Phonology of Exceptions
For Korean Grapheme-to-Phoneme Conversion

Sunhee Kim
Speech Information Technology Research Center
Kwangwoon University, Korea
sunhkim@daisy.kw.ac.kr

Abstract

Being an essential part of a Korean speech recognition system and a Text-To-Speech (TTS) system, a Korean Grapheme-to-Phoneme conversion system is generally composed of a set of regular rules and an exceptions dictionary [1, 2, 3]. The exceptions have been recorded in the dictionary in a simple and random manner, whereas the researches on the regular rules have been actively progressed. This paper presents a systematic description of the exceptions for a Grapheme-to-Phoneme conversion system based on the analysis of entries of a lexical dictionary [4] from the phonological point of view, showing that the exceptions are related with certain limited phonological phenomena.

1. Introduction

A Grapheme-to-Phoneme conversion is one of the main tasks of the linguistic processing part of a TTS system and a speech recognition system. It is usually carried out by an extensive word list, by a set of rules, or by a hybrid combining a word list (exceptions) and a set of rules. As the Korean language gives a good example to which a hybrid strategy applies, a Korean Grapheme-to-Phoneme conversion system is composed of a set of regular rules and an exceptions dictionary [1, 2, 3]. Most of studies on Korean Grapheme-to-Phoneme conversion have been focused on the regular rules, whereas very little research has been conducted to examine the characteristics of the words classified as exceptions.

The phonemic contexts in which exceptions are observed have never been examined and just considered irregular, so that the exceptions have been recorded in the dictionary in a simple and random manner. This paper aims to present a systematic description of the exceptions to the regular rules and an exceptions dictionary from the phonological point of view.

Following the research on the phonological alternations for the standard Korean pronunciation [5], all possible combinations of consonants and vowels and their realizations are examined through the analysis of a general dictionary [4] from the phonological point of view.

As mentioned above, a Korean Grapheme-to-Phoneme conversion system is composed of a set of regular rules and an exceptions dictionary. One example of regular rules is the Tensification of lenis consonant. When a Korean lenis obstruent letter, ’(p), (k), (s), or (c)’ is positioned after another Korean obstruent letter, the ’(p), (k), (s), or (c)’ is pronounced as a fortis consonant, [p][b], [k][t], [s][t], [c][?), e.g., the word /klkpi/ (top secret) is pronounced as ’[klkbi]’. This Tensification Rule has no exceptions in the given environment.

On the contrary, alternative pronunciations can be observed in a certain context, in which the choice of the

1. Introduction

A Grapheme-to-Phoneme conversion is one of the main tasks of the linguistic processing part of a TTS system and a speech recognition system. It is usually carried out by an extensive word list, by a set of rules, or by a hybrid combining a word list (exceptions) and a set of rules. As the Korean language gives a good example to which a hybrid strategy applies, a Korean Grapheme-to-Phoneme conversion system is composed of a set of regular rules and an exceptions dictionary [1, 2, 3]. Most of studies on Korean Grapheme-to-Phoneme conversion have been focused on the regular rules, whereas very little research has been conducted to examine the characteristics of the words classified as exceptions.

The phonemic contexts in which exceptions are observed have never been examined and just considered irregular, so that the exceptions have been recorded in the dictionary in a simple and random manner. This paper aims to present a systematic description of the exceptions to the regular rules and an exceptions dictionary from the phonological point of view.

Following the research on the phonological alternations for the standard Korean pronunciation [5], all possible combinations of consonants and vowels and their realizations are examined through the analysis of a general dictionary [4] from the phonological point of view.

As mentioned above, a Korean Grapheme-to-Phoneme conversion system is composed of a set of regular rules and an exceptions dictionary. One example of regular rules is the Tensification of lenis consonant. When a Korean lenis obstruent letter, ’(p), (k), (s), or (c)’ is positioned after another Korean obstruent letter, the ’(p), (k), (s), or (c)’ is pronounced as a fortis consonant, [p][b], [k][t], [s][t], [c][?), e.g., the word /klkpi/ (top secret) is pronounced as ’[klkbi]’. This Tensification Rule has no exceptions in the given environment.

On the contrary, alternative pronunciations can be observed in a certain context, in which the choice of the
pronunciation depends on the words (idiosyncratic). It is impossible to make rules for these words, which should be classified as exceptions. For example, ‘물고기 /mulkoki/ (fish)’ and ‘불고기 /pulkoki/ (barbecue)’ are respectively realized as ‘물고기 [mulkoki]’ and ‘불고기 [pulkoki]’. In ‘물고기 [mulkoki]’, a letter ‘ㄱ[k]’ located after a letter ‘ㄹ[l]’ is pronounced as [l][g], while in ‘불고기 [pulkoki]’, a letter ‘ㄱ[k]’ located after a letter ‘ㄹ[l]’ remains unchanged, e.g., ‘ㄱ[k]’. The Tensification of the former case is exceptional, which is not predictable, and needs to be recorded as an exception.

In general, there are three types of phonetic contexts where a phonological alternation can occur: (1) when a consonant follows another consonant; (2) when a vowel follows a consonant; (3) when a consonant follows a vowel; (4) when a vowel follows another vowel. We have examined all these contexts based on the analysis of the entries of [4], and found out that all the contexts except (4) are relevant to the exceptions. In the next section, the exceptions and their realizations will be presented in these three contexts.

2.1. When a consonant follows another consonant

When a consonant follows another consonant, two kinds of phonological alternations are observed: the one is related with the Tensification and the other the lateralization. The first type of words contain the sequences of a sonorant such as ‘s’ [n], ‘m’ [m], ‘n’ [n], a lenis consonant, and a nasal, e.g., ‘고래 [gorae], 고리 [gori]’. The sequences of a nasal and a sonorant are pronounced as two nasals [nn], which is called Nasalization. It may be impossible to make rules for these words, which should be classified as exceptions. In the next section, the exceptions and their realizations will be presented in these three contexts.

Table 3 shows the phonetic contexts, in which the Lexical Tensification occurs, examples in Korean presented in the shaded part, and the words sharing the same context without the Tensification also given in Korean in the non-shaded part.

<table>
<thead>
<tr>
<th>N</th>
<th>명범</th>
<th>장복</th>
<th>방숙</th>
<th>동진</th>
<th>황봉</th>
</tr>
</thead>
<tbody>
<tr>
<td>성범</td>
<td>중복</td>
<td>후복</td>
<td>정재적</td>
<td>덕봉</td>
<td></td>
</tr>
<tr>
<td>물보</td>
<td>장대</td>
<td>김성</td>
<td>정재</td>
<td>물범</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Lexical Tensification between a consonant and another consonant

Here are some examples with their realizations and their meanings:

1. /m/ + /p/
   a. pompi/ /pompib/ “rain in spring”
   b. hwamKimpib/ /hwamKimpib/ “golden ratio”
2. /n/ + /p/
   a. nunpyvN/ /nunbyvN/ “eye disease”
   b. kanpyvN/ /kanpyvN/ “nursing”
3. /N/ + /p/
   a. dENpyvT/ /dENbyvT/ “an intense of heat of the sunbeams”
   b. sVNpyvN/ /sVNpyvN/ “gender”
4. /l/ + /p/
   a. tIlpo/ /tIlbo/ “girder”
   b. /Cilpo/ /Cilbo/ “seven treasures”

The second type of words are related with the sequences of a nasal “/n/” and a lateral “/l/”. In Korean phonology, when a sonorant is followed by a lateral, they are both realized as two laterals [ll], which is called Lateralization. But, there are a group of words that do not show this alternation. Unlike most cases, the sequence of a nasal and a lateral is pronounced as two nasals [nn], which is called Nasalization of laterals, and needs to be recorded as exceptions.

Here are an example of the Nasalization of laterals (5a) and one of the Lateralization (5b):

5. /b/ + /m/ /bvmisvn/ /bvmisinn/ “pantheism”
   b. kwami/ /kwamii/ “administration”

2.2. When a consonant follows a vowel

Let us move to the sequences of a vowel and a consonant. In this case, the vowel should be the nucleus of the preceding syllable and the consonant the onset of the following syllable in the orthography, which means that the sequences of a vowel and a consonant in the coda position are excluded. In this context, some of the lenis consonants in the onset position are realized as fortis. The words showing this alternation are idiosyncratic, thus should be recorded as exceptions.

Table 4 shows the phonetic contexts, in which the Lexical Tensification occurs, examples in Korean presented in the shaded part, and the words sharing the same context without the Tensification also given in Korean in the non-shaded part.

<table>
<thead>
<tr>
<th>p</th>
<th>t</th>
<th>s</th>
<th>c</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>볼배</td>
<td>부분당</td>
<td>속서리</td>
<td>홍점</td>
<td>품길</td>
</tr>
<tr>
<td>황금비</td>
<td>남단비</td>
<td>감소</td>
<td>급지</td>
<td>급기</td>
</tr>
<tr>
<td>눈병</td>
<td>눈목</td>
<td>눈상</td>
<td>창점</td>
<td>눈가</td>
</tr>
<tr>
<td>간병</td>
<td>군대</td>
<td>군산</td>
<td>발점</td>
<td>분가</td>
</tr>
</tbody>
</table>

Table 4: Lexical Tensification between a vowel and a consonant (V: a vowel or a dipthong)
Here are some examples with their realizations and their meanings:

(6) V + /p/
  a. /sevp/ [sebo] “tax law”
  b. /sapvp/ [sado] “private law”

(7) V + /t/
  a. /tEkatEk/ [tEka] “distinguished family”
  b. /satE/ [sado] “worship of the powerful”

(8) V + /s/
  a. /yvkmasal/ [yvma] “spirit of a post horse”
  b. /sasal/ [sado] “kill by shooting”

(9) V + /c/
  a. /CEcvm/ [CEva] “scoring”
  b. /kEcvm/ [kEva] “opening of a shop”

2.3. When a vowel follows a consonant

When a vowel follows a consonant, this consonant should be the coda of the preceding syllable in the orthography and the vowel the nucleus of the following syllable containing a silent consonant ‘ㅇ’. (The letter ‘ㅇ’ is silent when it is used as the onset of the syllable, while it is pronounced /N/ in the coda position.) Through the analysis of [4], 5 types of phonological phenomena are observed: (1) Liaison, (2) /n/-Epenthesis, (3) Palatalization, (4) /h/-Deletion, (5) Liaison after the Neutralization in Coda or Simplification of consonant clusters. As the quality of the vowel of the following syllable does not influence the preceding consonant, the Table 5 is arranged according to the consonant or the consonant cluster which can be appear in the coda position of the preceding syllable.

Table 5: Phonological alternations between a consonant and a vowel

<table>
<thead>
<tr>
<th>/n/-Epenthesis</th>
<th>Palatalization/Simplification + Liaison</th>
<th>/h/-Deletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>잡일</td>
<td>법인</td>
</tr>
<tr>
<td>P</td>
<td>잡일</td>
<td>양일</td>
</tr>
<tr>
<td>t</td>
<td>방이</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>홍이불</td>
<td>갈이</td>
</tr>
<tr>
<td>s</td>
<td>나뭇잎</td>
<td>꼬직</td>
</tr>
<tr>
<td>S</td>
<td>늘어렇</td>
<td>방갈이</td>
</tr>
<tr>
<td>c</td>
<td>낯익다</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>낯익다</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>샛언덕</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>낮이</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>낮이</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>낮이</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>낮이</td>
<td></td>
</tr>
<tr>
<td>ps</td>
<td>값어치</td>
<td></td>
</tr>
<tr>
<td>ks</td>
<td>값어치</td>
<td></td>
</tr>
<tr>
<td>nc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Phonological alternations, exceptions, between a consonant and a vowel

If one of these irregular alternations does not occur in this context, it is one of the regular alternations that takes effect there. Following are the examples of the /n/-Epenthesis (14~16) and the Liaison following the Neutralization in the
coda or the Simplification of the consonant clusters (17~19), with their realizations and their meanings:

(14) /p/ + V
a. /japil/ [jamnil] “chore”
   b. /bvpin/ [pvpin] “legal person”

(15) /p/ + V
a. /aPil/ [amnil] “thing(s) to come”
   b. /kiPi/ [kiPi] “depth”

(16) /T/ + V
a. /hotipul/ [honnipul] “(bed) sheet”
   b. /kaTi/ [kaC i] “together”

(17) /T/ + V
a. /kvTos/ [kvtot] “outer wear”
   b. /kaTi/ [kaC i] “together”

(18) /s/ + V
a. /usos/ [otot] “jacket”
   b. /gegIsi/ [gegIsi] “tidily”

(19) /c/ + V
a. /pamnacvpsi/ [pamna topSi] “all the time”
   b. /nopnaci/ [nomnaci] “height”

In (14a), (15a) and (16a) it was shown that /n/ inserted by the /n/-Epenthesis triggers also other regular alternations like the Nasalization of the preceding obstruent [5, 6]. And, in (16b), the Palatalization takes effect in the same context.

2.4. Summary

We have examined the phonological phenomena that should be classified as the exceptions for the grapheme-to-phoneme conversion and their contexts in a systematic manner so far, which can be summarized as the following Table.

<table>
<thead>
<tr>
<th></th>
<th>p</th>
<th>t</th>
<th>s</th>
<th>c</th>
<th>k</th>
<th>l</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(II)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>(I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>(III)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Exceptions and their phonetic contexts
(C: a consonant of a consonant cluster; V: a vowel or diphthong)
(I) Lexical Tensification
(II) Nasalization of the lateral
(III) /n/-Epenthesis, Neutralization/ Simplification + Liaison

There are three types of the phonetic contexts in which the exceptions appear: (I) when a sonorant is followed by a lenis obstruent; (II) when a nasal consonant is followed by a lateral consonant; (III) when a consonant in the coda position is followed by the vowel which is the nucleus of the following syllable containing a silent consonant ‘ㅇ’. And the phonological phenomena in each context are: the Lexical Tensification in (I); the Nasalization of the lateral consonant in (II); and, finally, the /n/-Epenthesis and the Liaison following the Neutralization in the coda or the Simplification of the consonant clusters in (III).

3. Conclusions

In this paper, we have shown that, contrary to general expectations, the exceptions for the grapheme-to-phoneme conversion are characterized by certain phonological alternations with their limited contexts. Accordingly, this systematic study of the exceptions from the phonological point of view will enable a systematic development of a multiple pronunciation lexicon for Korean TTS or ASR systems of high performance.

This study was performed based on the assumption that the phonology for the grapheme-to-phoneme conversion differs from the phonology of the language, which needs to be further examined in the future. Finally, a syntactic and semantic analysis needs to be performed also in order to solve the pronunciation ambiguities in Korean such as /hwapyvN/, which is realized either [hwapyvN] with the meaning of “flower vase” or [hwabyvN] with the meaning of “disease caused by pent-up rage”.

4. References