing the task correctly, the error rates between the unviable change condition and the no-change condition were calculated. That is, when a participant's error rate in the no-change condition was either the same as or bigger than that of the unviable change condition, that participant was

[4] In both Korean and English, consonants in word-final position or before another consonant are usually unreleased. Thus, in the present study, cross-splicing was done with the unreleased word-final consonants (Iverson and Sohn 1994).

considered as failing to perform the task. No participants failed in either a Korean or an English task.

4.2 Results

4.2.1 Predictions

If word detection for assimilation is language-specific, Korean participants are expected to detect the target words in the viable change condition in the similar way as in the no-change condition, but not to detect them in the unviable change condition to the same extent as in the other two conditions. They should show compensation not only for Korean obstruent nasalization but also for English obstruent nasalization, even though the latter does not occur in English. Moreover, phonological compensation should operate on both words and nonce words. However, English participants should not evince any assimilation context effects, as obstruent nasalization is not a native process in English. Consequently, they should show the same response for the target words in both Korean and English, regardless of whether they occur in the viable change condition or in the unviable change condition. In contrast, if there is no language-specific compensation for the assimilation process, participants are predicted not to evince any context effect with respect to Korean and English obstruent nasalizations.

Gow(2003)'s Universal Feature Parsing model may work when assimilation is partial. However, as noted above, it would have difficulty accounting for complete assimilation of the stimuli in the present experiment, because there might not be enough detectable acoustic cues of the underlying phonemes. However, if compensation for the assimilation process still depends on some kinds of universal mechanisms, Korean participants are predicted to show equal amounts of compensation for the native and non-native nasalizations. Importantly, English participants should also evince the same pattern of compensation for Korean and English obstruent nasalizations, as obstruent nasalization is a phonologically attested process that occurs in several languages including Korean. Moreover, participants should show the same pattern for both words and nonce words.

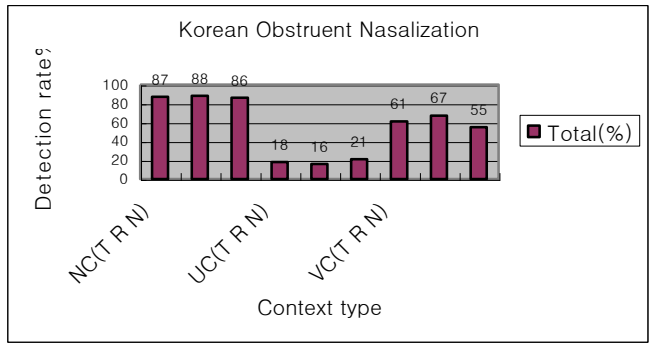
On the other hand, the lexical compensation model assumes insensitivity to phonological context. Thus, this model predicts that there should be no difference between the viable and the unviable contexts in terms of compensation. It also predicts that participants should show compensation for words but not for nonce words, as the lexical compensation mechanism crucially relies on stored lexical items. Consequently, even if compensation does occur even without any higher-order syntactic and semantic contextual information,

Korean participants are expected to show compensation only for words with respect to Korean and English assimilations. In contrast, English participants are predicted to evince compensation for words in English but not for words in Korean, because they are not speakers of the Korean language.

4.2.2 Results of Korean participants

As can be seen from Figure 1, the overall percent detection rate for the no-change condition in Korean obstruent nasalization reached more than 80%, with 87% for the total, 88% for the words, and 86% for the nonce words, respectively. The comparison of the percent detection rate between the viable change condition and the unviable change condition revealed that there was a significant effect of context condition, with higher detection rates for the viable change condition than for the unviable change condition; in the viable change condition, the percent detection rate was 61% for the total, 67% for the words, and 55% for the nonce words, yet in the unviable change condition it was 18% for the total, 16% for the words, and 21% for the nonce words.

Figure 1. The percent detection rate of targets in Korean obstruent nasalization by Korean participants



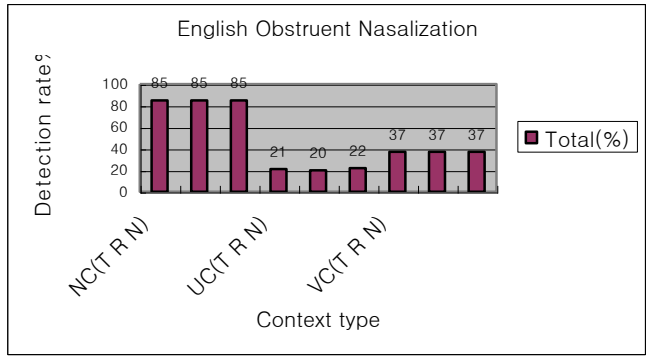
Note. NC=no-change; UC=unviable change; VC=viable change; T=total percentage of target word detection; R=total percentage of word detection; N=total percentage of nonce word detection.

The data were subjected to a two-way participant ANOVA, with variables of phonological context (viable change or unviable change) and lexical status (word or nonce word). There was a significant main effect of context, $F(1, 40)=132.510$, $p<.0001$, showing that participants were much more likely to detect target words in the viable contexts than the unviable contexts (61% (viable contexts) vs.

18% (unviable contexts)), regardless of whether the target was a labial, a coronal, or a velar segment. However, there was no main effect of lexical status, $F(1, 40)=1.695$, $p>.05$, meaning that there was no statistically significant difference between words and nonce words in terms of the detection of target words (41.3% (words) vs. 38.5% (nonce words)) across conditions (i.e., across both the viable and the unviable contexts). Yet, there was an interaction between phonological context and lexical status, $F(1, 40)=23.006$, $p<.0001$, which means that phonological context effects were much stronger for words (67% (viable contexts)) than nonce words (55.1% (viable contexts)).

As for English obstruent nasalization, the overall percent detection rate for the no-change condition was also high, with 85% for the total, 85% for the words, and 85% for the nonce words, respectively. The percent detection rate for the viable change condition was much higher than that of the unviable change condition; in the viable change condition, the percent detection rate was all 37% for the total, the words, and the nonce words, and in the unviable change condition it was 21% for the total, 20% for the words, and 22% for the nonce words, as can be seen from Figure 2.

Figure 2. The percent detection rate of targets in English obstruent nasalization by Korean participants



Note. NC=no-change; UC=unviable change; VC=viable change; T=total percentage of target word detection; R=total percentage of word detection; N=total percentage of nonce word detection.

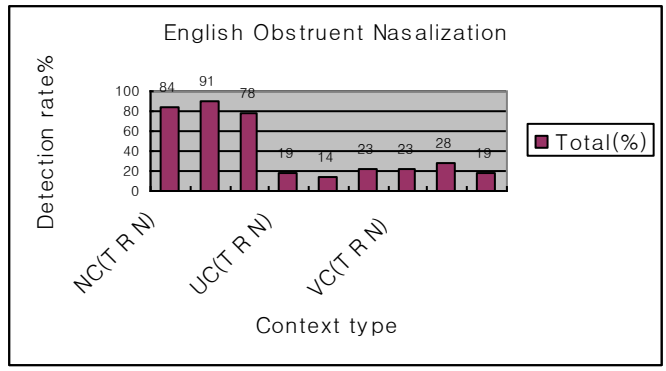
These data were also subjected to a two-way participant ANOVA in the same way as the Korean data. There was a main effect of phonological context, $F(1, 40)=81.924$, $p<.0001$, showing that Korean participants detected targets in a context-sensitive manner even for English obstruent nasalization (37.2% (viable contexts) vs. 20.7% (unviable contexts)), regardless of targets' place of articulation.

However, there was no main effect of lexical status, $F(1, 40)=.954$, $p>.05$, which means that there was no meaningful difference between words and nonce words as to the detection of target words across conditions, even though the detection rate for the nonce words was slightly higher than that of the words (28.2% (words) vs. 29.7% (nonce words)). There was no interaction between phonological context and lexical status, $F(1, 40)=.285$ $p>.05$, confirming that only phonological contexts played a crucial role in word detection.

4.2.3 Results of English participants

Now, let us move onto the results of English participants. As for English obstruent nasalization, the overall percent detection rate for the no-change condition was high, with 84% for the total, 91% for the words, and 78% for the nonce words, respectively. However, the percent detection rate between the viable change condition and the unviable change condition was not noticeably different. Specifically, in the viable change condition, the percent detection rate was 23% for the total, 28% for the words, and 19% for the nonce words, and in the unviable change condition it was 19% for the total, 14% for the words, and 23% for the nonce words, as given in Figure 3.

Figure 3. The percent detection rate of targets in English obstruent nasalization by English participants



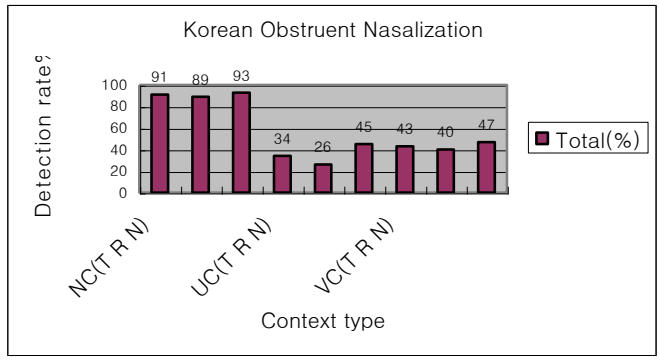
Note. NC=no-change; UC=unviable change; VC=viable change; T=total percentage of target word detection; R=total percentage of word detection; N=total percentage of nonce word detection.

A two-way participant ANOVA was carried out on the data, with variables of phonological context and lexical status as in the previous section. There was no main effect of context, $F(1,7)=2.097$, $p>.05$, showing that English participants didn't detect target words in a context-sensitive manner (23.3% (viable contexts) vs. 18.8%

(unviable contexts)), unlike Korean participants. There was no main effect of lexical status, $F(1,7)=.006$, $p>.05$, either, which reveals that the percent detection rate between the words and the nonce words across conditions (i.e., across both the viable and the unviable contexts) was not meaningfully different (20.8% (words) vs. 21.2% (nonce words)). However, the interaction between phonological context and lexical status, $F(1.7)=3.918$, $p=.088$, was marginally significant. This means that phonological context effects were noticeable only for the words (27.5% (viable contexts) vs. 14.2% (unviable contexts)) but not for the nonce words (19.2% (viable contexts) vs. 23.2% (unviable contexts)), which reflects the importance of lexical information in the detection of targets.

As for Korean obstruent nasalization, overall, the percent detection rate for the no-change condition was also high; 91% for the total, 89% for the words, and 93% for the nonce words. The percent detection rate for the viable change condition was a little bit higher than that of the unviable change condition; in the viable change condition the percent detection rate was 43% for the total, 40% for the words, and 47% for the nonce words, yet in the unviable change condition it was 34% for the total, 26% for the words, and 45% for the nonce words, as can be seen from Figure 4.

Figure 4. The percent detection rate of targets in Korean obstruent nasalization by English participants



Note. NC=no-change; UC=unviable change; VC=viable change; T=total percentage of target word detection; R=total percentage of word detection; N=total percentage of nonce word detection.

A two-way participant ANOVA revealed that there was no main effect of phonological context, $F(1,7)=2.913$, $p>.05$, as in the English case (43.3% (viable contexts) vs. 33.7% (unviable contexts)).[5] In

[5] Native speakers of English detected Korean targets 43.3% in the viable context, whereas Korean speakers of English detected English targets 37.2% in the same

contrast, there was a main effect of lexical status, $F(1,7)=8.128$, $p<.05$. Unexpectedly, however, more detection of targets was observed within nonce words than words across conditions (45.8% (nonce words) vs. 31.2% (words)). There was no interaction between phonological context and lexical status, $F(1,7)=2.195$, $p>.05$. However, as in English obstruent nasalization, there seemed to be a weak effect of phonological contexts only for the words (40% (viable contexts) vs. 26% (unviable contexts)) but not for the nonce words (47% (viable contexts) vs. 45% (unviable contexts)).

4.3 Discussion

The results of the experiment revealed that overall Korean participants compensated for both Korean and English obstruent nasalizations in a highly context-sensitive way, with much higher word detection rates for the viable change condition than the unviable change condition. This context-sensitive pattern of phonological compensation was found within not only words but also nonce words. In contrast, English participants didn't show phonological viability effects on Korean or English obstruent nasalization. This is consistent with the claims made by proponents of language-specific compensation mechanisms.

However, the interaction between phonological context and lexical status, which was observed in Korean obstruent nasalization by Korean participants, suggests that phonological context effects were much stronger for words than nonce words. Similarly, as for the English participants' results, the fact that the interaction between phonological viability and lexical status was marginally significant in English obstruent nasalization and that the same but a weak tendency was observed in Korean obstruent nasalization seems to suggest that phonological context effects were mainly restricted to the word stimuli. This reflects the importance of lexical information in the process of word detection, as the lexical compensation model claims. As for why English participants showed some effect of phonological viability even for the Korean word stimuli (but not for the nonce word stimuli), it might be due to the fact that most participants had stayed in Korea for more than two years. As a consequence, they

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context. Thus, it seems that native speakers of English detected Korean targets more than Korean speakers of English detected English targets, even though obstruent nasalization is not a native process in English. However, 41 Korean speakers of English participated in the experiment, compared with 8 native speakers of English. Consequently, the number of participants seems to answer for this. Additionally, Figure 4 shows that English participants also detected Korean targets more in the no-change context than Korean participants did Korean targets in the same context (cf. Figure 1). Thus, participant variation might also be responsible for the difference in the detection rates.

might have some knowledge of the Korean word stimuli, even though they could not speak Korean. Yet, the fact that Korean participants showed a significant phonological viability effect for both Korean and English assimilations including the nonce word stimuli and that English participants also showed a marginal effect of phonological contexts for the words seems to be at odds with some of the claims made by proponents of the lexical compensation model; in particular, insensitivity to phonological context cannot hold in the case of phonological compensation. Additionally, apart from the phonological context effects, Korean and English participants tended to detect the nonce words slightly more than the words for English obstruent nasalization. Similarly, English participants detected the nonce words more than the words for Korean obstruent nasalization when phonological context effects were not considered. This seems to suggest that participants might have a bias toward perceiving the target stimuli a little bit generously when the assimilation was non-native and the target stimuli were nonce words.

Turning to universal compensation mechanisms, the results of the present study do not appear to support Gow's (2001, 2003) Feature Parsing theory, because phonological compensation occurred even in complete assimilation where no tangible acoustic cues of the underlying phonemes were available. However, the fact that English participants showed a marginal effect of phonological viability for the English word stimuli, even though obstruent nasalization is not a legitimate process in English, and that they showed a similar but weak pattern for Korean obstruent nasalization seems to suggest that compensation for phonological variation could also be influenced by some universal mechanisms. For instance, although the present study attempted to produce the stimuli in a completely assimilated manner, some small degree of segmental ambiguity could be present in the stimuli, and thus some degree of universal feature parsing might have occurred, in addition to the language-specific ones.

Finally, the results of the experiment revealed that language-specific compensation mechanisms were at play even in compound noun structures, where any higher-level of syntactic/semantic contextual information was not given.

5. Conclusion

This paper investigated the role of language-specific mechanisms to compensate for Korean and English obstruent nasalizations by Korean speakers of English and native speakers of English, using a word detection task. Overall, it has been shown that compensation for phonological variation is brought on by language-specific mechanisms, which supports the findings obtained by Gaskell and

Marslen-Wilson (1998) with English listeners for English place assimilation. Moreover, Korean participants showed phonological viability effects for both words and nonce words. However, some universal mechanisms such as feature parsing and lexical compensation mechanisms may also contribute to compensation for phonological variation to some degree. This is because phonological viability was affected by lexical status even in the non-native process. In specific, Korean participants showed a strong viability effect for words for the native process and English participants showed a marginal effect for words for the non-native process. Additionally, it has been shown that language-specific compensation for phonological variation is at work even in a compound noun structure without any higher-order contextual information. However, the number of the English participants was rather small and thus similar experiments with more native speakers of English will be needed, in order to corroborate the findings of the present study.

Appendix A
Sample Stimuli for Korean Obstruent Nasalization

Words

Target	Unchanged form	Changed form	No-change context	Unviable context	Viable context
pap	[pap]	[pam]	[pyəŋsin]	[panc^{h}an]	[mul]
'rice'			'a cripple'	'a side dish'	'water'
			'an idler'	'a side dish'	'rice water'
pat^{h}	[pat]	[pan]	[t'æki]	[cakmul]	[noŋsa]
'a field'			'a patch'	'crops'	'farming'
			'a patch of field'	'produce'	'field farming'
hɨlk	[hɨk]	[hɨŋ]	[təmi]	[təŋi]	[næmsæ]
'soil'			'a heap'	'a lump'	'smell'
			'a heap of earth'	'a lump of soil'	'the smell of soil'

Nonce Words

Target	Unchanged form	Changed form	No-change context	Unviable context	Viable context
pip	[pip]	[pim]	[tampæ]	[tansok]	[nollim]
			'a cigar'	'control'	'teasing'
hit	[hit]	[hin]	[toŋnæ]	[tapal]	[nai]
			'a village'	'a bunch'	'age'
c^{h}ak	[c^{h}ak]	[c^{h}aŋ]	[t'ɨt]	[tacim]	[nunmul]
			'an intention'	'a pledge'	'tears'

Appendix B
Sample Stimuli For English Obstruent Nasalization

Words

Target	Unchanged form	Changed form	No-change context	Unviable context	Viable context
pop	[pap]	[pam]	gun	bottle	music
cat	[kæt]	[kæn]	scratch	tail	nap
stock	[stak]	[staŋ]	fund	broker	market

Nonce Words

Target	Unchanged form	Changed form	No-change context	Unviable context	Viable context
nipe	[naɪp]	[naɪm]	boat	bell	man
fet	[fɛt]	[fɛn]	lock	size	knob
pake	[peɪk]	[peɪŋ]	bar	break	mill

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