

Computer Codes for Korean Sounds: K-SAMPA

Jong-mi Kim*

*Kangwon National University

(Received 18 April 2001; revised 22 October; accepted 12 November 2001)

Abstract

An ASCII encoding of Korean has been developed for extended phonetic transcription of the Speech Assessment Methods Phonetic Alphabet (SAMPA). SAMPA is a machine-readable phonetic alphabet used for multilingual computing. It has been developed since 1987 and extended to more than twenty languages. The motivating factor for creating Korean SAMPA (K-SAMPA) is to label Korean speech for a multilingual corpus, or to transcribe native language (L1) interfered pronunciation of a second language learner for bilingual education.

Korean SAMPA represents each Korean allophone with a particular SAMPA symbol. Sounds that closely resemble it are represented by the same symbol, regardless of the language they are uttered in. Each of its symbols represents a speech sound that is spectrally and temporally so distinct as to be perceptually different when the components are heard in isolation. Each type of sound has a separate IPA-like designation.

Korean SAMPA is superior to other transcription systems with similar objectives. It describes better the cross-linguistic sound quality of Korean than the official Romanization system, proclaimed by the Korean government in July 2000, because it uses an internationally shared phonetic alphabet. It is also phonetically more accurate than the official Romanization in that it dispenses with orthographic adjustments. It is also more convenient for computing than the International Phonetic Alphabet (IPA) because it consists of the symbols on a standard keyboard. This paper demonstrates how the Korean SAMPA can express allophonic details and prosodic features by adopting the transcription conventions of the extended SAMPA (X-SAMPA) and the prosodic SAMPA (SAMPROSA).

Keywords: SAMPA, Korean SAMPA, K-SAMPA, Phonetic alphabet of Korean, Korean sounds for multilingual computing

1. Introduction¹⁾

A phonetic alphabet of Korean has been proposed for bilingual education or multilingual computing, following the convention of the Speech Assessment Methods Phonetic Alphabet (SAMPA)[2]. SAMPA is a keyboard-compatible coding of the International Phonetic Alphabet (IPA), in

which each type of sound is designated with a separate IPA-like symbol on a standard keyboard, dispensing with graphic symbols[3]. While the IPA includes graphic symbols, diacritics, and tone marks, SAMPA is proposed to be a standard alphabet that can be used to transmit the IPA-transcribed materials via electronic text delivery such as e-mail. Wherever the IPA character set is not available, SAMPA is a practical alternative. SAMPA was internationally developed in 1987, and since has been used in more than 20 languages. The phonetic alphabets

Corresponding author: Jong-mi Kim (kimjm@kangwon.ac.kr)
Kangwon National University, Chuncheon 200-701, S. Korea

¹⁾ An earlier version of this paper has been presented under the title "Speech Assessment Methods Phonetic Alphabet of Korean" in the 10th International Conference on Bilingualism held in Kuala Lumpur, Malaysia on June 29-30, 2001[1]. This paper has greatly been benefited from the suggestions from the participants of the conference and the anonymous reviewers in this journal.

posted in the SAMPA homepage are for Bulgarian, Croatian, Danish, Dutch, English, Estonian, French, German, Greek, Hungarian, Italian, Norwegian, Polish, Portuguese, Romanian, Russian, Slovenian, Spanish, and Swedish. Japanese SAMPA has been adopted by Japan Electronic Industry Development Association (JEIDA)[4]. Further, Korean SAMPA (K-SAMPA, henceforth) has been developed and implemented by Chung (1999); this paper necessarily incorporates his conventions wherever acceptable[5]. Under the aegis of COordinating COmmittee on Speech DATabases (COCOSDA), SAMPA is being extended to cover many other languages, and potentially to all languages[6]. SAMPA is, therefore, considered to be the most widely used phonetic alphabet for multilingual computing, when compared to other alternatives such as Worldbet, PHONASKII, or that of Ian Maddison[7-9]. Correspondingly, this paper aims to serve as a reference for the Korean SAMPA with the goal to annotate acoustic and other displays in the computer.

SAMPA, like the IPA, is implemented differently depending on the difference of the phonetic analysis that each phonetician takes. Thus, both SAMPA and the traditional IPA frequently employ the same symbol for a different sound in different languages; that is, the sounds that are objectively different from one another. For example, the default realization for /t/ in English is apicoalveolar and aspirated; /t/ in French is dental and unaspirated; in Swedish it is dental and aspirated; and, in Russian it is perhaps lamino-dental and velarized[10]. Such inconsistency in application to multilingual speech research requires a more detailed allophonic transcription that compares the sounds in different languages as well as first-language-interfered sounds.

Korean has its own phonemic writing alphabet, Hangeul, and a Romanization system (KOROM, henceforth) adopted by the government in July 2000[11]. KOROM with some phonetic extensions transcribes Korean sounds more effectively than K-SAMPA in most cases for monolingual annotation[12]. The corresponding Hangeul transcription, KOROM, and the IPA are also presented throughout the paper. The phonetic analysis underlying the proposed alphabet for K-SAMPA essentially follows that of KOROM.

All these transcription systems have different purposes and uses. The IPA is most useful for multilingual phonetic representation when its character set is available. Otherwise, SAMPA is a substitute for the IPA character set. Hangeul is most accurate when the transcription is limited to only Korean phonemes and no allophonic variations. KOROM is useful for the public to convert Hangeul into Roman letters. Thus, the purpose of this paper is not to replace any of these useful transcriptions and their different purposes, but to provide an ASCII encoding for Korean language computing using an international phonetic symbol set.

For expositional purposes, we will sequentially move from a broader to a narrower transcription. Narrowness is regarded as a continuum. Phonemic representation is known as "broad transcription"[13]. A systematic narrow transcription is an allophonic representation. A very narrow transcription can to an extent capture the acoustic segmentation, suitable for speech technology research where a close annotation of the acoustic signal is required.

II. Broad Transcription of Consonants

The standard Korean consonant phoneme inventory consists of fifteen obstruents (nine plosives, three affricates, and three fricatives) and four sonorants (three nasals and one liquid). There are two semivowels, [j] and [w], which will be discussed in the following section on vowels.

In Table 1, the plosives are classified into three manners of articulation: "lenis," "fortis," and "aspirated."

The sound quality of the lenis stops depends on the adjacent segments: they are voiceless and often lightly aspirated [b_0, d_0, g_0] in word-initial position, usually voiced [b, d, g] between voiced segments, and unreleased [p_}, t_}, k_}] in syllable-final position.²⁾ Fortis stops are

²⁾ A recent acoustic study by Kim (2000) argues that Korean lax consonants are underlyingly voiced and become devoiced domain-initially[14]. Her analysis is based on the observation that voiceless consonants lead to a H(L) tone and underlyingly voiced consonants lead to a LH(L) tone. She interprets the phenomenon as that the L tone is triggered by the phonological voicing of onset consonants. The tonal differentiation does not occur in domain-medial position.

Table 1. Plosives transcribed in SAMPA and other alphabets.

| Place | Manner | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | |
|----------|-----------|-------|----------------|---------|-------|--|---------------------|
| | | | | | | | |
| Bilabial | Lenis | b | b | ㅂ | b, p | 오바 oba 'coat' | 발 b_0al 'foot' |
| | Fortis | p_> | p' | ㅃ | pp | 오빠 op_>a 'brother' | 빨 p_>al 'sucking' |
| | Aspirated | p_h | p ^h | ㅍ | p | 오파 op_ha 'offer' | 팔 p_hal 'arm' |
| Alveolar | Lenis | d | d | ㄷ | d, t | 오다 oda 'come' | 달 d_0al 'moon' |
| | Fortis | t_> | t' | ㄸ | tt | unavailable | 딸 t_>al 'daughter' |
| | Aspirated | t_h | t ^h | ㅌ | t | 오타 ot_ha 'typo' | 탈 t_hal 'mask' |
| Velar | Lenis | g | g | ㄱ | g, k | 오가 oga 'the Oh's family' | 갈 g_0al 'going' |
| | Fortis | k_> | k' | ㄲ | kk | unavailable | 갈 k_>al 'spreading' |
| | Aspirated | k_h | k ^h | ㅋ | k | unavailable | 칼 k_hal 'knife' |

unaspirated, and produced with a partially constricted glottis and additional subglottal pressure. Aspirated stops are produced with heavy aspiration. All the plosives occur in syllable-initial position, while only lenis stops may occur in syllable-final position. The distinction among the plosives is signaled by the duration of constriction and intensity of the noise component.

Accordingly, the affricates in Table 2 are also categorized as "lenis," "fortis," and "aspirated."

Along with the earlier lenis stops, the lenis affricate /dZ/ becomes the voiceless, often lightly-aspirated [dZ_0] at the beginning of a word, and the unaspirated, often voiced [dZ] between voiced segments. The lenis affricates do not occur in syllable-final position and are realized as the unreleased variant [t_}] of the alveolar lenis stop.

Table 3 shows three fricatives: /s/ and /s_>/ in alveolar

position and /h/ in glottal position.

The intervocalic lenis fricative /s/ is not voiced [11,14].³⁾ The alveolar fricative /s/ becomes the postalveolar [S] when followed by the vowel /i/ [11]. The glottal fricative /h/ between voiced segments is the voiced [h\], often weakened to an approximant (frictionless continuant), or deleted [15-17]. /h/ does not occur in syllable-final position.

The sonorant consonants in Table 4 consist of three nasals /m, n, N/ and one liquid /l/.

Sonorant consonants [m, n, l] are short at the beginning of a syllable, but long [m:, n:, N:, l:] at the end of a syllable or before a pause [18]. The velar nasal [N] does not occur in syllable-initial position. The alveolar nasal /n/ becomes the palatalized [J] when followed by /i, j/, and [n] elsewhere [16,17]. The liquid /l/ becomes an alveolar tap [4] (i.e., the IPA [ɾ]) when between vowels, a palatal

Table 2. Affricates transcribed in SAMPA and other alphabets.

| Place | Manner | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | |
|----------|-----------|-------|-----------------|---------|-------|--|----------------------|
| | | | | | | | |
| Alveolar | Lenis | dZ | dʒ | ㅈ | j | 오자 odZa 'come' | 잘 dZ_0al 'well' |
| | Fortis | tS_> | tʃ' | ㅉ | jj | 오짜 otS_>a 'typo' | 잘 tS_>al 'squeezing' |
| | Aspirated | tS_h | tʃ ^h | ㅊ | ch | 오차 otS_ha 'deviation' | 찰 tS_hal 'kicking' |

Table 3. Fricatives transcribed in SAMPA and other alphabets.

| Phonetic Feature | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | |
|------------------|-------|-----|---------|-------|--|---------|
| Alveolar Lenis | s | s | ㅅ | s | 살 sal | 'flesh' |
| Alveolar Fortis | s_> | s' | ㅆ | ss | 쌀 s_>al | 'rice' |
| Glottal | h | h | ㅎ | h | 할 hal | 'doing' |

³⁾ This view contrasts to Lee (1999) who acknowledges the intervocalic voicing [17].

Table 4. Sonorant consonants transcribed in SAMPA and other alphabets.

| Phonetic Feature | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | | |
|------------------|-------|-----|---------|-------|--|-------|---------|
| Bilabial Nasal | m | m | ㅁ | m | 말 | mal | 'horse' |
| Alveolar Nasal | n | n | ㄴ | n | 날 | nal | 'day' |
| Velar Nasal | ŋ | ŋ | ㅇ | ng | 강 | g_0aN | 'river' |
| Lateral | l | l | ㄹ | r, l | 알 | al | 'egg' |

lateral [L] when between [I] and [i, j], and an alveolar lateral [l] elsewhere[15].

III. Broad Transcription of Vowels

There are ten simple vowels (five front and back vowels each) and two semivowels, /j/ and /w/, in Korean. Contrastive vowel length is reported to be disappearing among native speakers in Seoul and the younger speakers of other dialects as well[19].⁴⁾ The five front vowels consist of two high, two mid, and one low, as in Table 5. Some of these vowels are often absent in the speech corpus due to on-going sound changes of merging and diphthongization [11,16,20].

The vowels /e/ and /E/ are often merged into one vowel

[E]. The high front round vowel [ɨ], (i.e., [ø] in the IPA) often changes to the diphthong [we].

On the other hand, in Table 6, the five back vowels consist of two high, two mid, and one low. Their vowel qualities are still stable unlike diachronic sound changes of the front vowels.

The semi-vowels, [j] and [w], have been considered to be the components of diphthongs rather than independent consonants[17]. [w] is the voiced labio-velar approximant, and [j] the voiced palatal approximant. [w] combines with all the simple vowels that have non-high unround features, as shown in Table 7.

Some speakers who have one merged form [E] for the two simple vowels [e] and [E] only have one merged form [we] for both [we] and [wE]. These speakers tend to diphthongize the simple vowel [ɨ] to [we]. As a result,

Table 5. Front vowels transcribed in SAMPA and other alphabets.

| Height | Roundness | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | | |
|--------|-----------|-------|-----|---------|-------|--|-----|-----------|
| High | Unround | i | i | ㅣ | i | 시 | Si | 'hour' |
| | Round | wi | wi | ㅟ | wi | 쉬 | swi | 'quickly' |
| Mid | Unround | e | e | ㅓ | e | 세 | se | 'strong' |
| | Round | ɨ | ø | ㅟ | oe | 쇠 | sɨ | 'iron' |
| Low | Unround | E | ɛ | ㅘ | ae | 새 | sE | 'bird' |

Table 6. Back vowels transcribed in SAMPA and other alphabets.

| Height | Roundness | SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | | | |
|--------|-----------|-------|-----|---------|-------|--|------|--------|---------------|
| High | Unround | M | ɯ | ㅡ | eu | 그 | g_0M | 'the' | unavailable |
| | Round | u | u | ㅜ | u | 구 | g_0u | 'nine' | 수 su 'number' |
| Mid | Unround | ɤ | ʌ | ㅓ | eo | unavailable | 서 | sV | 'stop' |
| | Round | o | o | ㅛ | o | unavailable | 소 | so | 'cow' |
| Low | Unround | A | ɑ | ㅚ | a | 가 | g_0A | 'go' | 사 sa 'buy' |

⁴⁾ Their phonemic status has been exemplified with the following words: [mA:l] "speech," [mAl] "horse," [b_0V:l] "bee," [b_0Vl] "punishment." Refer to Lee (1999) for more examples[17].

Table 7. Diphthongs with [w].

| SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | | |
|-------|-----|---------|-------|--|------------------------------|-------------|
| | | | | | | |
| wɛ | wɛ | 에 | wɛ | 웬만 wenman 'tolerable' | 웨차다 k_>wechada 'take' | unavailable |
| wE | wɛ̃ | 애 | wac | unavailable | 꽤차다 k_>wEchada 'rather cool' | 왜 wE 'why' |
| wA | wɑ | 아 | wa | 완만 wAnmAn 'slack' | unavailable | 와 wA 'come' |
| wV | wʌ | 어 | wo | 원만 wVnmAn 'harmony' | unavailable | unavailable |

Table 8. Diphthongs with [j] and [M].

| SAMPA | IPA | Hangeul | KOROM | Transcription Example (Orthography / Transcription / Gloss) | | |
|-------|-----|---------|-------|--|--|--|
| | | | | | | |
| je | je | 예 | ye | 예기 jegi 'expect' | | |
| jE | jẽ | 얘 | yae | 얘기 jEgi 'story' | | |
| jA | ja | 야 | ya | 야기 jagi 'cause' | | |
| jV | jʌ | 여 | yʌ | 여기 jVgi 'here' | | |
| jo | jo | 요 | yo | 요기 jogi 'little food' | | |
| ju | ju | 유 | yu | 유기 jugi 'organic' | | |
| Mi | ɰi | 이 | ui | 이기 Migi 'righteousness' | | |

their pronunciation is transcribed like the following: [k_>we] for 에 'trick,' [k_>wE] for 얘 'link,' [k_>wE] for 얘 'rather.'

[j] combines with the simple vowels [e, E, A, V, o, u], as in Table 8.

Likewise, some speakers have one merged form [jE] for both [je] and [jE], especially when they have one merged form [E] for the two simple vowels [e] and [E]. As a result, they transcribe in the same way, [jEgi], for both words, 예기 'expect' and 얘기 'story.' The diphthong / Mi / can exceptionally be realized as both the onglide [Mi] and the offglide [Mj], while all other Korean diphthongs consist of the onglides [j, w]. / Mi / appears as [i] when preceded by a consonant, [e] when used as a possessive marker in colloquial speech, [Mj] at the end of syllable, and [Mi] elsewhere.⁹

IV. Narrow Transcription of Allophones in Speech Corpus

Allophones in a speech corpus are more diverse than

those mentioned in sections II and III. This section will discuss the context-dependent allophones commonly found in conversational speech, identifying which aids the consistent categorization and prediction of sounds in a speech corpus. We skip the discussion on context-free, sporadic, and idiosyncratic allophones, which may impede economical and consistent phonetic description of a language. For detailed description of the allophones selected, the symbols are often taken from X-SAMPA, an extension of the SAMPA standard and a proposed keyboard-compatible coding of the entire IPA symbols[10]. Diacritics other than those already employed in SAMPA are mapped onto a keystroke with a preceding underscore "_". Notice that uppercase must be distinguished from lowercase, and there is no need to separate successive symbols by spaces.

Allophonic details for any "system-specific-needs" are incorporated into K-SAMPA by adding mnemonic symbols to the base symbols. Refer to Table 9.

In addition to the phonemic transcription of the long vowels of those speakers discussed in the previous sections, there is an allophonic lengthening of the vowels before a pause in conversational speech in general[21]. In contrast, vowels are extra short when preceded by a nasal or a glottal fricative, partially devoiced when followed by the fricatives / s, s_>, h / or the aspirated stops / p_h, t_h,

⁹ This diphthong / Mi / is therefore often represented as the combination of two vowels without a glide[11,17].

Table 9. Allophonic details of K-SAMPA with examples in narrow transcription.

| Phonetic Feature | SAMPA | IPA | Transcription Example (Orthography / Transcription / Gloss) |
|-----------------------|------------------|------------|---|
| Long Vowel | : | : | 나가 [nA ~ XGA:] 'Go out!' |
| Extra-short Vowel | _X | ~ | 한번 [hA_X ~n:bV ~n:] 'once'; 내일 [nE_X ~il:] 'tomorrow' |
| Devoiced Vowel | _0 (figure zero) | ◌◌ | 다시 [d_0A_0Si_0] 'again'; 소포 [s_w0_0p_h_w0] 'parcel' |
| Nasalized Vowel | _~ | ~ | 내일 [nE ~ Xil:] 'tomorrow'; 동안 [d_0_w0 ~N:A ~n:] 'during' |
| Labialized Obstruent | _w | ◌w | 보약 [b_0_w0jak_] 'health food'; 토요일 [t_h_w0joil:] 'Saturday' |
| Palatalized Obstruent | _j | ◌j | 십이분 [S_jiB_jiB_wun:] '12 minutes'; 마디 [m_XA ~d_ji] 'joint' |
| Weakened Lenis Stop | B, G, z, Z | β, γ, z, ʒ | 그보다 [g_0MB_wodA:] 'rather'; 주거지 [dZ_0_wuGVZi] 'residence' |
| Glottal Stop | ? | ʔ | 일월일일 [il?wVil?il:] 'January 1st' |

k_h, tS_h /, and nasalized when adjacent to a nasal consonant[21]. Obstruents are labialized before a round vowel and palatalized before [i, j][15,21]. The lenis stops [b, g, dZ] are weakened to the voiced fricatives [B, G, Z] between vowels[14,15,20]. Speakers place a syllable break by inserting the glottal stop [ʔ] between a consonant and a vowel[21].

Notations in this section and the following section are optionally applicable, depending on needed narrowness of transcription. One may omit some of these notations in applying to his own system.

V. Prosody

In its basic form, SAMPA is essentially used for segmental transcription, particularly of the traditional phonemic or near-phonemic kind. Prosodic notation is compensated by using its proposed parallel system, SAMPROSA[22]. The prosodic and segmental transcriptions are kept distinct from one another on separate

representational tiers. This arises from the fact that certain symbols represent different meanings in SAMPROSA from their meaning in SAMPA. For example, [L] denotes the palatal-lateral approximant in SAMPA, but a low tone in SAMPROSA. In this respect, SAMPROSA can be replaced by ToBI, which also uses a prosodic tier independent from the segmental tier, and has been successively developed for multilingual computing[23-25]. Since Korean ToBI (K-ToBI, henceforth) has extensively been explored and implemented, we will tentatively limit our discussion on SAMPROSA to the extent that supplies the boundary information and the broad overview.

The boundary symbols and other major prosodic notations for the description of Korean are illustrated in Table 10.⁶⁾

Unlike K-ToBI, SAMPROSA contains diverse boundary symbols and tonal expressions for the segmental tier. SAMPROSA can keep the tonal expressions within the segmental tier, either by using an underscore or by defining a tier-escape symbol. For example, the English word 'ahead,' transcribed with the use of underscores, would be [@_LHE_Hd]; where [@] and [E] are the base symbols

Table 10. Prosodic notations in SAMPROSA.

| Boundary Feature | IPA | SAM PROSA | Tone Feature | IPA | SAM PROSA | SAMPROSA using underscore |
|------------------------------|-------------|-----------|---------------|------|-----------|---------------------------|
| Pause | unavailable | ... | High Pitch | é, ↑ | H | e_H |
| Syllable Boundary | | \$ | Low Pitch | è, ↓ | L | e_L |
| Word Boundary | unavailable | # | Rising Pitch | ẽ, ʌ | LH | e_R |
| Accentual Phrase Boundary | | | Falling Pitch | ê, ∨ | HL | e_F |
| Intonational Phrase Boundary | | | Downstep | ˘ | ! | unavailable |
| | | | Upstep | ˙ | ^ | unavailable |

⁶⁾ The word boundaries in Korean, being an agglutinative language, refer to phrasal-words.

indicating vowel segments, and [_L] and [_H] represent the tonal features of the base symbols. One may opt for employing the tier-escape symbols, the angled brackets, “<” and “>”, in order to mark the point at which the notation moves from the segmental tier to the prosodic tier, and back again. The angled brackets make available, for example, the English word ‘ahead’ with low pitch on the first syllable and high pitch on the second as [<L>@<H>HEd]. Hence, the first [<H>] is to be interpreted as “high pitch,” which can toggle back into the segmental mode, signaling that the second [H] stands for the voiced glottal stop. Use of the underscore and angled brackets enables SAMPROSA to keep the two types of notations separate from one another, yet in a single tier.

The major practical applications of SAMPROSA may be for two areas: prosodic transcription for linguistic purposes and prosodic labeling in speech technology. When

the multi-tiered transcription is inadequate for a given speech transcription, SAMPROSA can replace K-ToBI.

VI. Application

SAMPA can be applied to the construction of multilingual dictionaries, foreign language education, automatic language identification, and multilingual speech recognition and synthesis.⁷⁾ Table 11 illustrates the SAMPA transcription of English, spoken by a Korean learner. The speech in the recording on which the transcription is based is that of a 21-year-old student of English major who has grown up and spent most of her life in Cheongpyeong City, Kyonggi province of Korea. This area is near Seoul where people speaks the so-called “standard Korean,” and it has fewer

Table 11. SAMPA transcription of L1-interfered speech where English is the target language and Korean is the native language.

| Transcription System | Transcription Example |
|--|---|
| <i>Text or Lexicon</i> | Don't ask me to carry an oily rag like that. |
| <i>Very Broad Transcription in Hangeul (syllabic)</i> | 돈에스크미투캐리언오일래그라이크덴 |
| <i>Very Broad Transcription in the IPA (syllabic)</i> | donesuk ^h mit ^h uk ^h eli ^h noilegulaik ^h urdet |
| <i>Broad Transcription in SAMPA (phonemic)</i> | donEsk_hmit_huk_hEliVnoilEIEgMlaik_hdEt. |
| <i>Broad Transcription in the IPA (phonemic)</i> | donesk ^h mit ^h uk ^h eli ^h noilegulaik ^h det |
| <i>Narrow Transcription in SAMPA (allophonic)</i> | d_0o_~_wnEsk_hmit_hUK_hErIVnO_jlErEgMla_jk_hd_0Et_}. |
| <i>Narrow Transcription in the IPA (allophonic)</i> | ḑõ ^h nesk ^h mit ^h uk ^h ɛɹɹɹnɔ ^h ɹɛgulaik ^h dɛt ^h |
| <i>Very Narrow Transcription in SAMPA (acoustic)</i> | d_0o_~_wnEsk_hmit_hUK_hErIVn?O_jlE... rEgMla_x_jk_hd_0E:t_}<L> |
| <i>Very Narrow Transcription in the IPA (acoustic)</i> | ḑõ ^h nesk ^h mit ^h uk ^h ɛɹɹ?ɹn?ɔ ^h ɹɛ ɹɛgulaik ^h dɛ:t ^h |

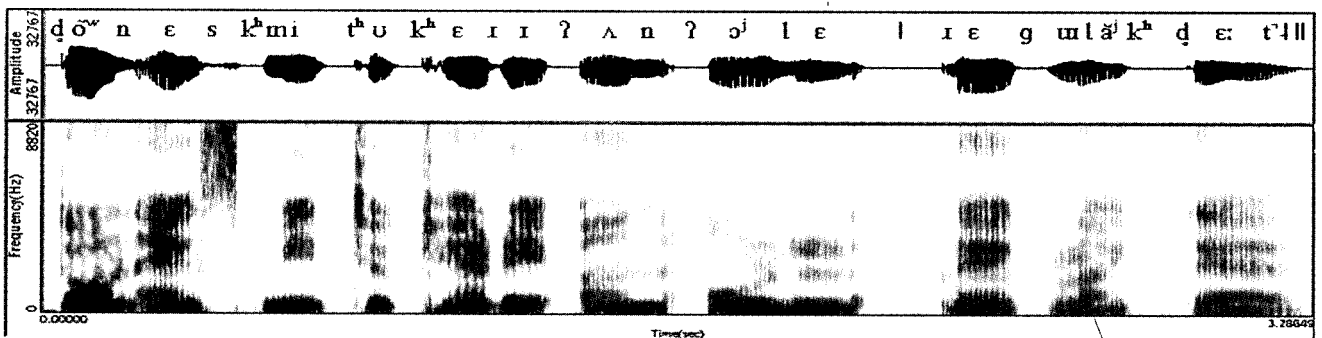


Figure 1. Waveform and spectrogram of an L1-interfered speech, “Don’t ask me to carry an oily rag like that.”

⁷⁾ An earlier version of this section has been presented under the title “Annotation of Korean English database” in the 11th Conference on Speech Sciences held in Pusan, Korea on November 2-4, 2001[26]. This paper has greatly been benefited from the suggestions from the participants of the conference.

immigrants speaking other dialects than Seoul. The waveform and spectrogram is presented in Figure 1. The recording text is taken from TIMIT(1990)[27].

Table 11 presents various degrees of narrowness by transcribing the same speech in Figure 1. Each transcription provides as detailed phonetic information as required to account for the relevant speech database. The Hangeul transcription is the broadest and always represented in syllabic forms due to the nature of the system. Based on the fact, the speech under consideration can be translated into SAMPA as in [donEsMk_hMmit_huk_hEliVnoilEIEgVlaik_hMdEt]. This transcription correctly represents the speaker's slip of tongue for the final vowel [E] in 'oily,' the inserted vowel [M] at the end of 'rag,' and the omission of [t] in 'don't.' Consonant [t] alone cannot form a syllable; thus, it is either omitted or followed by an epenthetic vowel in a syllabic transcription. For this speaker, it is omitted in this data.

On other grounds, such syllabic transcription incorrectly includes the non-present vowel [M] at the end of the words, 'ask' and 'like.' [k_h] in 'ask' cannot form a syllable; thereby, the vowel [M] is inserted in the transcription. Likewise, [k_h] in 'like' is not a possible syllable coda in Korean; consequently, the vowel [M] is again inserted in the transcription. This way, the syllabic transcription above shows a representation of phonotactically well-formed Korean sounds.

The Hangeul transcription is most useful in text-to-speech synthesis that requires the nativized Korean pronunciation of foreign words. It is, however, not particularly suitable for annotating speech databases acquired from foreign language education, where only the L1-interfered pronunciation is precisely targetted, extracted and annotated for teaching. Nor is it suitable for speech recognition, for which the mixture of, both, the native and target phonology is the clue for recognizing any L1-interfered speech.

A less broad transcription in the speech database is phonemic in Korean; that is, the native language of the speaker. This transcription correctly represents the absence of a vowel in 'ask' and 'like,' where the syllabic

representation fails. It also correctly represents the sound quality of native language transfer: the first consonant [d] in 'that' and the vowel [E] in 'ask,' [i] in 'me,' [E] in 'carry,' and [V] in 'an.'

However, it incorrectly represents the phonemically distinct sounds in the target language. The liquid consonant is misleadingly represented by [l] in 'carry' and 'rag,' the glide by [i] in 'oily' and 'like,' and vowels by [u] in 'to,' and [i] in 'carry.' In phonemic and allophonic transcriptions, it is common to include spaces to aid legibility, but their theoretical validity is problematic[13:p.29].

Most transcription systems proposed solely for Korean speech database are capable of transcribing the bilingual input speech up to this level of phonemic representation, but not to the next higher level of bilingual allophones. The examples of monolingual transcriptions of Korean are the official Romanization, KORBET, the ETRI system, and Cheongsanyusu[11,12,28,29].

The phonemic transcription can be convenient for transcribing the sound of a less fluent speaker of the target language who has not acquired any of the target allophones. However, the same transcription is not suitable for any professional speech databases for multilingual synthesis and recognition or foreign language education. This is because the transcription in native phonemes cannot represent either well-formed nativized sounds with the permissible syllabic forms or the target sounds actually uttered by the learner.

A narrower transcription is allophonic, including the allophones of both Korean and English. This level of transcription correctly represents the phonemically distinct sounds in the target language, which the broader levels in the preceding sections cannot. The liquid consonant [rʌ] in 'carry' and 'rag' is transcribed differently from the other liquid [l] in 'oily,' which are two different phonemes in English. Further, English phonemes [U, I] for the vowels in 'to' and 'carry,' are also represented differently from the vowels [u, i], which are in a different series of phonemes in the language. This level of transcription can represent the target pronunciation [I] in 'carry,' and the L1-interfered pronunciation [i] in 'me.' These phonemes

in English, the target language, are allophones in Korean, the native language.

Allophones of both the native and target languages are also represented in this level. English allophones [o_~_w, O_j, a_j] arise for the diphthongs in 'don't,' 'oily,' and 'like,' whose phonemic representations would be [o, OI, aI], correspondingly. The allophones in Korean appear, for example, in the unreleased stop [t_}] at the end of 'that.'

The allophonic transcription is useful for foreign language teaching, where differentiating the native allophones from the target allophones is necessary for transcription purposes. Thus, in this recording, the vowels [E, i, V, E] in 'ask,' 'mi,' 'an,' 'that' are the L1- transferred allophones that are either higher or more tensed than the target allophones. The stop consonants [k_h, t_h, k_h] in 'ask,' 'to,' 'like' are also the L1-transferred allophones that are more heavily aspirated than the target allophones. The inserted vowel [M] at the end of 'rag' is also the result of L1-transfer from Korean.

The narrowest transcription represents the acoustic signal. This level of transcription represents the speech phenomena as in detail as minor allophones, nasalization, length, pitch, and breath grouping. There is a glottal stop transcribed as [ʔ] before and after 'an' in the speech. There is also a slight pause after 'oily' followed by an accentual phrase boundary [||]. The symbol for a pause is [...] in SAMPA, which is not available in the IPA. The vowel [a_x_j] in 'like' is extra short, while the vowel [E:] in 'that' is long. The low tone [<L>] is at the end of the sentence, followed by an intonational phrase boundary [||].

The acoustic phonetic level of transcription is useful for speech recognition technology, where the input signal of sound waveforms can be represented only with some phonetic alphabets. These alphabets are in turn mapped to the lexicon of the given languages, so that the meaning can be recognized[30]. The transcription process in this acoustic level involves transcriptions vis-à-vis segmental phonology, supra-segmental features, pragmatic features of interjections and pause, and time-alignment of speech signal. Thus, this level of transcription is too intricate and time-consuming to apply for speech databases of synthesis

or education.

K-SAMPA transcription is useful in representing the speech phenomena using a standard keyboard, in detail as minor allophones, nasalization, length, pitch, and breath grouping. SAMPA transcription, whether broad syllabic or phonemic transcription or narrow allophonic or acoustic phonetic transcription, converts to the IPA through one-to-one mapping of the symbols as in Table 11. This is possible because SAMPA is one of the most specific transcription systems. Comparing K-SAMPA and Hangeul transcription is also useful for "text-to-speech synthesis," where foreign texts often need to be represented in Hangeul and synthesized into native-like Korean sounds. A transcription sample of monolingual Korean is presented in Appendix B.

VII. Concluding Remarks

K-SAMPA has been proposed for multilingual computer coding of Korean sounds. The broad transcription is presented in sections II and III, and the narrow one in sections IV through VI. Some disagreements on the use of symbols are expected because SAMPA, like the IPA, allows flexibility in adopting new symbols, and besides, the principles of their use apply differently as the theories in phonetics improve[5,10]. In particular, the Korean vowel inventory as discussed in section II is subject to disagreements regarding the number of monophthongs, vowel quality, and the presence or absence of contrastive lengthening. For this and other reasons, it may be pertinent to follow the analysis of more authentic material, the official Romanization, which has recently been adopted after collaboration with many phoneticians[11]. Allophonic details found in conversational speech are relatively unknown and not always predictable. Each of the allophones is introduced for reference in the appendix for the SAMPA symbol list and a sample transcription of a passage.

Appendix 1: K-SAMPA symbols for Korean

K-SAMPA symbols are presented in comparison with Hangeul, the IPA, and the official Korean Romanization (KOROM), along with their phonetic features and sample

transcriptions. The sound elements are sequenced in the order of transcription of consonantal and vowel allophones, narrow transcription of allophonic details, and prosody.

Table 12. Transcription symbols of consonantal allophones (The choice of the IPA symbols [b, d, ɰ] follow H-B Lee (1999)).

| Hangeul | SAMPA | IPA | KOROM | Feature | Example |
|---------|-------|-----------------|-------|---|-------------------------------------|
| ㄱ | g | g | g | voiced velar lenis plosive | 아가 [aga] 'baby' |
| ㄱ | g_0 | ɰ | g | voiceless velar lenis plosive | 가 [g_0a] 'go' |
| ㄱ | k_ɿ | k' | k | unreleased voiceless velar lenis plosive | 악 [ak_ɿ] 'evil' |
| ㄴ | k_ɿ | k' | kk | voiceless velar fortis plosive | 아까 [ak_ɿa] 'before' |
| ㄴ | n | n | n | alveolar nasal | 나 [na] 'I' |
| ㄴ | n: | n: | n | long alveolar nasal | 안 [an] 'inside' |
| ㄴ | ɲ | n' | n | palatalized alveolar nasal | 아나 [aɲa] 'no' |
| ㄷ | d | d | d | voiced alveolar lenis plosive | 오다 [oda] 'come' |
| ㄷ | d_0 | ɸ | d | voiceless alveolar lenis plosive | 다 [d_0a] 'all' |
| ㄷ | t_ɿ | t' | t | unreleased voiceless alveolar lenis plosive | 탓 [t_hat_ɿ] 'blame' |
| ㄷ | t_ɿ | t' | tt | voiceless alveolar fortis plosive | 따 [t_ɿa] 'pick' |
| ㄹ | l | l | l | alveolar lateral | 알 [al] 'egg' |
| ㄹ | ɭ | r | r | alveolar lateral | 사라 [saɭa] 'buy' |
| ㄹ | ɭ | ɻ | r | palatal lateral | 사려 [saɭjV] 'consideration' |
| ㅁ | m | m | m | bilabial nasal | 마 [ma] 'hemp' |
| ㅁ | m: | m: | m | long bilabial nasal | 암 [am] 'cancer' |
| ㅂ | b | b | b | voiced bilabial lenis plosive | 오버 [oba] 'overcoat' |
| ㅂ | b_0 | ɸ | b | voiceless bilabial lenis plosive | 밥 [b_0ap_ɿ] 'rice' |
| ㅂ | p_ɿ | p' | p | unreleased voiceless bilabial lenis plosive | 밥 [b_0ap_ɿ] 'rice' |
| ㅂ | p_ɿ | p' | pp | voiceless bilabial fortis plosive | 오빠 [op_ɿa] 'brother' |
| ㅅ | s | s | s | voiceless alveolar lenis fricative | 사 [sa] 'buy' |
| ㅅ | S | ʃ | s | voiceless alveo-palatal lenis fricative | 시 [Si] 'time' |
| ㅅ | s_ɿ | s' | ss | voiceless alveolar fortis fricative | 싸 [s_ɿa] 'cheap' |
| ㅅ | S_ɿ | ʃ' | ss | voiceless alveo-palatal fortis fricative | 씨 [S_ɿi] 'seed' |
| ㅇ | none | none | none | empty onset of a syllable | 아 [a] 'oh' |
| ㅇ | ŋ | ŋ | ng | velar nasal | 강 [kaŋ] 'river' |
| ㅈ | dʒ | dʒ | j | voiced alveo-palatal lenis affricate | 사자 [sadʒa] 'lion' |
| ㅈ | dʒ_0 | tʃ | j | voiceless alveo-palatal lenis affricate | 자 [dʒ_0a] 'ruler' |
| ㅉ | tʃ_ɿ | tʃ' | jj | voiceless alveo-palatal fortis affricate | 짜 [tʃ_ɿa] 'salty' |
| ㅊ | tʃ_h | tʃ ^h | ch | voiceless alveo-palatal aspirated affricate | 차 [tʃ_ha] 'tea' |
| ㅋ | k_h | k ^h | k | voiceless velar aspirated stop | 카 [k_ha] 'car' |
| ㅌ | t_h | t ^h | t | voiceless alveolar aspirated stop | 타 [t_ha] 'ride' |
| ㅍ | p_h | p ^h | p | voiceless bilabial aspirated stop | 꽂 [p_ha] 'dig' |
| ㅎ | h | fi | h | voiceless glottal fricative | 하 [ha] 'down' |
| ㅎ | h\ | fi | h | voiced glottal fricative | 저하 [dʒ_0VhWa] 'lowered' |
| ㅎ | C | ç | h(hh) | voiceless palatal fricative | 힘껏 [hhimkkeot] 'as hard as one can' |

Table 13. Transcription symbols of vowel allophones.

| Hangeul | SAMPA | IPA | KOROM | Feature | Example |
|---------|-------|-----|-------|--|---------------------------|
| ㅏ | A | ɑ | a | low back unround | 사 [sa] 'buy' |
| ㅑ | E | ɛ | ae | low front unround | 새 [sE] 'bird' |
| ㅓ | jA | jɑ | ya | palatal approximant + low back unround | 야기 [jagi] 'cause' |
| ㅕ | jE | je | yae | palatal approximant + mid front unround | 얘기 [jEgi] 'story' |
| ㅗ | V | ʌ | eo | mid back unround | 서 [sV] 'stop' |
| ㅛ | e | e | e | mid front unround | 세 [se] 'strong' |
| ㅜ | jV | jʌ | yeo | palatal approximant + mid back unround | 여기 [jVgi] 'here' |
| ㅠ | je | je | ye | palatal approximant + mid front unround | 예기 [jeg] 'expect' |
| ㅝ | o | o | o | mid back round | 소 [so] 'cow' |
| ㅟ | wA | wɑ | wa | labio-velar approximant + low back unround | 와 [wA] 'come' |
| ㅙ | wE | wɛ | wae | labio-velar approximant + low front unround | 왜 [wE] 'why' |
| ㅛ | ʌ | ø | oe | mid front round | 쇠 [sʌ] 'iron' |
| ㅠ | jo | jo | yo | palatal approximant + mid back round | 요기 [jogi] 'little food' |
| ㅜ | u | u | u | high back round | 수 [su] 'number' |
| ㅠ | wV | wʌ | weo | labio-velar approximant + mid back unround | 원만 [wVnmAn] 'harmony' |
| ㅠ | we | wɛ | we | labio-velar approximant + mid front unround | 원만 [wenman] 'tolerable' |
| ㅠ | wi | wi | wi | labio-velar approximant + high front unround | 쉬 [swi] 'easily' |
| ㅠ | ju | ju | yu | palatal approximant + high back round | 유기 [jugi] 'organic' |
| ㅡ | M | ɯ | eu | high back unround | 그 [g.OM] 'the' |
| ㅟ | Mɪ | ɯɪ | ui | velar approximant + high front unround | 의기 [Mɪgi] 'righteousness' |
| ㅟ | Mj | ɯj | ui | high back unround + labio-velar approximant | 수의 [sɯMj] 'shroud' |
| ㅣ | i | i | i | high front unround | 이기 [igi] 'convenience' |

Table 14. Extended transcription of allophonic details in speech corpus.

| SAMPA | IPA | Phonetic Feature | SAMPA | IPA | Phonetic Feature |
|------------------|-----|-------------------|---------|------------|-----------------------|
| : | : | long sonorant | _w | w | labialized obstruent |
| _X | ˚ | extra-short vowel | _y | ˚ | palatalized obstruent |
| _0 (figure zero) | . | devoiced vowel | B, G, Z | β, γ, z, ʒ | weakened lenis stop |
| _~ | ˜ | nasalized vowel | ʔ | ʔ | glottal stop |

Table 15. Boundary transcription.

| SAMPROSA | IPA | Boundary | SAMPROSA | IPA | Boundary |
|---------------|-------------|----------|----------|-------------|--------------------------|
| no underscore | unavailable | phoneme | | | minor (accent) group |
| \$ | | syllable | | | major (intonation) group |
| # | unavailable | word | ... | unavailable | pause |

Table 16. Tonal transcription.

| SAM PROSA | SAMPROSA using underscore | IPA | Tone Feature | SAM PROSA | SAMPROSA using underscore | IPA | Tone Feature |
|-----------|---------------------------|-------|--------------|-----------|---------------------------|------|---------------|
| H | e_H | é, ˥ | high pitch | HL | e_F | è, ˩ | falling pitch |
| L | e_L | è, ˩ | low pitch | ! | unavailable | ˩ | downstep |
| LH | e_R | è, ˨˨ | rising pitch | ^ | unavailable | ˩ | upstep |

Appendix 2: K-SAMPA Transcription of a Sample Passage

SAMPA symbols are used to transcribe a recorded speech of the fable “The North Wind and the Sun,” that is taken from the IPA handbook (1999). The recorded speech of the transcription is of a 21-year-old female who grew up and spent most of her life in Cheongpyeong City, Kyonggi Province, Korea. The area is where people speak the so-called “standard Korean,” and has fewer immigrants speaking other dialects than Seoul, which is nearby.

English text

The North Wind and the Sun were disputing which was the stronger, when a traveler came along wrapped in a warm cloak. They agreed that the one who first succeeded in making the traveler take his cloak off should be considered stronger than the other. Then the North Wind blew as hard as he could, but the more he blew the more closely did the traveler fold his cloak around him; and at last the North Wind gave the attempt. Then the Sun shone out warmly, and immediately the traveler took off his cloak. And so the North Wind was obliged to confess that the Sun was the stronger of the two.

Orthographic translation

바람과 햇님이 서로 힘이 더 세다고 다투고 있을 때, 한 나그네가 따뜻한 외투를 입고 걸어 왔습니다. 그들은 누구든지 나그네의 외투를 먼저 벗기는 이가 힘이 더 세다고하기로 결정했습니다. 북풍은 힘껏 불었으나 불면 불수록 나그네는 외투를 단단히 여몄습니다. 그 때에 햇님이 뜨거운 햇빛을 가만히 내리쬐니, 나그네는 외투를 얼른 벗었습니다. 이리하여 북풍은 햇님이 둘 중에 힘이 더 세다고 인정하지 않을 수 없었습니다.

Broad transcription in Hangeul: Representation of syllables and phonemes

바람과 햇님이 서로 힘이 더 세다고 다투고 이슬때, 한 나그네가 따뜨란 외투를 입고 거러와옵니다. 그드른 누구든지 나그네의 외투를 먼저 벗끼느니가 힘이 더 세다고하기로 결정해옵니다. 북풍은 힘껏 부러쓰나 불면 불수록 나그네는 외

투를 단단히 여며옵니다. 그때에 햇님이 뜨거운 햇배출 가만히 내리쬐니, 나그네는 외투를 얼른 버서옵니다. 이리하여 북풍은 햇님이 둘중예 히미 더 세다고 인정하지 아늘수 업써옵니다.

Narrow phonetic transcription in the IPA: Representation of major allophones

ɸaramgwa hɛnɲimi saro himi da sedago ɕatʰugo isʰultʰɛ, han nagumɛga tʰatʰultʰan wɛtʰurɯl ipkʰo ɕasa wasʰumɲida. ɕud ulɯl nugudumɲi nagumɛɯj wɛtʰurɯl mandʒa bakʰinɯ nigahimi da sedago hagiɾo ɕjalʰʃaŋ hesʰumɲida. ɸukʰpʰuɯm himkʰatʰ ɸucasʰuina ɸulmjan ɸulsʰurog nagumɛnɯm wɛtʰurɯl ɕandʌnɦi jʌnɦasʰumɲida. ɕultʰɛɛ hɛnɦimi tʰuɕaɯm hɛtʰpʰitʰul ɕamanɦi nɛɕja cʰwɛɦi nagumɛnɯm wɛtʰurɯl alɯm ɸasasʰumɲida. iriɦaja ɸukʰpʰuɯm hɛnɦimi ɕultʰuɕɛ himi ɕa sedago indʒaŋɦadzi anɯlsʰu apʰsʰasʰumɲida.

Narrow phonetic transcription in SAMPA: Representation of major allophones

b_0A4AmgwA hEnJimi sV4o himi dV sedAgo d_0At_hugo is_>Mt_>E, hAn nAgMnegA t_>At_>Mt_hAn wɛt_hu4Ml ip_}k_>o g_0V4VwAs_>M_mJidA. g_0MdM4Mn nugudMndZi nAgMneMj wɛt_hu4Ml mVndZV b_0Vt_}k_>inMnJigA himi d_0V sedAgo hAgi4o g_0jVltS_>VnɦEs_>MmJidA. b_0uk_}p_huNMn himk_>Vt b_0u4Vs_>MnA b_0ulmjVn b_0uls_>u4og nAgMnenMn wɛt_hu4Ml d_0AndAnɦi jVMjVs_>MmJidA. g_0Mt_Ee hEnJimi t_>MgVun hEt_}p_>itSMl g_0AmAnɦi nE4jVtS_>wɛɦi, nAgMnenMn wɛt_hu4Ml VllMn b_0VsVs_>MmJidA. i4ihAjV b_0uk_}p_huNMn hEnJimi d_0ultS_>uNe himi d_0 V sedAgo indZVnɦadZi AnMls_>u Vp_}s_>Vs_>MmJidA.

Very narrow phonetic transcription in SAMPA: Representation of minor allophones and suprasegmental features

b_0A4A_~mgwA#hE_~nJi_~mi<H>|sV4o#himi#dV#sed Ago#d_0At_hu_0go#is_>Ml#t_>E:<H>|hAn#nAGMnegA#t_>At_>Mt_hAn#wɛt_hu_04Ml#ip_}k_>_wo#g_0V4V#wAs_>M_XmJidA:<L>||g_0MdM4Mn#nuG_wudMndZi<H>|nA GMne_~Mj#wɛt_hu_04Ml#mV_~ndZV#bVk_>inM_~JiGA :<H>|ɦi_0_Xmi#dV#sedAG_wo#hAGi4o#g_0jVltS_>Vnɦ VEs_>MmJidA:<L>||b_0_wuk_}p_h_wuNM_~_Xn#himk_> Vt#b_0_wu4Vs_>MnA<H>|b_0_wulmjV_~n#b_wuls_>u4o

g#nAGMne_~nM_~n#wet_h_wu_04Ml:<H>|d_0AndAJi#j
 VmjVs_>MmJida:<L>||g_0Mt_>Ee#hEnJi_~mi:<H>|t_>M
 GVun#hE_0t_}p_>itSMl#g_0AmA_~nh\i_~#nE4jVtS_>we
 Ji_~<H>||nA_~GMne_~nM_~n#wet_h_wu_04Ml:<H>|Vl:
 Mn#b_0VsV_0s_>MmJida:<L>||i4ih\AjV#b_0_wuk_}p_h_
 wuNM_~n:<H>|hEnJi_~mi#dultS_>uNe#himi#d_0V#se_0d
 AGo#indZVnh\adZi#AnMls_>u#Vp_}s_>V_0s_>MmJidA:
 <L>||

Appendix 3: Korean phoneme inventory

The Korean phoneme inventory is presented in SAMPA symbols in Table 17-19. The corresponding Hangeul phonemes and the official Korean Romanization (KOROM) are also presented for reference.

References

1. Jong-mi Kim, "Speech Assessment Methods Phonetic Alphabet of Korean," *Proc. 10th International Conf. on Bilingualism*, pp. 65-72, Korean Society of Bilingualism, Kuala Lumpur, Malaysia, June 2001.
2. "Speech Assessment Methods Phonetic Alphabet (SAMPA): computer readable phonetic alphabet," [www.phon.ucl.ac.uk/home/sampa/home.htm], 2001.
3. International Phonetic Association, "The International Phonetic Alphabet," [www2.arts.gla.ac.uk/IPA/ipachart.html], 1996.
4. Japan Electronic Industry Development Association (JEIDA), "Standard of symbols for Japanese text-to-speech synthesizer," [In Japanese], JEIDA-62-2000, 2000.
5. Hyunsong Chung, "SAMPA description of Hanmal Romanization symbols," *Korean Language Diphone Database Hanmal (HNT)*, [www.phon.ucl.ac.uk/home/hchung/home.htm], 1999.
6. "International Committee for the Co-ordination and Standardization of Speech Databases and Assessment Techniques (COSCODA)," [www.slt.atr.co.jp/cocosda/], 2001.
7. James. L. Hieronymus, "ASCII phonetic symbols for the worlds languages: Worldbet," *Bell Labs Technical Memorandum*, 1993.
8. George. D. Allen, "The PNONASKII system," *Journal of International Phonetic Association*, Vol. 18, No. 1, pp.

Table 17. Consonants transcribed in SAMPA, Hangeul, and KOROM, respectively.

| Manner \ Place | | Bilabial | | Alveolar | | Alveo-palatal | | Velar | | Glottal | | | |
|----------------|-----------|----------|---|----------|-----|---------------|------|-------|---|---------|-----|---|----|
| | | | | | | | | | | | | | |
| Stop | Lenis | b | ㅂ | b, p | d | ㄷ | d, t | dʒ | ㅈ | j | g | ㄱ | gk |
| | Fortis | p_> | ㅃ | pp | t_> | ㄸ | tt | tʃ_> | ㅊ | jj | k_> | ㅋ | kk |
| | Aspirated | p_h | ㅍ | p | t_h | ㅌ | t | tʃ_h | ㅊ | ch | k_h | ㅋ | k |
| Fricative | Lenis | | | | s | ㅅ | s | | | | | ㅎ | h |
| | Fortis | | | | s_> | ㅆ | ss | | | | | | |
| Liquid | | | | | l | ㄹ | l | | | | | | |
| Nasal | | | | | m | ㅁ | m | | | | N | ㅇ | ng |

Table 18. Simple vowels transcribed in SAMPA, Hangeul, and KOROM, respectively.

| Height \ Depth | | Front | | | | | | Back | | | | | |
|----------------|--|---------|---|----|-------|---|----|---------|---|-------|---|---|---|
| | | Unround | | | Round | | | Unround | | Round | | | |
| High | | i | ㅣ | i | wi | ㅟ | wi | M | ㅡ | eu | u | ㅜ | u |
| Mid | | e | ㅔ | e | 2 | ㅚ | oe | V | ㅓ | eo | o | ㅛ | o |
| Low | | E | ㅓ | ae | | | | A | ㅑ | a | | | |

Table 19. Diphthongs transcribed in SAMPA, Hangeul, and KOROM, respectively.

| Height \ Depth | | Front | | | | Back | | | | | | | |
|----------------|--|---------|---|-------|----|---------|-----|-------|---|-----|----|---|-----|
| | | Unround | | Round | | Unround | | Round | | | | | |
| High | | | | | | Mj | ㅟ | euy | | | | | |
| Mid | | je | ㅟ | ye | we | ㅟ | we | jV | ㅟ | yeo | wV | ㅟ | weo |
| Low | | jE | ㅓ | yae | wE | ㅓ | wae | jA | ㅓ | ya | wA | ㅓ | wa |

- 9-25, 1988.
9. Ian Maddison, *Patterns of Sound*, Cambridge University Press, Cambridge, 1984.
 10. John C. Wells, "Computer-coding the IPA: a proposed extension of SAMPA," [www.phon.ucl.ac.uk/home/sampa/x-sampa], 2001.
 11. "The official Romanization system," Available in [www.sejong.or.kr/b_4.htm] and [www.korean.go.kr/bbs/pds.html], Ministry of Culture and Tourism, Republic of Korea, 2000.
 12. Jong-mi Kim, "Phonetic extension of the official Korean Romanization," *Korean Journal of Linguistics*, Vol. 26, No. 4, pp. 669-694, 2001.
 13. *Handbook of the International Phonetic Association: A Guide to the Use of the International Phonetic Alphabet*, London: The Association, 1999.
 14. Mi-Ryoung Kim, *Segmental and Tonal Interactions in English and Korean: A Phonetic and Phonological Study*, Ph. D. dissertation, University of Michigan, 2000.
 15. Sang-Oak Lee, "Distribution of phonemes and allophones," [In Korean], *Proc. of the 10th National Conf. on Speech Sciences*, pp.13-27, Korean Association of Speech Sciences, Seoul, May 2001.
 16. *A Korean Pronunciation Dictionary*, [In Korean], Korean Broadcasting System ed., Seoul: Eomungak, 1993.
 17. Hyun Bok Lee, "Korean," *Handbook of the International Phonetic Association*, pp. 120-123, London: The Association, 1999.
 18. Jong-mi Kim, "Experimental phonology of consonantal allophones in Korean words," [In Korean], *Journal of Acoustical Society of Korea*, Vol. 13, No. 5, pp. 69-76, 1994.
 19. Hyunsoon Kim and Jeong-Im Han, "Vowel length in modern Korean: an acoustical analysis," *Proc. 11th International Conf. on Korean Linguistics*, ed. B.S. Park, and James H.-S. Yoon, pp. 412-418, University of Hawaii Press, 1998.
 20. Ok-Young Kim, "Analysis of Korean vowels / \emptyset / and /y/ through acoustic experiment," [In Korean], *Proc. 10th National Conf. on Speech Sciences*, pp. 123-129, Korean Association of Speech Sciences, Seoul, May 2001.
 21. Kook Chung, Suk-Jin Chang, Kiyong Lee, Jae-woong Choe, Hee-San Koo, Kee-Ho Kim, Chan-Do Lee, Minsuck Song, Su-Uk Ji, and Ji-Eun Kim, *A Study of Phonological and Grammatical Structures of Korean for the Implementation of Automatic Telephone System*, [In Korean], Research No. 94-37, Korea Telecom Research Laboratories, 1994.
 22. J. Wells, W. Barry, M. Grice, A. Fourcin and D. Gibbon, "SAMPROSA: SAM prosodic transcription," *Standard Computer-Compatible Transcription*, ESPRIT project 2589 (SAM), Doc. no. SAM-UCL-037, London: Phonetics and Linguistics Dept., UCL., 1992.
 23. Sun-ah Jun, "K-ToBI (Korean ToBI) labeling conventions," *Speech Sciences*, Vol. 7, No.1, pp.143-170, Korean Association of Speech Sciences, 2000.
 24. Yong-Hyung Cho, "A prosodic labeling system of intonation patterns and prosodic structures in Korean," *Speech Sciences*, Vol. 4, No. 1, pp. 113-134, Korean Association of Speech Sciences, 1998.
 25. Hye-suk Lee, Hye-Young Um, and Kee-Ho Kim, "Korean speakers' realization of focus and information structure on English intonation: comparison with English native speakers," [In Korean], *Proc. 10th Conf. on Speech Sciences*, pp.147-154, Korean Association of Speech Sciences, Seoul, May 2001.
 26. Jong-mi Kim, "Annotation of Korean English speech database," *Proc. 11th Conf. on Speech Sciences*, pp. 195-201, Korean Association of Speech Sciences, Pusan, Nov. 2001.
 27. *TIMIT: Acoustic-Phonetic Continuous Speech Corpus CD-ROM*, DARPA database distributed by LDC, UPENN, [http://www ldc.upenn.edu], 1990.
 28. *ETRI Speech Database (Manual)*, [In Korean], Spoken Language Team, Electronics and Telecommunications Research Institute, Korea, 1995.
 29. Kim, Hyung Soon, *Manual of the Text-to-Speech System, "Cheongsanyusu"*, (Version 1.0.), [In Korean], Speech Communication Lab., Pusan National University, 2000.
 30. Jong-mi Kim, "Computerized sound dictionary of Korean and English," *Speech Sciences*, Vol. 8, No. 1, pp. 271-296, Korean Association of Speech Sciences, 2001.

[Profile]

• Jong-mi Kim



Jong-mi Kim received a B.A. degree in English Education in 1981 from Chonbuk National University in Jeonju, Korea. Subsequently, she acquired M.A. and Ph.D. in Linguistics in 1983 and 1986, respectively, from University of Southern California in Los Angeles, U.S.A. Since 1987, she has served as a professor in the Department of English Language and Literature at Kangwon National University in Korea. Her research interests are computational phonology, phonetics and morphology.