High-toned [il] in Korean: Phonetics, intonational phonology, and sound change

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A R T I C L E   I N F O

A B S T R A C T

This study investigates recent changes in Korean intonation where an Accentual Phrase-initial [il] syllable is produced with a High tone by some speakers, introducing an exception to the model of intonational phonology of Seoul Korean (Jun, 1993, 1996, 2006). Data from eighty speakers of Seoul Korean born between 1952 and 1990 show that this phenomenon, found most often when [il] means 'Number 1', is employed by Seoul speakers born since 1970, and is not triggered by glottalization at vowel onset. It is proposed that enhancing a perceptual distinction between two similar-sounding morphemes is one of the major motivations for this phenomenon, and various factors affecting this High-toned-[il] phenomenon are examined. In the discussion, the tonal change on [il] is compared with the changes in the VOT values in Korean stops which have been claimed to have been initiated by the same age groups in the same dialect. Finally, individual variation and the implications of this phenomenon for the model of intonational phonology of Seoul Korean are discussed.

1. Introduction

The intonational structure of Standard (Seoul) Korean is proposed to have three prosodic units larger than a word. From the highest to the lowest are an Intonational Phrase (IP), an Intermediate Phrase (ip), and an Accentual Phrase (AP), similar to languages such as Japanese (Beckman & Pierrehumbert, 1986; Pierrehumbert & Beckman, 1988), French (Jun & Fougeron, 1995, 2000, 2002), Bengali (Khan, 2008, 2014), Georgian (Vicenik & Jun, 2014), and Mongolian (Karlsson, 2014). However, what is unique to Korean is that the tonal pattern of an AP is influenced by the laryngeal feature of the AP-initial segment (Jun, 1993, 1996, 1998). Specifically, when the segment has either [+spread glottis] or [+constricted glottis] (i.e., is an aspirated or tense consonant, /s/, or /h/; Halle & Stevens, 1971; Lombardi, 1991), the AP begins with a High tone.[1] Otherwise (i.e., the segment is either a lenis iconsonant, a sonorant consonant, or a vowel), the AP begins with a Low tone.[2] Segmental effects on $f0$, i.e., microprosody, have been well attested over various languages (e.g., Gandour, 1974; Hombert, 1978; Hombert, Ohala, and William, 1979; Kingston & Diehl, 1994; Kohler, 1982; Silverman, 1986) in such a way that the $f0$ at vowel onset is higher after a voiceless consonant but is lower after a voiced or breathy consonant. Such microprosodic effects are known to occur during the transition between segments, lasting for about 20–40 ms after the vowel onset. However, in Korean, the segmental effects persist over the whole syllable and the degree of $f0$ change is much greater (on average about 80 Hz in female speech) than those found in other languages (Jun, 1996).

These facts support the claim that the microprosody exhibited by Korean is phonologized at the level of intonational phonology, and is incorporated into the model of Korean intonation proposed by Jun (1993, 1996, 2006, 2007, 2011). The model is summarized in (1), where the "Ha" symbol represents the AP-final boundary tone ('a' is a diacritic denoting an AP). In particular, the tonal pattern of an AP is either HHLH or LHLH, with the initial tone determined by the laryngeal feature of the AP-initial segment mentioned above.

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[1] Korean has a three way laryngeal contrast in stops and affricates: aspirated (i.e., /pʰ, tʰ, kʰ, tʃʰ/), tense (i.e., /p*, t*, k*, tʃ*, s*/), and lenis (/p, t, k, tʃ/). Among the fricatives (/s, s*, h/), the dental fricatives have a two-way laryngeal contrast, i.e., /s/ vs. /s*/. Here, /s/ patterns with a lenis consonant in segmental phonological processes, but, together with /h/, it patterns with an aspirated consonant in the intonational phonology. This is likely due to the fact that /s/ in Korean is phonetically aspirated (Cho, Jun, & Ladefoged, 2002).

[2] Exceptions to this tone-segment mapping are few, with only 5.7% of AP-initial tones violating it in an analysis of radio interview data (Kim, 2004).

That is, the basic tonal pattern of an AP includes the possibility of a "double rise" when there are more than 3 syllables in an AP: one realized during the last two syllables (i.e., a L tone on the penult and a H tone on the final), and one during the first two syllables (i.e., a L or H on the first syllable and a H on the second syllable[3]). Any syllables between the second syllable and the penultimate syllable in an AP lack tonal specifications and instead get their surface f0 by interpolation between the H on the second syllable and the L on the penult. When an AP has fewer than 4 syllables, one or both of the AP-medial tones are optionally undershot, resulting in either LLH, LHH, LH, H(H)LH, or HH tone patterns.[4] An ip, which can have more than one AP, is marked by pitch reset and optionally by a boundary tone (T-) on its right edge. When there is a boundary tone on an ip-final syllable, the syllable is moderately lengthened. Finally, an IP, which can have more than one ip, is obligatorily marked by a boundary tone (T%) on its right edge and the final syllable is substantially lengthened. When a syllable is associated with more than one type of boundary tone (i.e., AP- and ip-boundary tones, or AP-, ip-, and IP-boundary tones), the tone of a higher prosodic unit overrides that of a lower prosodic unit. Therefore, an AP-final syllable is realized as a L tone, i.e., carrying a L% IP boundary tone, when the AP is the last AP of an IP marking the end of a declarative sentence.

(1) Intonational model of Seoul Korean (Jun, 1993, 2006, 2011)[5]: IP=Intonational Phrase, ip=Intermediate Phrase, AP=Accentual Phrase, w=Word, s=Syllable, T=L or H tone, Ha=AP-final H tone, T-=ip-final boundary tone, T%=IP-final boundary tone.
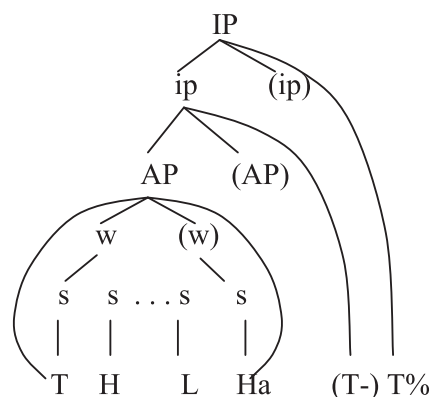
Since the AP begins with a Low tone when its initial segment is a vowel, it is predicted that APs beginning with a vowel /i/ would begin with a Low tone. However, as first reported by Jun and Cha (2011), some Seoul speakers show a tendency to produce a High tone on a particular syllable – namely [il], when it is AP-initial – even when it is not related to focus or emphasis. This *High-toned*-[il] phenomenon, which represents an exception to the intonational pattern of Seoul Korean, was first noticed by the first author in 1995, while recording a few female Seoul speakers in their early 20s reading a list of Korean sentences including the digit (e.g., 1, 2, 3) before each sentence. The speakers produced high pitch on [il] 'digit 1' when it occurred AP initially (e.g., '1' in a multi-digit number '21' was produced with high pitch when it was read as [isip]#[il]; [isip] '20', [il] '1', #=AP boundary). Since then, this phenomenon seems to have spread to other lexical items beginning with the [il] syllable, and indeed this diffusion has occurred in a wider speech community, as shown in Jun and Cha (2011).

In Jun and Cha (2011), we examined data from 40 speakers of the Seoul dialect living in Los Angeles, California (8 speakers (4 males and 4 females) each in their 20s, 30s, early 40s, late 40s, and 50s) and 11 speakers of the Seoul dialect living in Seoul, Korea (4 speakers in 20s, 2 speakers in early 40s, 3 speakers in late 40s, and 2 speakers in 50s). We also examined speech from 26 speakers of the Chonnam dialect of Korean (spoken in Southwestern South Korea, especially from the city of Gwangju (265 km south of Seoul); 10 speakers were in their 20s, 6 speakers in 30s, 2 speakers in early 40s, 4 speakers in late 40s, and 4 speakers in their 50s). It was found that even though the degree of usage of this High-toned-[il] differed slightly between the two groups of Seoul speakers (especially among speakers above age 40), both groups showed frequent use of High-toned-[il] by speakers below the age of 40 (as of the year 2011, thus speakers born around 1971 and later). Specifically, Seoul speakers living in Los Angeles showed High-toned-[il] more often if they were younger than 40, but Seoul speakers living in Seoul showed this phenomenon if younger than 45. On the other hand, no speakers of the Chonnam dialect showed the phenomenon.[6] It was therefore clear that the High-toned-[il] phenomenon has become a feature of Seoul dialect, but only among those younger than middle-aged population. However, the speech of Seoul speakers living in Los Angeles in that study, especially those in their 40s and older, may not be representative of the current status of the Seoul dialect; most of the speakers had immigrated to the United States about 20 years earlier. Additionally, the data from Seoul speakers living in Seoul included only 7 Seoul speakers older than 40, and no speakers in their 30s. Therefore, data from a larger group of Seoul speakers living in Korea is needed to clarify the nature of the High-toned-[il] phenomenon.

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[3] This H tone can be realized on the third syllable when the AP is long.

[4] The AP-final H tone is sometimes realized as a Low tone, La, creating four AP tonal pattern variants: LL, HL, LHL, HHL. The reason for this is not fully understood, but a likely factor is tonal interaction (see Jun, 1996, and the Korean-ToBI homepage: http://linguistics.ucla.edu/people/jun/ktobi/k-tobi.html).

[5] This is a revision of Jun's (1993) model, and adds to that original model an Intermediate Phrase (ip). However, because the prosodic unit of interest here is the AP, this matter will not be relevant to the present paper.

[6] With the exception of two speakers with short-term experience living in Seoul during their early 20s: One speaker spent 2 months in Seoul and showed 15% of High-toned-[il] usage and the other speaker spent 1.5 years in Seoul and showed 30% of High-toned-[il] usage.

In this paper, we present such a study. The current state of the High-toned-[il] phenomenon is examined in the speech of eighty speakers of the Seoul dialect residing in Seoul, Korea, whose ages were evenly distributed (as of 2012) from 20s to 50s (i.e., speakers born between 1952 and 1990). We examine the phonetic realization of this phenomenon and investigate the phonetic (voice quality), phonological (length of AP, the location of [il] within AP, types of AP-initial syllable), lexical (the meaning of [il]), and sociolinguistic (age, gender) factors that might affect this phenomenon and discuss possible motivations of this sound change, together with the implications for the intonational model of Seoul Korean. We further discuss a possible connection between the High-toned-[il] phenomenon with the sound change of VOT merger in Korean which has been reported to have occurred between aspirated stops and lenis stops by speakers born around 1970 and later (Kang, 2014; Silva, 2006).

2. Experiment

2.1. Subjects

Eighty native speakers of the Seoul dialect of Korean, living in Seoul, Korea, participated in the experiment. There were 16 speakers (8 male, 8 female) in each of the five age groups: 20s (born in 1984–1990), 30s (born in 1973–1982), early 40s (born in 1968–1972), late 40s (born in 1963–1967), and 50s (born in 1952–1962). The 40s age group was further divided into two groups as in Jun and Cha (2011) because it was predicted that the phenomenon might have been initiated by people in their early 40s. Table 1 shows the mean and standard deviation of the participants' age in each Gender and Age group. Almost all the subjects were above average in terms of education level (college or graduate students or graduated from college or postgraduate school) and socioeconomic status.

2.2. Materials

Two sets of stimuli were used for the experiment. The Stimuli Set 1 was the same as what was used in Jun & Cha (2011) – 124 target words placed as the second word of a three-word sentence (e.g., *Jayminika **il**teungeul kilokhayssta* [tʃɛminiga **ilt*iɲil** kirokʰɛtt*a/ 'Jaymin-NOM., 1st place-ACC., to record-PAST.' => 'Jaymin won the first place'). Among these, 83 target words contained the syllable [il] (일) and varied in the number of syllables in the word (1–4 syllables), the location of the [il] syllable in the word, and the meaning of the syllable [il]. There were four meaning categories of [il] syllable: it can be a monosyllabic Sino-Korean word, meaning 'number 1' or 'day', a monosyllabic pure Korean word meaning 'work', or it can be part of a multi-syllabic pure Korean word, and thus having no meaning on its own. A few example words for each type of [il] are shown in (2) (a full list of target words is in Appendix A). Within each meaning category, [il] was located either in an AP-initial (17 sentences for the 'number 1' meaning and 10 sentences each for other meanings of [il]) or AP-medial position[7] (9 sentences for each meaning of [il]). For the AP-initial condition, we included more sentences with the 'number 1' meaning of [il] than other meanings of [il] in order to test the effect of AP length on the High-toned-[il] phenomenon. This is because Jun and Cha (2011) found High-toned-[il] to occur more frequently when [il] meant 'number 1'. All target APs across all meaning categories were between 2 and 5 syllables long, and contained one target word plus a case marker or postposition.

(2) Four types of [il] meaning and example words where [il] is either word-initial (thus AP-initial) or non-initial (thus AP-medial)[8]

a. 'One' (一): /**il**pʌn/ 'number one', /**il**paŋtʰoŋhɛn/ 'one way'; /o**il**pʰal/ '518'
b. 'Day' (日): /**il**ki/ 'diary', /**il**joil/'Sunday'; /tʃuŋ**il**tʃʌntʃɛn/ 'the China-Japan war', /tʃu**il**/ 'a weekend'
c. 'Work' (pure Korean): /**il**son/ 'a worker', /**il**tʃali/ 'a job'; /tʃap**il**/ 'a chore'
d. Others: /**il**hɨn/ '70', /**il**tʃ*ik/ 'early', /**il**pulʌ/ 'purposely'; /kwa**il**/ 'fruit'

The rest of the target words (41 words) either did not contain the [il] syllable or was a digit containing [il] '1'. They were 10 AP-initial words beginning with a High-tone triggering consonant followed by a vowel /i/ (e.g., /**h**im/ 'power', /**iʃ**ilpʰan/ 'a blackboard', /**s**iltʃe/ 'reality'), 15 number words beginning with numbers other than '1' (e.g., *2 teung* '2nd rank', *9 peon* 'number 9', *55 myong* '55 people'), and 16 multi-digit numbers containing '1' (i.e., 11, 21, 31, …, 161). All 124 target phrases/sentences were randomized with 56 filler sentences, resulting in 180 sentences.

The Stimuli Set 2 (39 sentences) was created to test whether the High-toned-[il] phenomenon spreads to any word beginning with a [i] vowel (e.g., /ipak/ 'two nights', /ihon/ 'a divorce', /ijaki/ 'a story') or a word whose first syllable is an [il] with an underlying complex coda of which the [l] is the first part. This includes forms (where '.' is a syllable boundary) such as /ilk.ɨl.su.lok/ -> [il.gɨl.su.rok] '(as we) read (it)', /ilh.ko.na.ni/->[il.kʰo.na.ni] 'after (I) lost (it)', and /ilh.ʌ.pʌ.lin.tʃi/ -> [i.rʌ.bʌ.rin.dʒi] 'since I lost (it)'.[9] There were 17 /i/-initial words, 2 /ilk/-initial words, and 2 /ilh/-initial words. These 21 target sentences were randomized with 18 filler sentences and added after the Stimuli Set 1. The final script therefore included 219 sentences.

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[7] In the AP-medial position, all the target word started with a sonorant or lenis consonant so that the tonal pattern of the AP always began with a Low tone, i.e., LHLH or LLH or LHH.
[8] Since an AP contained one word plus a case marker or postposition, a word-final [il] syllable was always followed by a case marker or postposition, thus being AP-medial.
[9] The second consonant of a complex coda /lk/ is resyllabified as an onset of the following syllable if that syllable has no onset. The second consonant of a complex coda /lh/ is not realized when followed by an onsetless syllable (and the /l/ becomes a flap between vowels) but, when followed by a lenis consonant onset, it makes the lenis consonant to be aspirated (e. g., /ilh.ko.na.sʌ/-> [il.kʰo.na.sʌ] 'after losing'

Table 1
The mean age (standard dev.) of the participants in each Gender and Age group.

Age group	Gender	No. of speakers	Mean age (sd)	Range of birth years
20s	Male	8	24.5 (2.20)	1985–1990
	Female	8	23.8 (2.31)	1984–1990
30s	Male	8	35.0 (3.20)	1973–1982
	Female	8	35.6 (2.92)	1973–1982
Early 40s	Male	8	42.1 (1.80)	1968–1972
	Female	8	40.5 (0.53)	1971–1972
Late 40s	Male	8	47.0 (1.77)	1963–1967
	Female	8	47.1 (1.64)	1963–1967
50s	Male	8	53.4 (2.97)	1956–1962
	Female	8	55.1 (2.35)	1952–1960

2.3. Procedures

Speakers were told to read each sentence naturally two times at normal speed, and were familiarized with a script containing 219 sentences before recording. Each sentence was displayed in the middle of a Power Point presentation slide, and speakers pressed a key on the keyboard when they were ready to read the next sentence. Readings were directly recorded to a laptop computer at 22 kHz Sampling Rate using *Praat* (Boersma & Weenink, 2011). The mean recording time was 12 min, ranging from 9 min 12 s to 14 min 19 s. The mean and range of recording times were similar across age and gender groups, suggesting similar speech rates across speakers in each group.

The location of the 145 target syllables in an Accentual Phrase (i.e., AP-initial or medial) and the tone of the target syllable were transcribed for each speaker (145 × 80 speakers = 11,600 target syllables) following the K-ToBI conventions (Jun, 2000, 2005). The transcription was done first by the second author and confirmed by the first author independently (there were only 28 cases where the tonal category was changed by the first author; those were either due to an error in the typing made by the second author or an ambiguous token). Since the target sentences were designed in such a way that the target syllable was produced AP initially (e.g., the target syllable was word-initial and the word was located after a topic/subject word or a sentential adverb) or AP-medially (i.e., the target syllable was word-medial), almost all target sentences were produced in the intended prosodic phrasing by all speakers, and both authors fully agreed in labeling accentual phrasing. The tonal category (i.e., H or L) of the target syllable was labeled based on the labeler's perception and by reference to pitch tracks and spectrograms; the $f0$ value of the target syllable's midpoint was also collected for each word using a *Praat* script.

Finally, to see if the High-toned [il] syllable begins with a glottal stop or a glottalized vowel, we probed for evidence of these characteristics from the target [i] vowels in Stimuli Set 1 items. We visually inspected the waveform for evidence of a glottal stop or glottalization and further probed for glottalization acoustically, collecting measures of voice quality using *VoiceSauce* (Shue, 2010; Shue, Keating, Vicenik, & Yu, 2011). The reason for testing for the presence of initial glottalization was as follows. If the vowel onset is glottalized when produced with a High tone but not glottalized when produced with a Low tone, the High-toned-[il] would not in fact represent an exception to the model of intonational phonology of Seoul Korean after all, as such vowels begin with the feature [+constricted glottis], one of the High-tone triggering features in Seoul Korean intonation.

3. Results

The results reported in this section are all from the Stimuli Set 1 because, for the Stimuli Set 2, no speakers produced a High tone on [i]-initial words and only a few speakers produced a High tone on the complex coda [il] syllable.[10]

3.1. Realization of 'High [il]'

The target syllable [il] was produced either as a Low tone or a High tone when it was the first syllable of an AP. An example pitch track of each type is shown in Fig. 1(a) 'Low [il]' and (b) 'High [il]', respectively. In Fig. 1(a), the target word, /iltʃunjʌn-i/ '1st anniversary-NOM.', forms a single AP (defined by a LHLH tone pattern), beginning with a L tone on the first syllable [il]; this is the predicted pattern from the intonational phonology model of Seoul Korean. Fig.1(b) shows a pitch track of the same sentence as in (a) but with a H tone on the initial syllable [il] of the target word. This H is realized higher than the H tone (i.e., Ha) of the preceding AP.[11] This pattern of $f0$ realization is very similar to the case where the AP-initial syllable is High when the AP-initial segment is a High tone triggering segment. An example pitch track is shown in Fig. 1(c) 'High-C', where the 1st syllable of the second word (/tʃʰilpʰanil/ 'blackboard-ACC.') begins with an aspirated consonant, one of the H-triggering segment types. The tonal contour of the second AP in

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[10] Only five speakers (2 males in their 20s, 1 male in his 30s, 1 male in his early 40s, and 1 female in her early 40s) produced a High tone on all four complex-coda [il] syllables, and only four speakers (1 male in his 20s, 1 female in her 30s, and 2 females in their early 40s) produced a High tone on only the complex coda /ilk/ syllable. Not surprisingly, these nine speakers produced a High-toned [il] most of the time in the Stimuli Set 1.

[11] As pointed out by the editor, the fact that the same [il] syllable can be produced with a Low or High tone suggests that intrinsic vowel height cannot explain this phenomenon.
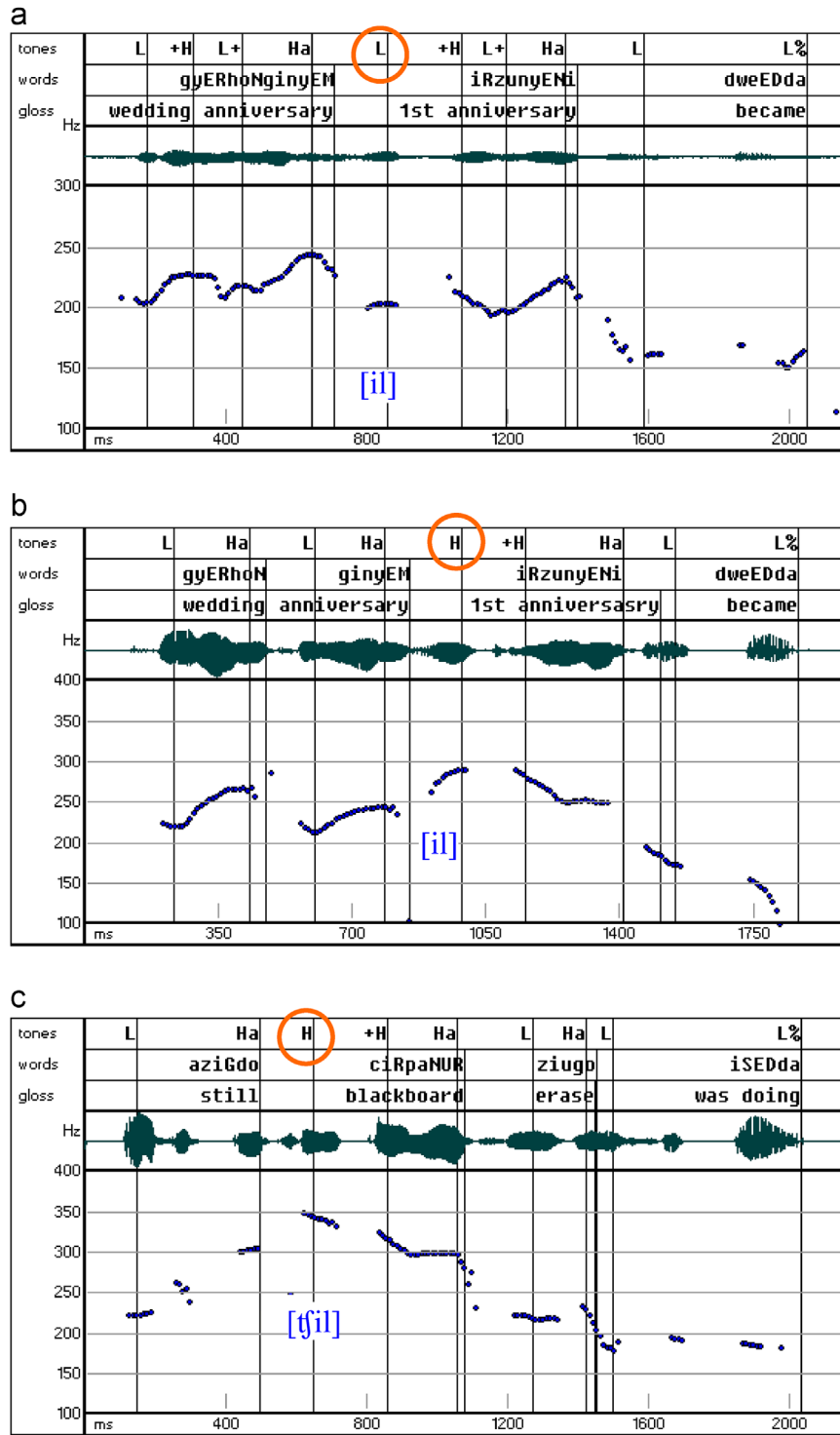
Fig. 1. Example pitch tracks of (a) Low [il], on the initial syllable of the second word in the sentence, [kjʌlhon ginjʌm iltʃ*unjʌni twɛʌtt*ɑ] 'wedding, anniversary, 1st anniversary, became' = > "The first wedding anniversary has arrived.", (b) High [il], from the same sentence as (a), (c) High-C, H-initial AP due to a H-tone triggering consonant [tʃʰ] onset in the second word's initial syllable in the sentence [atʃikt*o tʃʰilpʰaniɫ tʃiugo its*ʌtt*ɑ] 'still, ɑ blackboard-ACC, erase-prog.' = > "(They) were still erasing the blackboard". In the tones tier, 'Ha' marks the end of an AP.

(c) shows a very similar f0 pattern as that of (b), i.e., H +H Ha, with the undershoot of the L tone on penult, though H in (c) is realized slightly higher than that in (b). (Importantly, (b) and (c) were produced by the same speaker.)

The same relation of f0 values among the three tone categories illustrated in Fig. 1 can be seen in Fig. 2 where the average f0 value (in Hz) for each tone category is shown (i.e., High [il], Low [il], and High-C) based on the data combined from three Age groups (20s, 30s, and early 40s), separately for each gender.

Table 2 shows the fixed-effects factors of the linear mixed effects regression model of f0 built for males and females separately. Each model contained the three level "tone category" factor as fixed effect. Random effects included intercepts for subject and
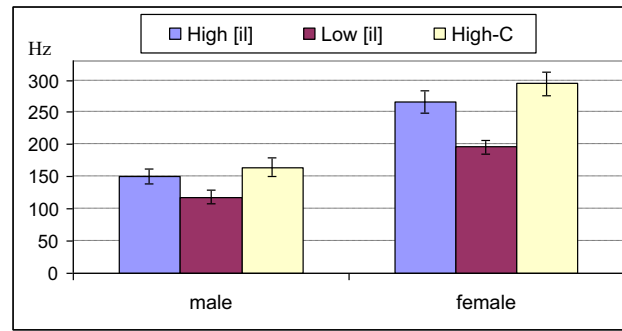
Fig. 2. Average *f*0 (Hz) of H-toned [il], L-toned [il], and a H-toned [i] due to H-triggering consonants (High-C), combined across Seoul speakers in their 20s, 30s, and Early 40s, for each Gender.

Table 2
The output of linear mixed effects regression models of *f*0 values, with the tonal category as fixed-effects factors (comparison of the three tone categories; H=High [il], L=Low [il], H-C=High-C), for males and females.

Fixed effects:	Estimate	SE	z	*p* value
Males				
(Intercept)	164.881	5.33	30.93	<0.001
Tone (H vs. H-C)	−13.55	5.357	−2.53	0.028
Tone (L vs. H-C)	−47.354	3.185	−14.869	<0.001
Tone (L vs. H)	−33.804	6.27	−5.391	<0.001
Females				
(Intercept)	293.225	8.538	34.34	<0.001
Tone (H vs. H-C)	−21.894	4.064	−5.387	<0.001
Tone (L vs. H-C)	−94.114	6.139	−15.331	<0.001
Tone (L vs. H)	−72.22	4.164	−17.346	<0.001

sentence, and a by-subject random slope for tone category. P-values were corrected for multiple comparisons using the *mcp* function in the *multComp* package (Hothorn et al., 2008) of R statistics (R Development Core Team, 2014). For both males and females, the *f*0 value of High [il] is significantly higher than that of Low [il]. However, the *f*0 value of the [i] vowel in the High-C condition was significantly higher than that of High [il] for females, but similar for males.

When the target [il] syllable was in the AP-medial position, the tone on the syllable varied depending on its location in an AP and the length of AP. Following the intonation pattern proposed in Jun (1993, 1998, 2006, 2011), the AP-medial [il] was High when it was the second syllable of an AP which is longer than 3 syllables (i.e., LH**L**Ha); it was Low when it was the penultimate syllable of an AP longer than 4 syllables (i.e., LH**L**Ha); it was either Low or High or in the transition between Low on the AP-initial syllable and High on the AP-final syllable when it was the second syllable of a three-syllable AP (i.e., L**L**Ha, L**H**Ha, or **LH**a). In all these cases, however, the AP-medial High tone was never as high as the High tone in the AP-initial position, which is the realization rule of an AP in the intonational phonology of Seoul Korean (Jun & Oh, 1996; Lee, 1999; Jun, 2000). As can be seen in Fig. 1(a), the High tone on the second syllable in the 2nd AP (4 syllable long) is only slightly higher than the preceding L tone, thus much lower than the final H tone (Ha) of the first AP. The AP-initial High tones in Fig. 1 (b, c) are, on the other hand, substantially higher than the final Ha tone of the first AP.

Other number words beginning with a sonorant or a lenis stop (e.g., /opʌn/ 'No. 5', /kupʌn/ 'No. 9', /isipitiŋ/ '22nd in rank') all showed a Low tone on their first syllable when they were AP-initial, as predicted from the intonation model of Seoul Korean. That is, a High tone on [il] in AP-initial position is not a prosody of marking a number word.

3.2. Age group

Fig. 3 shows the percentage of speakers, grouped by Age, who produced a High tone on AP-initial [il] syllables, regardless of [il]'s meaning. The "Early 40s" age group includes speakers born between 1968 and 1972 (i.e., 40–44 years of age at the time of recording) and the "Late 40s" group includes speakers born between 1963 and 1967 (i.e., 45 and 49 years old). As shown in Fig. 1, Seoul speakers younger than 40 produced a High tone on the [il] syllable about 46–54% of the time and speakers in their early 40s used a High tone on [il] about 32% of the time. For speakers above the age of 45, the usage dropped dramatically (to below 4%).

Statistical analysis was performed in R (R Development Core Team, 2010). The probability of a High [il] response in the stimulus set 1 was modeled using mixed effects logistic regression (Pinheiro & Bates 2000; Baayen, Davidson, & Bates, 2008) implemented by the lme4 package (Bates, Maechler, Bolker, & Walker, 2014). The logistic model included Age as a fixed-effect predictor and Speaker and Sentence as random effects. There was a significant main effect of Age ($\chi^2 = 80.62$, df=4, $p<0.001$), and a post-hoc Tukey contrasts test using a *glmer* function (see Table 3) showed, firstly, that the younger Age groups (i.e., the 20s, 30s, and early
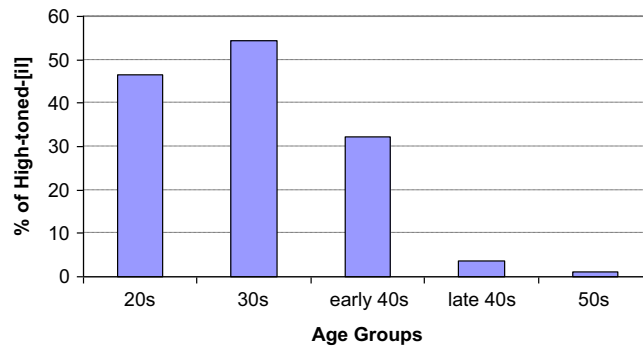
Fig. 3. Percentage of High tone on [il] across all Age groups. Birth years are 1984–1990 for 20s, 1973–1982 for 30s, 1968–1972 for early 40s, 1963–1967 for late 40s, and 1952–1962 for 50s.

Table 3
The output of a Post-hoc Tukey contrast test in a logistic mixed-effects model. 40a is the Early 40s and 40b is the Late 40s Age group.

	Estimate	Std. error	z value	Pr(> |z|)
30s vs. 20s	0	0.5572 0.6441	0.865	0.896
40a vs. 20s	−1.2680	0.6738	−1.882	0.300
40b vs. 20s	−4.5804	0.6790	−6.746	<0.001 ***
50s vs. 20s	−6.4577	0.9151	−7.057	<0.001 ***
40a vs. 30s	−1.8252	0.9556	−1.910	0.285
40b vs. 30s	−5.1376	0.9748	−5.270	<0.001 ***
50s vs. 30s	−7.0149	1.2262	−5.721	<0.001 ***
40b vs. 40a	−3.3124	0.8550	−3.874	<0.001 ***
50 s vs. 40a	−5.1897	0.8609	−6.029	<0.001 ***
50s vs. 40b	−1.8773	0.9909	−1.895	0.293

*** $p < .0001$.

40s) did not differ from each other. Secondly, the Age groups Late 40s and 50s, which did not differ from each other, were significantly different from the three other, younger age groups.

This pattern is different from what was found in Jun and Cha (2011) for the Seoul speakers in Los Angeles, where the High-toned-[il] phenomenon was rarely observed in the Early 40s group. The pattern is similar to that of Seoul speakers in Korea in Jun and Cha (2011) but the magnitude of the High-toned-[il] usage was much higher in that study (around 65%, based on only two speakers) than the current study.

3.3. Four meanings of [il]

The High-toned-[il] phenomenon was also found for [il] meanings other than 'number 1', although it was produced most often for the meaning of 'number 1'. It was produced least often for [il] meaning 'work', consistent with the findings of Jun and Cha (2011), and the other meanings fell in-between (see Fig. 4). Since only 1% of the speakers in their 50s produced High on [il], these data are not included in Fig. 4.

We also found that, for speakers younger than 40s, if a High tone was produced on [il] meaning 'No. 1', it was very likely that a High tone was also produced on the 'digit 1' meaning in multi-digit number phrases (e.g., 2**1**, 3**1**, 10**1**) when it was AP-initial. However, for speakers in their early 40s, this was not the main pattern; there were speakers who produced High on the digit 1 most of the time but rarely produced High on [il] meaning 'No. 1' (as well as other meanings). In addition, as shown in Table 4, speakers in their early 40s seem to show various patterns: They either produced a High tone on [il] consistently for all cases of 'No. 1' meaning and 'digit 1' only (see M3, F1, F4, F7, F8), or they rarely produced a High tone on [il] (e.g., M1, M2, F2), or they produced a High on [il] almost all the time (see M5, F3).

3.4. Gender and the length of AP

As the High-toned-[il] phenomenon is found more often among younger speakers, it appears to be a new "trend" in the speech of Seoul Koreans. Following the cross-linguistic tendency that females lead sound change, we expected female speakers to show the phenomenon more often than male speakers (Labov, 1990) and this was what we found.

However, as shown in Fig. 5, females did not always produce High-toned-[il] more often than males in all Age groups. In the 20s Age group, the opposite pattern was found. The same lack of consistent gender effects across Age groups was found in Jun and Cha (2011) for Seoul speakers living in Los Angeles.

To see if there is a significant interaction between Gender and Age, the probability of High [il] usage was modeled using a mixed effects logistic regression model, with Gender and Age as fixed-effect predictors and Speaker and Sentence as random effects. This
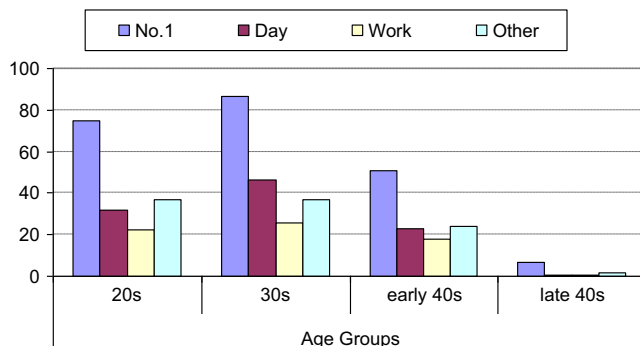
Fig. 4. % of High-toned-[il] depending on its meaning in each Age group.

Table 4
Frequency of High on [il] by speakers in their early 40s, for each of the four meanings of [il] and a digit '1' in multi-digit numbers. The total number of each [il] category is given in the parenthesis in the first column. Gray cells represent cases where the proportion of High tones for each [il] category is more than 76%.

Male speakers in Early 40s	M1	M2	M3	M4	M5	M6	M7	M8
Digit 1 (15)	2	1	15	1	15	15	15	15
No.1 (17)	3	1	16	8	17	0	3	0
Day (10)	1	0	0	1	10	1	1	0
Work (10)	0	0	2	0	10	0	0	0
Others (10)	0	0	2	1	10	0	0	1

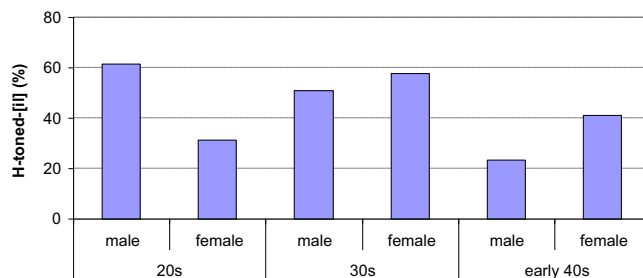| Female speakers in Early 40s	F1	F2	F3	F4	F5	F6	F7	F8
Digit 1 (15)	14	3	2	15	1	15	15	15
No.1 (17)	15	5	17	15	10	0	13	16
Day (10)	3	0	10	1	3	0	0	6
Work (10)	1	0	9	0	2	0	0	5
Others (10)	4	2	10	0	2	1	0	5

Fig. 5. The percentage of High-toned-[il] for each Gender in three Age groups where the High-toned-[il] usage is common.

Table 5
The output of a logistic mixed-effects model including Gender and Age as fixed-effect predictors and Speaker and Sentence as random effects.

Fixed effects:	Estimate	Std. error	z value	Pr(> |z|)
(Intercept)	0.46496	0.24881	1.869	0.0617
gender(male)	−0.37165	0.17186	−2.163	0.031
age(20s vs. 30s)	−1.49372	0.18129	−8.239	<.001
age(40s vs. 30s)	−0.26773	0.17172	−1.559	0.119
gender(male)$_*$age(20s vs. 30s)	2.0761	0.25227	8.23	<.001
gender(male)$_*$age(40s vs. 30s)	−0.03116	0.24295	−0.128	0.898
gender(male)$_*$age(40s vs. 20s)	1.226	0.1799	6.814	<.001

was done using the *glmer* function of the *lme4* package in R. The output of the model, given in Table 5, shows that there was a significant main effect for Gender such that males showed overall less use of High-toned [il]; additionally, there was a significant main effect for Age, such that speakers in their 30s (the comparison group in the model) used H-toned [il] more than those in their 20s and early 40s. The model also shows there was a significant interaction between Gender and Age: Males used more High toned [il] than females in the 20s age group only, while females showed more High toned [il] in both 30s and early 40s age groups. The significant
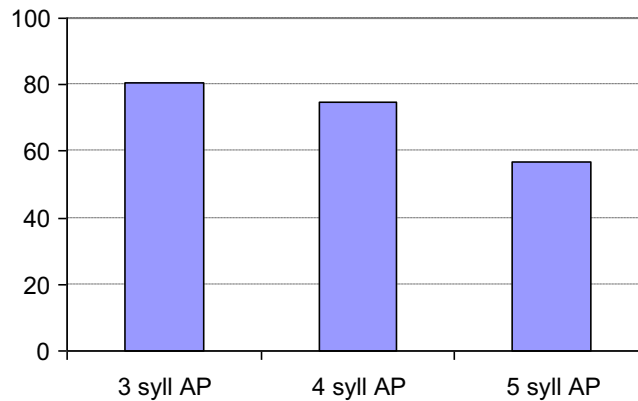
Fig. 6. The percentage of High-toned-[il] (with the meaning 'No. 1') as a function of AP length, counted in number of syllables.

interaction in the model was driven by the difference between males and females in their 20s with each of these other two age groups (the difference between males and females were statistically equivalent for the 30s and early 40s age groups).

We also found that the High-toned-[il] phenomena is influenced by the length of the AP, and was more common in shorter APs than longer ones. The effect of AP size was significant ($\chi^2 = 23.52$, df$=2$, $p < .0001$). Fig. 6 shows the percentage of High-toned-[il] meaning 'No. 1', when the AP was 3, 4, or 5 syllables long, averaged across speakers in their 20s, 30s, and early 40s.

3.5. Voice quality

Table 6 provides the number (percentage) of [il] tokens whose vowel onset begins with a glottal stop or is glottalized (e.g., irregular pulses, strong burst energy) when the [il] was produced either with a High or Low tone, separately for Gender and Age. The voice quality was categorized based on the visual inspection of the waveform and spectrogram. Only data from speakers in their 20s and 30s are examined because these Age groups showed the High-toned-[il] phenomenon more often than other groups. The percentage of glottalized tokens in each tonal category is given in parenthesis and the difference in the percentage between the High [il] and Low [il] categories is given in the last column.

The data show that [il] tokens were produced with about 20% more glottalization when produced with a High tone (43–66%) than in Low tone (22–46%) for each Gender in both 20s and 30s. The presence of glottalization on the Low-toned [il] could be due to the low $f0$, as exhibited, for example, by Tone3 (low rising tone) of Mandarin or Tone 4 (low falling) in Cantonese (Davison, 1991; Yu & Lam, 2014). The overall percentage of glottalization may be higher in the current data due to vowel hiatus. That is, for all sentences, the target [il] word was preceded by the case marker or postposition of the sentence-initial word, which was either a vowel or a sonorant consonant. However, assuming that the degree of any such hiatus-driven glottalization should be similar for each tone category, it would seem that the 20% difference in glottalization between the two tonal categories would be attributable to the High tone itself. This therefore suggests that the High-toned-[il] is not *triggered by* glottalization ([+constricted glottis]), but rather *generates* glottalization as a by-product of tensing of the vocal folds.

Since glottalization during a vowel can be measured by the harmonic and noise components during voicing even when there is no visible glottal stop preceding a vowel (Gordon & Ladefoged, 2001; Garellek, 2012, 2013; Garelleck & Keating, 2011; Kuang, 2013; Khan, 2012), several acoustic measurements of voice quality were obtained using *VoiceSauce* (Shue et al., 2011) during the first quarter (roughly 30ms) of the syllable [il] for the two tonal categories. The measures chosen were H1*–H2* (the difference in energy between the first and the second harmonics; '*' indicates that a harmonic amplitude has been corrected for the influence of formant frequencies and bandwidths, using the algorithm by Iseli, Shue, & Alwan, 2007), H1*–A1*, H1*–A2*, A1*–A3* (the difference between the first harmonic and the first, second, third formants, respectively), and HNR (the harmonic to noise ratio below 500 Hz). These were chosen because they have been shown to distinguish modal phonation from breathy and creaky phonation (Garellek, 2012). Higher values on all these measures except for HNR would indicate more breathy – and thus less creaky – phonation, while lower values on HNR (especially during the frequency below 500 Hz) would indicate more irregular or noisier phonation. In addition, the same acoustic values were obtained for the vowel [i] when it was produced with a High tone due to the High-tone-triggering consonant.[12]

The results of a linear mixed-effects model showed a main effect of Tone for H1*–H2* ($\chi^2 = 6.85$, $p = 0.032$), H1*–A3* ($\chi^2 = 72.76$, $p < .0001$), and HNR ($\chi^2 = 33.0661$, $p < .0001$), as well as a main effect of Gender on H1*–A3* ($\chi^2 = 4.62$, $p = 0.031$) and HNR ($\chi^2 = 8.3864$, $p < .001$). However, as shown in Table 7, there was a significant three-way interaction between Tone$_*$Age$_*$Gender for all voice measures except H1*–A3*, for which only two-way interactions between Tone$_*$Gender and Age$_*$Gender were significant. Posthoc tests comparing Tone categories across Gender and Age showed that, for speakers in their 20s, male speakers in general produced more irregular or noisier voice quality than females (see the negative 'estimate' value for HNR in Table 7), but within each

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[12] The High-tone triggering consonants in the dataset were all aspirated except for one tense consonant. Since the voice quality of vowels after aspirated consonants are either slightly tense or modal while that of tense consonant is tense (Cho et al., 2002), we did not consider the comparison between this tone category vs. High or Low [il] category meaningful. Therefore, only the comparison between the High [il] and Low [il] categories is shown in Table 7.

Table 6

The number (percentage) of glottalized vowel onsets in each tonal category, High- [il] and Low-[il], separately by Gender in the 20s and 30s Age group. The difference in % of glottalization between the two tonal categories is given in the last column.

		No. (%) of glottalized V in High-[il] tokens	No (%) of glottalized V in Low-[il] tokens	Difference in %
20s	Male	103 (44.59)	33 (22.76)	21.83
	Female	63 (53.39)	87 (33.72)	19.67
30s	Male	83 (43.23)	41 (22.28)	20.95
	Female	144 (66.36)	74 (46.54)	19.82

Table 7

The output of a linear mixed-effects model and a post-hoc Tukey contrasts test for the comparison between High [il] and Low [il] for (a) H1*–H2*, (b) H1*–A3*, and (c) HNR.

(a) H1*−H2*

	df	χ^2	$Pr(>\chi^2)$		
Tone	2	6.8358	0.03278 *		
Age	1	0.4688	0.49356		
Gender	1	1.4776	0.22415		
Tone:Age	2	21.3287	2.336e−05 ***		
Tone:Gender	2	146.262	<2.2e−16 ***		
Age:Gender	1	94.7692	<2.2e−16 ***		
Tone:Age:Gender	2	20.2529	4.001e−05 ***		
		Estimate	Std. error	z value	$Pr(>|z|)$
High- vs. Low-[il] in 20s	Female	0.83638	0.68545	1.22	0.72729
	Male	2.1644	0.64618	3.35	0.00631 **
High- vs. Low-[il] in 30s	Female	−2.4367	0.7714	−3.159	0.0122 *
	Male	1.8795	0.7998	2.35	0.12

H1*−A3*

	df	χ^2	$Pr(>\chi^2)$		
Tone	2	72.7626	<2.2e−16 ***		
Age	1	0.0091	0.9242		
Gender	1	4.6233	0.03154 *		
Tone:Age	2	4.0125	0.13449		
Tone:Gender	2	79.5455	<2.2e−16 ***		
Age:Gender	1	43.7169	3.795e−11 ***		
Tone:Age:Gender	2	2.5726	0.27629		
For 20s and 30s		Estimate	Std. error	z value	$Pr(>|z|)$
High- vs. Low-[il]	Female	−5.6767	0.8162	−6.955	< 0.001 ***
	Male	1.9401	0.8286	2.341	0.11458

HNR

	df	χ^2	$Pr(>\chi^2)$		
Tone	2	23.0661	6.604e−08 ***		
Age	1	0.7851	0.375601		
Gender	1	8.3864	0.003780 **		
Tone:Age	2	5.6565	0.059117		
Tone:Gender	2	15.1620	0.000510 ***		
Age:Gender	1	19.8304	8.463e−06 ***		
Tone:Age:Gender	2	8.7073	0.012860 *		
	df	χ^2	$Pr(>\chi^2)$		
Gender, for 20s	1	6.5707	0.0103671 *		
		Estimate	Std. error	z value	$Pr(>|z|)$
Male vs. female	1	−5.282	2.086	−2.532	0.0113 *
	df	χ^2	$Pr(>\chi^2)$		
Gender, for 30s	1	1.9697	0.1605		

*** $p<.0001$, ** $p<.001$, * $p<.05$,

gender, female speakers used more tense phonation for High [il] than Low [il] (see the negative 'estimate' value for H1*–A3* in Table 7), but male speakers used breathier phonation for High [il] than Low [il] (see the positive 'estimate' value for H1*–H2* data for males in their 20s in Table 7). For speakers in 30s, female speakers used more tense phonation for High [il] than Low [il] again (see the negative 'estimate' value for H1*–H2* and H1*–A3* data in Table 7), but male speakers did not show any phonation difference between High [il] and Low [il]. In sum, there was no consistent pattern of voice quality difference between the High-toned and Low-toned [il] across all genders and ages. Instead, a High-toned [il] was produced with breathier phonation by males in their 20s but with more tense, i.e., less breathy, phonation by females in their 20s and 30s. Males in their 30s did not show any difference in voice quality between High- vs. Low-toned [il].

4. Discussion and conclusion

4.1. Possible motivations of High-toned-[il]

We have shown that the High-toned-[il] phenomenon is found in Seoul Korean, especially by speakers below their mid-40s as of 2012 (i.e., those who were born around 1970 and later). How did it start? What might have been the motivation? And why is [il] meaning 'No. 1' the most common to have a High tone? We propose three possible motivations or driving forces of this phenomenon. They are the perceptual confusion between [il] '1' and [i] '2', the cultural emphasis on being the best or the first, and the influence from the Kyungsang dialect.

First, [il] '1' and [i] '2' in modern Seoul Korean are quite similar acoustically and perceptually, as they have lost their former vowel length contrast, especially for speakers below the age of 60 (Kang, Yoon, & Han, 2014). (In the Chonnam dialect, the vowel length contrast is still preserved, with a long vowel in [i:] '2', but a short vowel in [il] '1'.) It is quite plausible that producing high pitch on [il] would enhance the perceptual difference between the two digits, either when the digit is produced in isolation or when it is followed by a morpheme representing a unit (e.g., /pʌn/ 'number or turn (a unit of digit)' as in [ilbʌn] 'No. 1' vs. [ibʌn] 'No. 2'.[13]).

In addition, the fact that most speakers in their early 40s use a High tone on digit 1 at a much higher rate (about 76%, see Table 4) than their overall usage of High-toned-[il] (about 32%, see Fig. 3) suggests that this phenomena must have started from producing digit 1. This is further supported by the fact that most instances of High-toned-[il] in each Age group (including those in their 50s) are from [il] with the meaning 'No. 1' − not from other meanings of [il]. In fact, 'digit 1' is where this phenomenon was first noticed by the first author in 1995.

Second, if the goal is only to distinguish the digit 1 ([il]) from the digit 2 ([i]), then what would be the driving force of producing a High tone on [il], instead of on [i]? This could be explained by the cultural emphasis on being 'number one', i.e., 'the best' or 'the first', in the highly competitive society of Korea. That is, by adding a high tone on [il], the meaning of 'the best' might be emphasized. This is so because one of the main prosodic realizations of focus in Korean is to expand the pitch range of the focused word (Jun & Lee, 1998). Furthermore, f0 of an individual syllable is raised locally if the syllable is contrastively focused, starting a new Accentual Phrase and a new Intermediate Phrase (in the revised model shown in (1)) (Jun, 2011). This suggests that the syllable [il] 'No. 1' might have been even more encouraged to be produced with a high pitch as a way to emphasize the meaning of 'the best' or 'the first'.

Finally, this High-toned-[il] phenomenon could be also influenced by the Kyungsang dialect. Unlike Seoul or Chonnam dialects, the Kyungsang dialect, spoken in the Southeastern part of South Korea, features lexical pitch accent. In this dialect (especially people from the two major cities, Taegu and Pusan), [il] 'work' has a Low tone while [il] 'No. 1' and [il] 'day' have a High tone; High tones are also seen, albeit less consistently, on other meanings of [il]. Despite its status as non-standard, this dialect of Korean is often depicted as the dialect of political power in movies and comedies, because most former presidents and high-level political figures in modern Korea originate from the Kyungsang area. Furthermore, because many current residents of Seoul also originate from the Kyungsang province, the tonal pattern of [il] words in the Kyungsang dialect, or simply the presence of a high tone in Kyungsang-accented words, may have influenced Seoul speech.

4.2. High-toned-[il] and VOT merger

The next question is whether this sound change of High-toned [il] is an isolated one. The special linguistic behavior of people born around 1970s and later can also be observed in another sound change underway in Korean. Recent studies have found that people born around that time are responsible for the merger of Voice Onset Time (VOT) between lenis and aspirated stops (Kang & Guion, 2008; Kong, Beckman, & Edwards, 2011; Kang, 2014; Oh, 2011; Silva, 2006; Wright, 2007). As mentioned earlier, Korean has a three-way laryngeal contrast in obstruents: lenis, aspirated, and tense. This three-way contrast is maintained by various acoustic cues, a primary one being the duration of VOT (Lisker & Abramson, 1964; Kim, 1965; Han and Weitzman, 1970; Cho et al., 2002). Aspirated stops have long VOT, lenis stops have moderately long VOT, and tense stops have zero to very short VOT. However, the VOT became shorter for aspirated stops and longer for lenis stops, causing them to overlap. As can be seen in Fig. 7 (taken from Silva, 2006, Fig. 2) where the difference in VOT (in ms) between aspirated and lenis stops is shown against subjects' year of birth, the sound change in VOT seems to be carried by those who were born around 1970 and later. That is, the VOT difference is around

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[13] /pʌn/ becomes [bʌn] in these examples because the voiceless lenis stop, /p/, becomes voiced between sonorants within a word in Korean (Kim-Renaud, 1974; Cho, 1990; Silva, 1992; Jun, 1993).

30ms or more for those who were born in the 1960s, but it became 10ms or smaller (a negative value means that VOT is longer for lenis stops than aspirated stops) for people born around 1970 and later.

A similar plot from the current data is shown in Fig. 8, where the percentage of High-toned-[il] (out of 47 words, including all four meanings of [il]) is plotted against each subject's year of birth (for a total 80 participants). A sharp increase in the percentage is clearly shown from people born around 1970.

The VOT merger between aspirated and lenis stops increased the functional load of $f0$ among younger speakers. Kang and Guion (2008) found that, in clear speech, older speakers (those born before 1966) solely used VOT to enhance the contrast between lenis and aspirated stops, while younger speakers (those born after 1977) used $f0$ as a primary cue and VOT as a secondary cue. Here, $f0$ cues refer to the $f0$ difference at vowel onset after aspirated or lenis consonants when these consonants are produced AP-initially. This suggests that speakers born around 1970 and later must have become more sensitive to the pitch of the vowel in the AP-initial position. This sensitivity to pitch on AP-initial syllables could have encouraged people to use pitch to distinguish [il] from [i] and start a new AP when the pitch is High even though the syllable begins with a vowel.

4.3. High-toned-[il] and glottalization

The pitch distinction made for the three-way stop contrast is also related to laryngeal distinctions. That is, the aspirated and tense stops that trigger a High tone AP-initially have [+spread glottis] and [+constricted glottis], respectively; the lenis stops that trigger a Low tone AP-initially have [-stiff glottis]. One can therefore argue that the High tone on [il] might be triggered by a word-initial, prevocalic glottal stop, which has [+constricted glottis], thus forming a natural class with the tense consonants. However, the findings of the current study provide little support for this scenario, since High-toned [il] syllables began with a glottal stop (or glottalization) only about 20% more often than low-toned [il] syllables. Further, a range of voice quality measures revealed no consistent pattern of [i]-laryngealization associated with a particular tone. Instead, it seems that glottalization at the onset of High-toned [il] syllable occurs as an optional by-product of producing the vowel with high pitch, which requires more tension in vocal folds (and which is intrinsically linked to higher intensity; Raphael, Borden, & Harris, 2007). This explains why only about half of the High-toned [il] syllables begin with a glottal stop or glottalization and why so much variation was evident across speakers. It is possible, however, that the presence of glottal stop or glottalization on High-toned [il] might become more common if it enhances the perceptual salience of the [il] morpheme. It is also possible that perceptually salient [il] through glottalization might help to signal the exception to the general segment-tone mapping rule of intonational phonology of Seoul Korean.

Producing a High tone on [il] to enhance the perceptual salience of the syllable might explain why short APs beginning with [il] tend to begin with a High tone more often than longer APs do. In the current study, a 3-syllable AP (a short AP) typically consisted of a monosyllabic word, [il] 'No.1', followed by a unit of measurement and a case marker/postposition (e.g., /il+to+ka/ '1+unit of Celsius degree+ NOM' => '1 C°-NOM', /il-pun-to/ '1- minute-also' => 'also 1 min'), while a 5-syllable AP (a long AP) included a 4-syllable
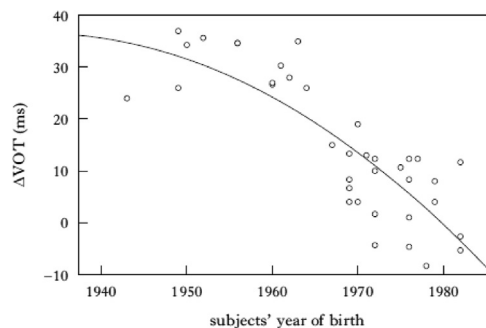

Fig. 7. VOT difference between aspirated stops and lenis stops as a function of subjects' year of birth. The best-fit curve of a quadratic function (R^2=0.686) is shown. (Fig. 2 from Silva (2006, p. 293)).
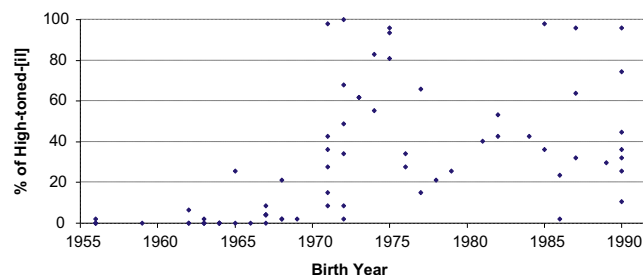

Fig. 8. Percentage of High-toned-[il] usage for each speaker in the current study, arranged by their birth year, from the oldest (born in 1956, 56 years old as of 2012) to the youngest (born in 1990, 22 years old as of 2012).

lexical item plus a case marker/postposition (e.g., /ilpaŋtʰoŋhɛŋ+i/ 'one way+NOM'). Parsing a short lexical item in running speech would be more demanding than parsing a longer lexical item because less information about the word would be available to the listener. A shorter word might therefore need to be marked with higher pitch to boost its salience. It is also possible that a short-word-[il] is more often produced with a High tone than is a long-word-[il] because the former is more frequent than the latter. In that case, the High-toned-[il] phenomenon might have spread first from high frequency words and then later to low frequency words (Coetzee & Kawahara, 2013; Pierrehumbert, 2001). Further study is needed to identify any such effects of word frequency on the High-toned-[il] phenomenon.

4.4. Generalization to other words and the implications of High-toned-[il] for the intonational model

Our finding from the Stimuli Set 1 suggests that the High-toned-[il] phenomenon, which started from [il] meaning 'No. 1', has spread to other meanings of [il]. This means that the High tone-[il] mapping is no longer driven by meaning, but by the sound [il]. The results from the Stimuli Set 2 suggest that this is to some degree true because the words beginning with [il] in the surface form due to resyllabification from the underlying complex coda, /ilk/ and /ilh/, were sometimes produced with a High tone by some speakers who had a strong tendency to produce High-toned-[il] in the Stimuli Set 1. If the High tone is triggered by the sound [il], would the first vowel [i] be enough to trigger a High tone? Results from the Stimuli Set 2 suggest that this is not the case. None of the 17 words beginning with an /i/ syllable were produced with a High tone. Therefore the High tone's phonological target is, at least at the moment, not simply the high front vowel [i], but the whole syllable [il]. This is expected if the original motivation of High-toned-[il] is to avoid confusion between [il] '1' and [i] '2'.

The question now is what the status of this High tone is in the intonational phonology of Seoul Korean. Seoul Korean is an intonation language, as pitch is not distinctive. The intonation pattern of a sentence is solely determined by prosodic phrasing of the sentence and the phrase-initial segment types – not by the meaning of a word or morpheme. The High tone on [il] may have started as a morpheme-specific pitch accent, i.e., targeting the digit '1' or a word meaning 'Number 1', but now the association with this pitch accent has become weakened, and it is instead realized as a phrasal tone. This is supported by the tonal pattern of an AP beginning with the target [il] syllable. As mentioned earlier (Section 3.1), the AP beginning with a High [il] syllable shows the same tonal pattern, HHLH, as the AP beginning with a High-tone triggering consonant (see Fig. 1(b) and (c)).

However, the fact that an AP can begin with a High tone when its first segment is a vowel is a clear exception to the tone-segment mapping rule established for the intonational phonology of Seoul Korean. This would remain as an exception to the rule for a while and future generations could "correct" this violation by epenthesizing a glottal stop before the syllable [il]. Alternatively, a subsequent generation of speakers could add further exceptions to the rule, thus creating a new intonation pattern in the language. In fact, such additional exception seems to be in progress. Examination of the filler sentences confirms our informal observation that the digit '4' in /sapʌn/ 'No. 4' is often produced with a Low tone even though /s/, having [+spread glottis], is one of the High tone triggering segments. Again, this might have been motivated by the need to avoid confusion between /sampʌn/ 'No. 3' and /sapʌn/ 'No. 4' (This would not be the case, however, in the Chonnam dialect, where the first syllable of 'No. 4' is underlyingly long, /sa:pʌn/). It is possible that /sampʌn/ is consistently produced with a High tone AP-initially in Seoul Korean because the first syllable is heavy and thus perceptually more salient than the light syllable /sa/ in /sapʌn/. If exceptions to the general intonation pattern keep increasing, Korean could eventually become a tone language, conforming to the hypothesis of the tonogenetic sound change in Seoul Korean recently proposed by researchers based on the VOT merger and increased use of *f*0 data (Kang and Han, 2013; Kang, 2014; Silva, 2006).

4.5. Individual variation in High-toned-[il] usage

The current data based on 80 speakers (40 males and 40 females) revealed a significant variation in the usage of High-toned-[il] across the Gender and Age factors and their interaction. Though females were slightly more likely to employ the High-toned-[il] phenomenon than males overall, females in their 20s used the phenomenon significantly less than males in their 20s. Only those females in their 30s and early 40s used High [il] more often than males. This pattern may be explained by the speaker's attitude toward the High-toned-[il] phenomenon depending on their ages. Since this phenomenon is a recent trend associated with youth, females in their 30s and older may prefer to use it. On the other hand, females in their 20s may regard it as "less cool" because it can be associated with immaturity and informality. For example, they would not hear the High [il] from the speech of their parents or established middle age professionals. That is, the phenomenon is sensitive to both gender and age because what is considered to be "cool" or "desirable" differs by age even in the same gender.

We have also seen substantial variation in the percentage of High-toned-[il] usage across individuals. Though a general trend is to use more High-toned-[il] among Seoul speakers younger than mid-40s, the degree of this usage varied within the same Age group, and as seen in Fig. 8, even among the speakers of the same birth year (in Fig.8, each dot represents the percentage of High-toned-[il] usage by each speaker). A further interesting fact is that one male speaker in his early 40s (born in 1972, Speaker M5) produced High on [il] 100%, but his older brother who was born in 1968, thus also in the same age group, produced High-toned [il] only 21% of the time. Both of them were highly educated and above average in socioeconomic status. This suggests that the use of High-toned [il] is not predictable based on the level of education or socioeconomic status, or the family background. Factors such as friends and work environment may also affect the use of High-toned [il]. Regardless of the variation, however, it is expected that this High-toned-[il] phenomenon will become a social marker of Seoul speech, and more research may find further sound change related to this phenomenon.

The findings from the current study suggest that an intonational tone can change to enhance a distinction in lexical meaning even if it violates the phonological pattern of the language. This may be possible in Korean because the tonal characteristics of an AP are not distinctive, i.e., they do not convey the kind of pragmatic meanings that are encoded in English pitch accents (Pierrehumbert & Hirschbert, 1990; Jun, 2005). That is, the H versus L opposition in the Korean AP represents the surface $f0$ contour, but it does not reflect a lexical item's status in the discourse. The findings also suggest that changing the pitch to a high level increases perceptual salience of the syllable or the word, mimicking the prosodic mechanism of marking semantic focus or pragmatic emphasis. Cross-linguistically, it has been found that an expanded pitch range or High tone is used to mark narrow focus, in addition to longer duration or increased amplitude (Jun, 2014). So, in languages where a delayed rising tone ($=f0$ minimum on or just before the stressed syllable and $f0$ peak on the following syllable, i.e., L*+H in the ToBI style notation; Jun & Fletcher, 2014) is the default pitch accent in a sentence (e.g., Spanish, Greek), narrow focus is often marked by aligning the $f0$ peak with the stressed vowel (i.e., L+H*). This illustrates that a High tone has a special function linguistically, i.e., it marks semantic salience. Furthermore, a High tone may also have a special function sociolinguisically by delivering the meaning of something important. Further study is needed to confirm the interpretations proposed in the paper and to find equivalent function of a High tone in other languages.

Acknowledgments

Appendix A. Target words

Target words are grouped in each of the four meanings of [il], AP-initially (Table A1) and medially (Table A2). Each target word is given in Korean hangul, the IPA transcription, and English glosses.

Table A1
Target words used in the AP-initial position

No. 1 [il]			Work [il]		
Korean	IPA	English gloss	Korean	IPA	English gloss
일등	/iltiŋ/	1st (in rank)	일손	/ilson/	Worker
일번	/ilpʌn/	1st (in order)	일복	/ilpok/	Destined to work a lot
일도	/ilto/	1 degree	일삯	/ilsak/	Wages
일분	/ilpun/	1 min	일터	/iltʰʌ/	Workplace
일년	/ilnjʌn/	1 year	일삼아	/ilsama/	Do something habitually
일주년	/iltʃunjʌn/	1st anniversary	일거리	/ilkʌli/	Things to do
일리터	/illitʰʌ/	1 l	일자리	/iltʃali/	A job, work
일킬로	/ilkʰillo/	1 kilo	일하는	/ilhanin/	To work
일주일	/iltʃuil/	1 week	일없는	/ilʌpnin/	No work to do
일등품	/iltiŋpʰum/	A 1st class article	일보러가고	/ilpolʌkako/	To carry on a business
일사분기	/ilsapunki/	1st quarter			
일번타자	/ilpʌntʰatʃa/	A leadoff hitter			
일초차이	/iltʃʰotʃʰai/	1 s difference			
일회용품	/ilhwɛjoŋpʰum/	Disposables			
일학년생	/ilhaknjʌnsɛŋ/	A 1st year student			
일방통행	/ilpaŋtʰoŋhɛŋ/	One way			
일종면허	/iltʃoŋmjʌnhʌ/	A 1st class license			

Day [il]			Other [il]		
Korean	IPA	English gloss	Korean	IPA	English gloss
일과	/ilkwa/	A daily lesson	일찍	/iltʃ*ik/	Early
일몰	/ilmol/	Sunset	일흔	/ilhin/	Seventy
일정	/iltʃʌŋ/	Schedule	일화	/ilhwa/	Anecdote
일기	/ilki/	Diary	일부러	/ilpulʌ/	On purpose
일상	/ilsaŋ/	Daily life	일일이	/ilili/	One by one
일사병	/ilsapjʌŋ/	Heatstroke	일찌감치	/iltʃ*ikamtʃʰi/	A little early
일요일	/iljoil/	Sunday	일쑤	/ils*u/	Habitual practice
일교차	/ilkjotʃʰa/	Daily temperature range	일어나기	/ilʌnaki/	To rise
일기예보	/ilkijɛpo/	A weather forecast	일어서기	/ilʌsʌki/	To stand up
일식	/ilsik/	A solar eclipse	일곱	/ilkop/	Seven

Table A1 (*continued*)

High-C		
Korean	IPA	English gloss
힘	/him/	strength
칠판	/tʃʰilpʰan/	blackboard
힘없이	/himʌpsi/	feebly
실제	/siltʃɛ/	reality
킹콩	/kʰiŋkʰoŋ/	King Kong
신나게	/sinnakɛ/	cheerfully
키	/kʰi/	height
티눈	/tʰinun/	a corn
필사적	/pʰilsatʃʌk/	desperate
끼니	/k*ini/	meal

Table A2
Target words used in the AP-medial position

No. 1 [il]			Work [il]		
Korean	IPA	English gloss	Korean	IPA	English gloss
213	/iilsam/	213	잡일	/tʃapil/	Chores
오일육	/oiljuk/	16-May	뱃일	/pɛtnil/	Work aboard ship
101호	/pɛkilho/	Room 101	물일	/mulil/	Work with water
공일	/koŋil/	zero-one	농사일	/noŋsail/	Farmwork
518	/oilpʰal/	18 May	집안일	/tʃipanil/	Housekeeping
김일병	/kimilpjʌŋ/	Private first classman, Mr. Kim	막일꾼	/makilk*un/	An odd-jobber
91–673	/kuil-ɛ-juktʃʰilsam/	91–673	발일	/patil/	Field work
119	/ililku/	119	잡일하기	/tʃapilhaki/	Doing chores
114	/ililsa/	114	논일	/nonil/	Work in a rice paddy

Day [il]			Other [il]		
Korean	IPA	English gloss	Korean	IPA	English gloss
당일	/taŋil/	The very day	일일이	/ilili/	One by one
오일	/oil/	5 days	과일	/kwail/	Fruit
주일	/tʃuil/	Weekend	미사일	/misail/	Missile
월요일	/wʌljoil/	Monday	이메일	/imɛil/	Email
납기일	/napkiil/	Deadline of payment	마일	/mail/	Mile
전남일보	/tʃʌnnamilpo/	Chonnam Daily News	보일러	/poillʌ/	Boiler
매일	/mɛil/	Every day	라일락	/laillak/	Lilac
중일전쟁	/tʃuŋiltʃʌntʃɛŋ/	Chinese-Japan war	나일론	/naillon/	Nylon
주일	/tʃuil/	A week	마일리지	/mailitʃi/	Mileage

References

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modelling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390–412.

Bates D, Maechler M, Bolker B and Walker S (2014). *lme4: Linear mixed-effects models using Eigen and S4*. R package version 1.1-7, ⟨http://CRAN.R-project.org/package=lme4⟩.

Beckman, M., & Pierrehumbert, J. (1986). Intonational structure in Japanese and English. *Phonology Yearbook*, *3*, 255–309.

Boersma, P., & Weenink, D. (2011). *Praat: Doing phonetics by computer*. Version 5.3.56. ⟨http://www.praat.org/⟩.

Cho, T., Jun, S.-A., & Ladefoged, P. (2002). Acoustic and aerodynamic correlates of Korean stops and fricatives. *Journal of Phonetics*, *30*, 193–228.

Cho, Y. Y. (1990). Syntax and Phrasing in Korean. In S. Inkelas, & D. Zec (Eds.), *The phonology-Syntax connection* (pp. 47–62). Chicago: University of Chicago Press.

Coetzee, Andreis, & Kawahara, Shigeto (2013). Frequency biases in phonological variation. *Natural Language and Linguistic Theory*, *31*, 47–89.

Davison, D. S. (1991). An acoustic study of so-called creaky voice in Tianjin Mandarin. *UCLA Working Papers in Phonetics*, *78*, 50–57.

Gandour, J. (1974). Consonant types and tone in Siamese. *Journal of Phonetics*, 2.

Garellek, M. (2012). The timing and sequencing of coarticulated non-modal phonation in English and White Hmong. *Journal of Phonetics*, *40*, 152–161.

Garellek, M. (2013). *Production and perception of glottal stops* (Ph.D. dissertation). Los Angeles: University of California.

Garellek, M., & Keating, P. (2011). The acoustic consequences of phonation and tone interactions in Jalapa Mazatec. *Journal of the IPA*, *41*, 185–205.

Gordon, M., & Ladefoged, P. (2001). Phonation types: a cross-linguistic overview. *Journal of Phonetics*, *29*, 383–406.

Halle, M., & Stevens, K. N. (1971). *A note on laryngeal features* (MIT quarterly progress report). Research Laboratory of Electronics101.

Han, M. S., & Weitzman, R. S. (1970). Acoustic features of Korean /P, T, K/, /p, t, k/ and /pʰ, tʰ, kʰ/. *Phonetica*, *22*, 112–128.

Hombert, J.-M. (1978). Consonant types, vowel quality, and tone. In Victoria Fromkin (Ed.), *Tone: A linguistic survey* (pp. 77–111).

Hombert, J.-M., Ohala, J., & William, E. (1979). Phonetic explanations for the development of tones. *Language*, *55*, 37–58.

Hothorn, T., Bretz, F., & Westfall, P. (2008). Simultaneous Inference in General Parametric Models. *Biometrical Journal*, *50*(3), 346–363.

Iseli, M., Shue, Y.-L., & Alwan, A. (2007). Age, sex, and vowel dependencies of acoustic measures related to the voice source. *Journal of the Acoustical Society of America*, *121*, 2283–2295.

Jun, S. -A. (1998). The Accentual Phrase in the Korean prosodic hierarchy. *Phonology, 15*(2), 189–226.

Jun, S. -A. (2007). The intermediate phrase in Korean intonation: evidence from sentence processing. In C. Gussenhoven, & T. Riad (Eds.), *Tones and tunes: Studies in word and sentence prosody* (pp. 143–167). Berlin: Mouton de Gruyter.

Jun, S. -A. & Cha, J. (2011). High-toned [il] in Seoul Korean. In *Proceedings of the 17*th *ICPhS*. Hong Kong, China.

Jun, S.-A. (1993). *The phonetics and phonology of korean prosody* (Ph.D. dissertation). New York, NY: The Ohio State University. [published in 1996 by Garland Publishing Inc.

S.-A. Jun, J. Cha / Journal of Phonetics 51 (2015) 93–108

Jun, S.-A. (1996). Influence of microprosody on macroprosody: a case of phrase initial strengthening". *UCLA Working Papers in Phonetics*, *92*, 97–116.

Jun, S.-A. (2000). Korean-ToBI labeling conventions. *UCLA Working Papers in Phonetics*(99), 149–173.

Jun, S.-A. (2006). *Intonational phonology of Seoul Korean revisited. Japanese-Korean Linguistics 14*. Stanford: CSLI.

Jun, S.-A. (2011). Prosodic markings of complex NP focus, syntax, and the pre-/post-focus string. In *Proc. 28*th *WCCFL* (pp. 214–230).

Prosodic typology II: The Phonology of intonation and phrasing. In S.-A. Jun (Ed.), Oxford University Press.

Jun, S.-A., & Fletcher, J. (2014). Methodology of studying intonation: From data collection to data analysis. In Sun-Ah Jun (Ed.), *Prosodic typology II: The phonology of intonation and phrasing* (pp. 493–519). Oxford University Press.

Jun, S.-A. & Lee, H.-J. (1998). Phonetic and phonological markers of contrastive focus in Korean. In *Proceedings of the 5th international conference on spoken language processing* (Vol. 4, pp. 1295–1298). Sydney, Australia.

Jun, S.-A., & Oh, M. (1996). A Prosodic analysis of three types of wh-phrases in Korean. *Language and Speech*, *39*(1), 37–61.

Jun, S. A. (2005). Korean intonational phonology and prosodic transcription. In S.-A. Jun (Ed.), *Prosodic typology: The phonology of intonation and phrasing* (pp. 201–229). Oxford University Press.

Jun, S.-A. & Fougeron, C. (1995) The accentual phrase and the Prosodic structure of French, in the Proceedings of XIIIth International Congress of Phonetic Sciences, Vol. 2, 722-725. Stockholm, Sweden.

Jun, S.-A., & Fougeron, C. (2000). A Phonological Model of French Intonation. In Antonis Botinis (Ed.), *Intonation: Analysis, Modeling and Technology* (pp. 209–242). Kluwer Academic Publishers.

Jun, S.-A., & Fougeron, C. (2002). The Realizations of the Accentual Phrase in French Intonatoin. *Probus*, *14*, 147–172.

Kang, K.-H., & Guion, S. G. (2008). Clear speech production of Korean stops: Changing phonetic targets and enhancement strategies. *Journal of the Acoustical Society of America*, *124*, 3909–3917.

Kang, Y. (2014). Voice Onset Time merger and development of tonal contrast in Seoul Korean stops: A corpus study. *Journal of Phonetics*, *45*, 76–90.

Kang, Y., & Han, S. (2013). Tonogenesis in early Contemporary Seoul Korean: A longitudinal case study. *Lingua*, *134*, 62–74.

Karlsson, A. (2014). The intonational phonology of Mongolian. In Sun-Ah Jun (Ed.), *Prosodic typology II: The phonology of intonation and phrasing* (pp. 187–215). Oxford University Press.

Khan, S. (2008). *Intonational phonology and focus prosody of Bengali* (Ph.D. dissertation). UCLA.

Khan, S. D. (2012). The phonetics of contrastive phonation in Gujarati. *Journal of Phonetics*, *40*, 780–795.

Khan, S. D. (2014). The intonational phonology of Bangladeshi Standard Bengali. In Sun-Ah Jun (Ed.), *Prosodic typology II: The phonology of intonation and phrasing* (pp. 81–117). Oxford University Press.

Kim, C.-W. (1965). On the autonomy of the tensity feature in stop classification. *Word*, *21*, 339–359.

Kim-Renaud, Y. (1974). *Korean consonantal phonology* (Ph.D dissertation). University of Hawai'i.

Kingston, J., & Diehl, R. (1994). Phonetic knowledge. *Language*, *70*, 3.

Kohler, K. (1982). *F*0 in the production of lenis and fortis plosives. *Phonetica*, 39.

Kong, E. J., Beckman, M., & Edwards, J. (2011). Why are Korean tense stops acquired so early? The role of acoustic properties. *Journal of Phonetics*, *39*, 196–211.

Labov, W. (1990). The intersection of sex and social class in the course of linguistic change. *Language Variation and Change*, *2*, 205–254.

Lee, H.-J. (1999). *Tonal realization and implementation of the Accentual Phrase in Seoul Korean* (MA thesis). Dept. of Linguistics, UCLA.

Lisker, L., & Abramson, A. S. (1964). Cross-language study of voicing in initial stops: acoustical measurements. *Word*, *20*, 384–422.

Lombardi, L. (1991). *Laryngeal features and laryngeal neutralization* (Ph.D dissertation). University of Massachusetts, Amherst.

Oh, E. (2011). Effects of speaker gender on voice onset time in Korean stops. *Journal of Phonetics*, *39*, 59–67.

Pierrehumbert, J. B. (2001). Exemplar dynamics: Word frequency, lenition and contrast. In J. Bybee, & P. Hopper (Eds.), *Frequency effects and the emergence of linguistic structure* (pp. 137–157). Amsterdam: John Benjamins.

Pierrehumbert, J. B., & Beckman, M. (1988). *Japanese tone structure*. MA: MIT Press.

Pierrehumbert, J. B., & Hirschbert, J. (1990). The meaning of intonation contours in the interpretation of discouse. In P. R. Cohen, J. Morgan, & M. E. Pollack (Eds.), *Intentions in communication* (pp. 271–311). Cambridge, MA: MIT Press.

R Development Core Team (2014). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing Vienna, Austria.

Raphael, L., Borden, G., & Harris, K. (2007). *Speech science primer* (5th ed.). Lippincott Williams and Wilkins.

Shue, Y.-L. (2010). *The voice source in speech production: Data, analysis and models* (Ph.D. Dissertation). UCLA.

Shue, Y.-L., Keating, P. A., Vicenik, C., & Yu, K. (2011). VoiceSauce: A program for voice analysis. In *Proceedings of the international congress of phonetic sciences* (pp. 1846–1849). Hong Kong.

Silva, D. J. (1992). *The phonetics and phonology of stop lenition in Korean* (Ph.D. dissertation). Cornell Univeristy.

Silva, D. J. (2006). Acoustic evidence for the emergence of tonal contrast in contemporary Korean. *Phonology*, *23*, 287–308.

Silverman, K. (1986). *F*0 segmental cues depend on intonation: The case of the rise after voiced stops. *Phonetica*, *43*, 776–791.

Vicenik, C., & Jun, S.-A. (2014). An autosegmental-metrical analysis of Georgian intonation. In Sun-Ah Jun (Ed.), *Prosodic typology II: The phonology of intonation and phrasing* (pp. 154–186). Oxford University Press.

Wright, J. D. (2007). *Laryngeal contrast in Seoul Korean* (Ph.D. dissertation). University of Pennsylvania.

Yu, K. M., & Lam, H. W. (2014). The role of creaky voice in Cantonese tone perception. *Journal of the Acoustical Society of America*, *136*(3), 1320–1333.