



Perception of Prosodic Boundaries by Native English Speakers and Korean Learners of English in Public Speech*

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Received: September 2, 2024

Revised: September 23, 2024

Accepted: October 15, 2024

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ABSTRACT

Im, Suyeon. 2024. Perception of prosodic boundaries by native English speakers and Korean learners of English in Public Speech. *Korean Journal of English Language and Linguistics* 24, 1101-1120.

Korean and English have distinct prosodic systems. Due to these differences, Korean learners of English may have difficulty perceiving prosodic boundaries and tones. To this end, the present study investigates the perception of prosodic boundaries by Korean learners of English compared with native English speakers using public speech. As perception can be influenced by the speech style of the speaker, we first examined the production of prosodic boundaries and tones by a native English speaker in the stimulus materials and observed five boundary types (prosodic word, L-, H-, L-L%, and H-H%). Next, we examined the perception of prosodic boundaries in relation to prosodic strength (prosodic word, intermediate phrase, and intonational phrase) and boundary tones (high tone and low tone) by native English speakers and Korean learners of English. The two groups of listeners differed significantly in that Korean learners of English, compared with native English speakers, were more likely to perceive prosodic boundaries for the intonational phrase, especially one conveying a high tone (i.e., H-H%). These results suggest that Korean learners of English may (a) rely on a bottom-up process and (b) transfer L1 prosody to the perception of L2 prosody. This study calls for exposure to various speech styles during L2 prosody acquisition.

KEYWORDS

prosody, boundary, phrasal tone, English, public speech, L1 transfer, L2 prosody, Korean learners of English

1. Introduction

Speakers make prosodic boundaries to breathe in the course of speech or prepare upcoming messages (i.e., thought groups). According to the Autosegmental-Metrical theory (Lieberman 1975, Pierrehumbert 1980), American English has two prosodic boundaries, intermediate phrases (ip) and intonational phrases (IP), which may broadly correspond to syntactic phrases and clauses, respectively. In (1), for instance, a speaker can produce two intermediate phrases, while making a brief pause after “new.” The word “new” becomes the location of intermediate boundary. These two intermediate phrases constitute an intonational phrase. The word “days” is considered as a location of intonational boundary. If a word simultaneously carries an intermediate boundary and an intonational boundary, it is considered as the location of the intonational boundary. In the Autosegmental-Metrical theory, the stronger prosodic boundary (i.e., the intonational boundary) overrides the weaker prosodic boundary (i.e., the intermediate boundary).

- (1) [[try something new]_{ip} [for thirty days]_{ip}]_{IP}

The difference between the ips and IPs manifests in several aspects of speech signals, such as pause duration, word lengthening, pitch, intensity, and voice quality (Beckman and Pierrehumbert 1986, Klatt 1976, Shattuck-Hufnagel and Turk 1998). The IPs have a greater boundary strength than the ips. The IPs are characterized by more extreme pitch changes and pre-boundary lengthening than the ips (Wang and Hirschberg 1992).

Prosodic boundaries (ips and IPs) convey a phrase accent (or boundary tone), which is either a high tone (H) or low tone (L). This would yield several tonal inventories of prosodic boundary, for example, H- or L- for the intermediate phrase [symbolized with a dash (-)], and H-H% or L-L% for the intonational boundary [symbolized with a percent (%) combined with an intermediate boundary tone H- or L-]. Boundary tones (H or L) deliver a certain semantic or pragmatic message in context (Couper-Kuhlen 2001, Ladd 1996, Ohala 1983, Pierrehumbert and Hirschberg 1990). High boundary tones (e.g., H- and H-H%) are used when the current and upcoming utterances are related. For instance, they mark a yes/no question (corresponding to an interrogative sentence), the uncertainty of the message, or the continuation of an upcoming utterance. In comparison, low boundary tones (e.g., L- and L-L%) are used when the current and upcoming utterances are unrelated. For example, they indicate the completion of a message (broadly mapped with a declarative sentence) or the certainty of the message (du Bois et al. 1993, Fletcher et al. 2002, Ladd 1996, Ohala 1983, Shokier 2008, Smith and Clark 1993, Tomlinson Jr. and Fox Tree 2011).

Korean has three prosodic domains: Accentual Phrases (ap), Intermediate Phrases (ip), and Intonational Phrases (IP), which broadly correspond to words, phrases, and clauses, respectively (Jun 2000, 2006, 2011). In Korean, the accentual phrase is a smaller (or weaker) prosodic unit than the intermediate and intonational boundaries. Accentual phrases carry a specific tonal contour. For instance, in four-syllable words, the accentual phrase conveys either LHLH or HHLH (LHLH becomes HHLH if the first syllable of ap starts with an aspirated sound, a tense sound, /h/, or /s/). The final high tone (H) of the accentual phrase seems to be a strong cue for native Korean speakers to segment a stream of speech into smaller prosodic domains (Kim et al. 2012, Kim and Cho 2009). Kim and Cho (2009) investigated the use of tonal and durational cues in the perception of nonsense speech by native Korean speakers and native Dutch speakers. The results showed that native Dutch speakers exploited durational cues more extensively than tonal ones. In comparison, native Korean speakers preferred tonal to durational cues. Native Korean speakers correctly identified when the nonsense words ended with a high tone rather than with a low tone. This was especially true when the high tone of the syllable was followed by a low tone in the next

syllable (which would be mapped with a canonical ap tonal contour LHLH LHLH). These results suggest that a high tone plays an important role in the segmentation of speech for native Korean speakers.

In Korean, intonational phrases carry eight boundary tones for semantic or pragmatic information in context: L%, HL%, LHL%, HLHL%, H%, LH%, HLH%, and LHLH% (Jun 2000). L% is commonly found when stating facts in declaratives. H% is observed for seeking information in the yes/no questions. LH% is more widely used for questions, continuation rises, explanatory endings, annoyance, irritation, or disbelief. HL% is observed for declaratives and wh-questions. LHL% is found for persuasion, insistence, confirmation, annoyance, or irritation. HLH% is used to express confidence and predict listeners' agreement. LHLH% is associated with intensified annoyance, irritation, or disbelief. HLHL% is used to nag or persuade one's opinion. LHLHL% is observed for extreme annoyance.

Native Korean speakers seem sensitive to the edges of utterances (You 2012). You (2012) conducted a perception experiment with native Korean speakers using conversational speech (interviews) in Korean. She found that native Korean speakers had moderate agreement on prosodic boundaries, comparable to native English speakers. Native Korean speakers tended to pay attention to two levels of prosodic boundaries: sentence-level boundaries (corresponding to IP boundaries) and clausal-level boundaries (corresponding to ip boundaries). You (2012) argued that, compared to native English speakers, native Korean speakers can be more sensitive to boundary cues (e.g., pauses) because pragmatic information is mostly conveyed by boundary tones in Korean, whereas it can be conveyed by pitch accents or boundary tones in English.

In second language acquisition, there has been research on the perception of prosodic boundaries by Korean learners of English (Chang and Park 2011, Im and Ahn 2019, Um 2006, Yun 2009). The previous studies examined the role of acoustic cues in speech segmentation with Korean learners of English, but they differed in that most studies (Chang and Park 2011, Um 2006, Yun 2009) focused on the word-level segmentation while very few studies (Im and Ahn 2019) looked into the phrase-level segmentation. Chang and Park (2011) examined the perception of prosodic word in relation to acoustic cues (VOT and glottal stop) by Korean learners of English. Participants listened to a list of near-homophonous phrases (e.g., "keeps talking" vs. "keep staking"), varying with VOT and glottal stop, and identified the heard phrases. The results found that Korean learners of English were more likely to rely on the glottal stop than VOT in word segmentation in L2 English, perhaps due to their prior experiences in L1 Korean where the glottal stop (creakiness or silence), rather than VOT, plays an important role in word segmentation. Im and Ahn (2019) investigated the perception of prosodic boundaries (ips and IPs) as a function of acoustic cues (max F0, mean phone duration) by Korean learners of English compared to native English speakers, using public speech. The results showed that the overall pattern of perceived boundaries was similar between the native English speakers and Korean learners of English. The two groups of listeners were more likely to mark prosodic boundaries on IPs than on ips while relying on both F0 and durational cues. Nevertheless, the two groups of listeners differed in that Korean learners of English had a significantly higher assignment of boundary marks on IPs and a higher reliance on F0 than native English speakers. The authors suggest that Korean learners of English have a higher sensitivity to IPs and F0 in L2 English because of the influence of L1 Korean prosody.

Research on the production of prosodic boundaries by Korean learners of English has produced complex results (Choe 2016, 2020, Kim 2009, Lee 2005, 2008, Lee and Kim 2007, Lee et al. 2001, Park et al. 2000). Lee (2005) examined the use of high boundary tones in coordinate and subordinate sentences by Korean learners of English. She found that both elementary- and advanced-level Korean learners of English had a preference for high boundary tones (H-, L-H%, and H-L%) over low boundary tones (L- and L-L%) in utterances, similar to native English speakers. The successful use of high boundary tones across all levels of Korean learners of English was considered

evidence of the (positive) transfer of L1 Korean accentual boundary tones (LHLH and HHLH). Choe (2016) investigated the use of boundary tones for declarative and interrogative sentences in stories and news articles for children by Korean learners of English. The results showed that Korean English learners were more likely to produce prosodic boundaries than native English speakers. Whereas native English speakers paused at positions with punctuation marks, Korean learners of English made additional pauses at positions without punctuation marks, mostly corresponding to syntactic junctures between words (e.g., between a subject and verb). The results also showed that Korean learners of English preferred to use high boundary tones (H-, L-H%, and H-H%) over low boundary tones (L- and L-L%) more than native English speakers in all types of sentences. Choe (2016) argued that the overuse of high tones by Korean learners of English may arise from the (negative) transfer of L1 Korean prosody, in which utterances end in a high tone (LHLH and HHLH). Park et al. (2000) examined the use of boundary tones in relation to the discourse functions of Korean learners of English. The results showed that native English speakers assigned a low boundary tone (L-L%) to utterances conveying certainty and completion and a high boundary tone (L-H%) to utterances delivering uncertainty and continuity. Korean learners of English, however, used a low boundary tone (L-L%) for all utterances, varying with the level of certainty and completion. In summary, these studies have shown that (a) Korean learners of English tend to produce prosodic boundaries more frequently than native English speakers. Korean learners of English do not pause at random locations and assign an additional pause at syntactic junctures (e.g., between a subject and verb) within an utterance. In addition, (b) Korean learners of English in some studies (Choe 2016, Park et al. 2000) failed to use appropriate boundary tones to convey pragmatic messages.

Considering that perception is related to production, it is possible that sensitivity to high tone (or F0) in perception may lead to overproduction of high tone in speech by Korean learners of English. This raises the question of how Korean learners of English perceive prosodic boundaries (ips and IPs) in relation to boundary tone in English. In previous research on perception, Im and Ahn (2019) found that Korean learners of English tended to show higher sensitivity to IPs and maximum F0 than native English speakers. Im and Ahn (2019) considered the maximum F0 and mean phone duration of words, which can be considered important acoustic cues associated with boundary tones. However, these acoustic cues may not fully capture the phonological features of the boundary tones. More specifically, the maximum F0 is the highest F0 at a single point in time over a word and may not represent the shape of F0 stretched over the word. Therefore, it remains unclear how Korean learners of English perceive prosodic boundaries in interactions with boundary tones (H-, H-H%, L-, and L-L%) in English.

This study investigates how Korean learners of English, compared to native English speakers, perceive prosodic boundaries in relation to boundary strength (ips and IPs) and boundary tones (H-, H-H%, L-, and L-L%) in public speech in English. In a perception experiment, native English speakers and Korean learners of English judged prosodic boundaries while listening to a public speech. Prosodic boundaries in the speech materials were annotated by linguistic experts following the ToBI Convention (Veilleux et al. 2006). The analyses were carried out in the two folds. First, we examined how prosodic boundaries were realized by a native English speaker using speech materials. The speaker's speech style might influence the judgment of prosodic boundaries by the listeners in the perception experiment. Second, we analyzed the perception of prosodic boundaries by native English speakers and Korean learners of English. Based on prior research on the perception and production of prosodic boundaries discussed above, we have the following three hypotheses:

- (2) Korean learners of English differ from native English speakers in their perception of prosodic boundaries.
- (3) Korean learners of English pay more attention to intonational boundaries than native English speakers.
- (4) Korean learners of English rely on high boundary tones to a greater extent than native English speakers.

These results extend our knowledge of English prosodic boundaries. Based on an analysis of the production of a TED talk speaker, we understand how native English speakers exploit various prosodic features, especially boundary strength and tones, in a clear and engaging speech style. In addition, from the analysis of the perception experiment, we learn how native English speakers and Korean learners of English perceive prosodic boundaries as a function of boundary strength and tones in public speech. We will discuss the results in relation to (a) the cognitive processes (top-down vs. bottom-up process) involved in language and (b) the transfer of L1 prosody to L2 prosody. This study has pedagogical implications for L2 prosody acquisition.

2. Method

2.1 Corpora

2.1.1. Participants

We used two corpora: one for Korean learners of English and the other for native English speakers. For the corpus of Korean learners of English, 30 undergraduate students (4 males and 26 females, mean age 20.6) in the Department of English Education of a university in Seoul, Korea, participated in a perception experiment. For the city of birth, 16 participants were born in Seoul and Gyeonggi, while 14 were not (Gyeongsang: 9, Chungcheong: 3, Jeolla: 2). For the experience of living abroad, 19 participants did not have experience while 11 participants did (average stay length = 4 months). The participants were advanced learners of English, with an average score of 820 (out of 990) in the TEPS, equivalent to 930 (out of 990) in the TOEIC, and 109 (out of 120) in the TOEFL (<https://www.teps.or.kr/InfoBoard/ConversionTable#>). Advanced learners of English were recruited intentionally for the purpose of this study. Advanced learners of English were expected to have few difficulties in understanding the meaning of utterances and focusing on the rhythmic aspects of utterances in speech materials.

For the corpus of native English speakers, 35 native English speakers who were undergraduate or graduate students (12 males and 23 females, mean age 24.3) from a Midwestern university in the U.S. participated in the perception experiment. All the participants, except one, were born in the U.S. 25 participants were born in the Midwest (IL: 24, MO: 1) while 7 participants were not (PA: 3, VA: 2, MD: 1, CA: 1). Three participants did not identify their city of birth. For the experience of living abroad, 18 participants did not have experience while 16 participants did (average stay length = 16 months). One participant did not identify the experience of living abroad. Native English speakers were used as the reference group. The results of native English speakers were compared with those of Korean learners of English.

None of the participants reported any hearing-related issues. The participants received either monetary compensation or course credit.

2.1.2 Task

The procedure for the perception experiment was based on Rapid Prosody Transcription (Cole et al. 2010). Participants were asked to mark the prosodic boundaries while listening to the speech materials twice. Prosodic boundaries were defined as the disjuncture between words, which occurs when speakers break up long stretches of speech into smaller pieces to breathe in or think what they have to say next.

During the perception experiment, participants were provided with a transcript of the speech materials on a

computer screen through an online interface called Language Markup and Experiment Design Software (LMEDS; Mahrt 2013) as shown in Figure 1. The transcripts did not include capital letters or punctuation marks. Such visual cues may influence auditory perception of prosodic boundaries by informing participants about the beginning or end of an utterance. Therefore, visual cues were intentionally removed from the speech materials. The participants marked prosodic boundaries if they perceived rhythmic disjunctures between words. In Figure 1, the black vertical lines between words indicate the prosodic boundaries marked by participant. The red words designate the prominent words marked by the identical participant during the experiment, which was not analyzed in the present study.

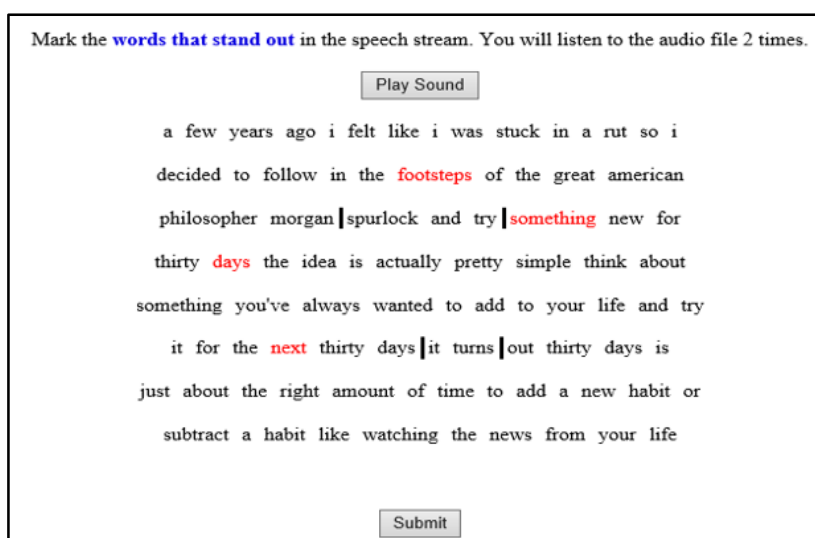


Figure 1. Perception Experiment through Online Interface LMEDS

Speech materials were selected from the TED Talk. The speech was titled “Try something new for thirty days” (https://www.ted.com/talks/matt_cutts_try_something_new_for_30_days) conveyed by a male native speaker of American English in a clear and lively speech style. The TED talk speaker did not show distinct regional, ethnic, or socioeconomic characteristics in his speech. He tended to speak slowly and make frequent prosodic boundaries to convey content of speech in a clear and succinct manner. Also, he tended to raise his pitch at the end of prosodic boundaries and used rhetorical questions to attract audience’s attention. Speech was chosen because it covered an everyday (or non-genre-specific) topic and had a plain vocabulary. The excerpt of speech is shown in Figure 1. The speech materials consisted of 361 words (length: 2’ 25”). They were divided into four pieces and presented chronologically during the perception experiments. The last word at the end of each piece was removed from the analysis due to the visual display of words in the LMEDS. In total, 357 words (361 words - 4 words) were submitted for analysis in the present study.

2.2 Data Analysis

2.2.1 Prosodic annotation

Before addressing our research question on the perception of prosodic boundaries, we examined the production of prosodic boundaries in speech materials. This informed us about how many different types of prosodic strengths

(ip vs. IP) combined with prosodic tones (low tone vs. high tone) were produced by the native English speaker in the speech materials. Such information was considered important because the speaker's speech style could have influenced the listeners' perception of prosodic boundaries in our experiment. For this purpose, we analyzed the annotation of prosodic boundaries by human experts. Two human experts labeled the strength of the prosodic boundaries (i.e., prosodic words, intermediate phrases, or intonational phrases) and the type of boundary tone (i.e., unaccented, high tone, or low tone) based on visual and auditory inspection of the F0 contour using Praat (Boersma and Weenink 2024). The annotation procedure followed the ToBI Convention (Veilleux et al. 2006). In total, five boundary labels (i.e., boundary types) were obtained from the speech materials: (a) prosodic word (unaccented: prosodic word; $n = 270$), (b) H- (high tone: intermediate phrase; $n = 18$), (c) H-H% (high tone: intonational phrase; $n = 11$), (d) L- (low tone: intermediate phrase; $n = 19$), and (e) L-L% (low tone: intonational phrase; $n = 39$). A summary is presented in Section 3.1.1.

2.2.2 Descriptive analysis

The analysis was carried out in the two folds. First, we performed a descriptive analysis following Rapid Prosody Transcription (Cole et al. 2010). The boundary (b-) scores for each word in the speech materials were calculated using the following formula:

$$(5) \text{ b - scores} = \frac{\text{number of participants who marked the prosodic boundaries for a word}}{\text{total number of participants}}$$

The b-scores represent the percentage of participants who perceived a prosodic boundary in the words. The b-scores range from 0 to 1, where 0 indicates that none of the participants marked the prosodic boundary on a word and 1 indicates that all the participants marked the prosodic boundary on a word. Visualization of the b-scores of the words enabled us to visually inspect the words that were most likely to be considered prosodic boundaries by the listeners.

2.2.3 Statistical analysis

We also performed statistical analysis. The statistical results informed us about how the listeners' L1 backgrounds and the TED talk speaker's boundary types in the speech materials influence the judgment of prosodic boundaries by the listeners in our perception experiment. For this, the generalized linear-mixed effects model was submitted to model the perceptual judgment of prosodic boundaries by the listeners (0 for the word without a boundary mark, 1 for the word with a boundary mark) in relation to the listeners' L1 (native English speaker, Korean learner of English), the TED talk speaker's boundary types (prosodic word, H-, H-H%, L-, L-L%), and the interaction between the listeners' L1 and the TED talk speaker's boundary types. Based on this model, a post-hoc pairwise comparison was performed. The model was run using the lme4 package (Bates et al. 2015) and emmeans package (Lenth 2024) in R (R Core Team 2024).

2.3 Hypotheses

In the present study, we are interested in how Korean learners of English, compared to native English speakers, perceive prosodic boundaries in clear and engaging English speech. Based on previous research on the perception

and production of L2 prosodic boundaries (Choe 2016, Im and Ahn 2019), we had three hypotheses. First, we hypothesized that Korean learners of English differ from native English speakers in their perception of prosodic boundaries. In previous research, Korean learners of English were found to perceive (or produce) a greater number of prosodic boundaries than native English speakers. Therefore, Korean learners of English are expected to perceive prosodic boundaries more frequently than native English speakers (P1). We also hypothesized that Korean learners of English would be more sensitive to intonational boundaries. Korean has a large inventory of intonational boundary tones (L%, HL%, LHL%, HLHL%, H%, LH%, HLH%, and LHLH%) associated with various types of semantic and pragmatic information. Korean learners of English, compared to native English speakers, are expected to be more sensitive to intonational boundary tones (H-H%, L-L%), considering that they might transfer their L1 prosody to processing L2 prosody. Moreover, we hypothesized that Korean learners of English pay more attention to high tones. Previous research (Choe 2016, Im and Ahn 2019, Kim et al. 2012, Kim and Cho, 2009) has shown the reliance of the high tone by native Korean speakers in the segmentation of L1 prosodic boundaries, or by Korean learners of English in the perception and production of L2 prosodic boundaries. Thus, Korean learners of English are expected to rely on a high intonational boundary tone to a greater extent than native English speakers in the current study (P3). Our predictions are summarized as follows:

P1: Korean learners of English are more likely to perceive prosodic boundaries than native English speakers.

P2: Korean learners of English pay more attention to intonational boundaries than native English speakers.

P3: Korean learners of English are more sensitive to high boundary tones than native English speakers.

3. Results

In Section 3.1, we present the results of TED speaker's production of prosodic boundaries in the speech materials. In Section 3.2, we move on to the results of the perception of the prosodic boundaries of words in speech materials by Korean learners of English compared with native English speakers.

3.1 Production of Prosodic Boundaries

3.1.1 Prosodic annotation

Table 1 summarizes the prosodic boundaries in speech materials annotated by human experts as a function of boundary strength and tones. The boundary strength (topmost row) includes three labels: prosodic words, intermediate phrases (often corresponding to syntactic phrases), and intonational phrases (often corresponding to syntactic sentences). The boundary tones (leftmost column) contained three labels: unaccented (no tone), high tone, and low tone. In total, we observe five labels in the speech materials: (a) prosodic word without a prosodic boundary tone (unaccented: prosodic word), (b) H- (high tone: intermediate phrase), (c) H-H% (high tone: intonational phrase), (d) L- (low tone: intermediate phrase), and (e) L-L% (low tone: intonational phrase). Empty cells indicate ineligible labels, following the ToBI Convention (Veilleux et al. 2006). According to the ToBI Convention, a prosodic boundary (intermediate phrase, intonational phrase) must convey a boundary tone (high tone, low tone), whereas a prosodic word does not. Cells (a)–(e) contain the percentage (%) of occurrences and the number of occurrences (in parentheses) of the boundary types in the speech materials.

In Table 1, the total in the bottommost row shows the total number of observations based on the boundary strength. Three-fourths of the words in the speech materials (75.63%) were annotated as prosodic words and one-fourth (24.37%) were labeled as either intermediate phrases (10.36%) or intonational phrases (14.01%). In other words, one of the four words in public speech carries a rhythmic juncture (ips or IPs). In addition, the total in the rightmost column displays the total number of observations by boundary tones. Three-quarters of the words in the speech materials (75.63%) did not convey a boundary tone, whereas one-quarter (24.37%) did. The high tone (8.12%) was half of the low tone (16.25%). In other words, one out of the four words in the public speech conveyed a boundary tone. When it appeared, the boundary tone was high one out of three times.

Table 1. Number of Observations by Boundaries Strength and Boundary Tones

| Label | Prosodic Word | Intermediate Phrase | Intonational Phrase | Total |
|------------|--|-----------------------------|--------------------------------|---------------------|
| Unaccented | (a) prosodic word 75.63% (n = 270) | — | — | 75.63% (n = 270) |
| High Tone | — | (b) H- 5.04% (n = 18) | (c) H-H% 3.08% (n = 11) | 8.12% (n = 29) |
| Low Tone | — | (d) L- 5.32% (n = 19) | (e) L-L% 10.92% (n = 39) | 16.25% (n = 58) |
| Total | 75.63% (n = 270) | 10.36% (n = 37) | 14.01% (n = 50) | 100% (n = 357) |

We visualized the pitch contour of the five prosodic boundary types using ggplot2 (Wickham 2016) in R (R Core Team 2024). In Figure 2, the x-axis displays the normalized time points and the y-axis shows F0 (Hz) of the male native English speaker in the speech materials. The red line indicates the mean of F0 contour of each word (in colored lines).

For prosodic word (a), the mean F0 contour is almost flat over the entire normalized time point. For high tones (b, c), the mean pitch contours increase in the middle of the time (around normalized time point 4). The high tones (b, c) differ in that the high intonational boundary tone (c) exhibits a steeper increase than does the high intermediate boundary tone (b). For low tones (d, e), the mean pitch contours fall in the middle of the time period (around time points 4-6). The low tones (d, e) differ in that the low intonational boundary tone (e) has an earlier and steeper fall than the low intermediate boundary tone (d).

Thus, the following can be summarized: First, compared to words without a boundary tone (a), words with a boundary tone (b-e) exhibited a more dramatic pitch change over time. The high boundary tones (b-c) have rising pitch contours, and the low boundary tones (d-e) had falling pitch contours. Second, words with stronger boundary strength (i.e., intonational boundaries) showed greater pitch changes than those with weaker boundary strength (i.e., intermediate boundaries). Regardless of whether they had a low or high tonal target, the intonational boundaries (c, e) showed earlier and more dramatic contrasts in pitch than the intermediate boundaries (b, d). The five boundary types showed greater pitch movement in the following order: prosodic word (a) < intermediate phrase (b, d) < intonational phrase (c, e).

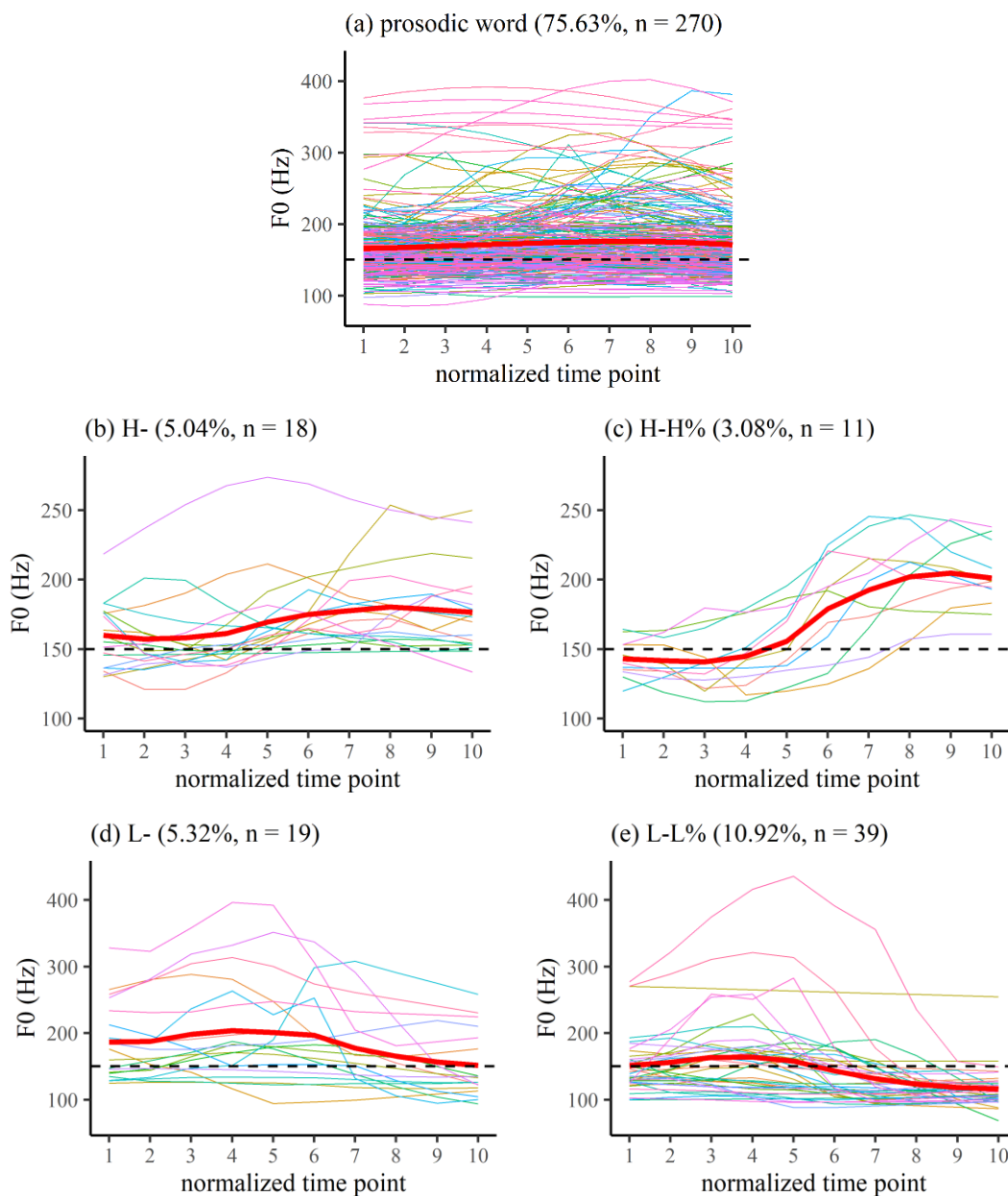


Figure 2. Five Boundary Types in Speech Materials

3.2 Perception of Prosodic Boundaries

3.2.1 Descriptive analysis

First, we present the results of a descriptive analysis of the perception of prosodic boundaries by native English speakers and Korean learners of English. Figure 3 shows the b-scores of one utterance from the speech materials, “every November, tens of thousands of people try to write their own fifty thousand-word novel from scratch in

thirty days.” The x-axis displays the words in the utterance. The y-axis represents the b-scores of the words. The red solid line indicates the native English speaker. The blue dotted line represents Korean learners of English. Our casual observation was that the two groups of listeners showed a similar pattern in that they tended to mark prosodic boundaries for most nouns in the utterance. However, the two groups differed in that the Korean learners of English tended to show higher b-scores for the nouns, “November,” “people,” and “novel.” Korean learners of English had a b-score of almost 1, indicating that almost all Korean learners of English perceived prosodic boundaries for these words. In comparison, the native English speakers had b-score of approximately 0.5, meaning that approximately half of the native English speakers perceived rhythmic junctures for identical words. In summary, we have a couple of remarks. First, the overall perceptual patterns were similar between the two groups. Korean learners of English perceive prosodic boundaries for words identical to those of native English speakers. Second, Korean learners of English, however, were more likely to perceive rhythmic junctures for words in this public speech than native English speakers.

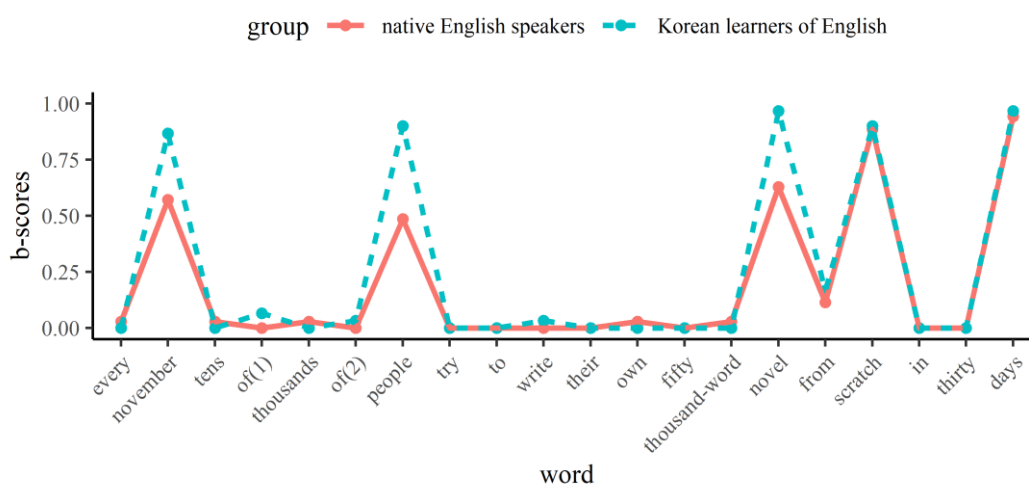


Figure 3. Boundary (b-) Scores of Words by Native English Speakers and Korean Learners of English

3.2.2 Statistical analysis

To examine the statistical differences between native English speakers and Korean learners of English in their perception of prosodic boundaries, a generalized mixed-effects model was submitted in relation to the groups of listeners (native English speakers and Korean learners of English), boundary types of the TED talk speaker in the speech materials [(a) prosodic word, (b) H-, (c) H-H%, (d) L-, (e) L-L%], and the interaction between the groups of listeners and boundary types of the TED talk speaker. A summary of the generalized mixed-effects model is presented in Table 2. The observations in Table 2 are summarized as follows.

- The main effect of the group was not significant, indicating that, in general, Korean learners of English did not differ from native English speakers set as the reference level for the perception of prosodic boundaries.

- The main effects of the boundary type were significant, suggesting that the effects of prosodic boundaries [(b) H-, (c) H-H%, (d) L-, and (e) L-L%] clearly differed from those of the prosodic word [(a) prosodic word] set as the reference level.
- The interaction effects between the groups and boundary types were significant for Korean learners of English when they perceived intonational boundaries [(c) H-H%, (e) L-L%], but not intermediate boundaries [(b) H-, (d) L-]. These results indicate that Korean learners of English differed from native English speakers in their perception of intonational boundaries but not intermediate boundaries.

Table 2. Summary of Estimated Perceived Boundary as a Function of Listeners’ Groups, Boundary Types and Interaction

| Variable | est. | SE | z | p-value |
|--------------------------------------|-------|------|--------|------------|
| (Intercept) | -5.06 | 0.17 | -29.58 | < 0.001*** |
| <i>Group</i> | | | | |
| Korean learners of English | 0.15 | 0.25 | 0.61 | 0.54 |
| <i>Boundary type</i> | | | | |
| (b) H- | 4.46 | 0.15 | 30.35 | < 0.001*** |
| (c) H-H% | 7.16 | 0.20 | 35.35 | < 0.001*** |
| (d) L- | 5.14 | 0.15 | 35.26 | < 0.001*** |
| (e) L-L% | 6.84 | 0.15 | 46.57 | < 0.001*** |
| <i>Group: Boundary type</i> | | | | |
| Korean learners of English: (b) H- | 0.16 | 0.21 | 0.75 | 0.46 |
| Korean learners of English: (c) H-H% | 1.66 | 0.44 | 3.80 | < 0.001*** |
| Korean learners of English: (d) L- | 0.19 | 0.21 | 0.91 | 0.36 |
| Korean learners of English: (e) L-L% | 0.89 | 0.23 | 3.86 | < 0.001*** |

For a closer examination, we performed a post-hoc pairwise comparison. Figure 4 displays the estimated effects on perceived boundary (y-axis) by listener group (x-axis: NES for native English speakers; KLE for Korean learners of English) and boundary type (panel: PW for prosodic words). Results from the post-hoc pairwise comparison confirmed that Korean learners of English significantly differed from native English speakers in perceiving the two intonational boundary tones (for H-H%, $\beta = -1.82$, $z = -4.15$, $p < 0.001$; for L-L%, $\beta = -1.04$, $z = -4.50$, $p < 0.001$). Korean learners of English were more likely to perceive rhythmic disjuncture for high intonational boundary tone (H-H%) and low intonational boundary tone (L-L%). The two groups did not significantly differ in perceiving the prosodic word ($\beta = -0.15$, $z = -0.61$, n.s.) and the intermediate boundary tones (for H-, $\beta = -0.31$, $z = -1.41$, n.s.; for L-, $\beta = -0.35$, $z = -1.59$, n.s.).

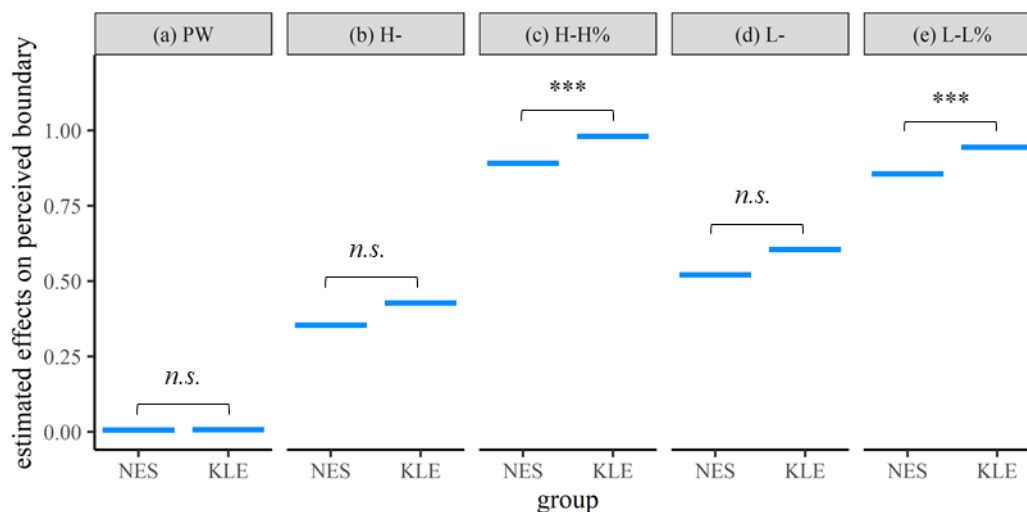


Figure 4. Estimated Effects on Perceived Boundary by Listeners' Group (NES for Native English Speakers; KLE for Korean Learners of English) and Boundary Type (PW for Prosodic Word)

Figure 5 shows the estimated effects on the perceived boundary (y-axis) by boundary type (x-axis; PW for prosodic words) and listener group (panel). For native English speakers (left panel), there was a significant difference in the estimates between all pairs of boundary types, except for the pair H-H% vs. L-L% (for prosodic word vs. H-, $\beta = -4.46$, $z = -30.35$, $p < 0.001$; for prosodic word vs. H-H%, $\beta = -7.16$, $z = -35.35$, $p < 0.001$; for prosodic word vs. L-, $\beta = -5.14$, $z = -35.26$, $p < 0.001$; for prosodic word vs. L-L%, $\beta = -6.85$, $z = -46.57$, $p < 0.001$; for H- vs. H-H%, $\beta = -2.71$, $z = -14.80$, $p < 0.001$; for H- vs. L-, $\beta = -0.68$, $z = -5.68$, $p < 0.001$; for H- vs. L-L%, $\beta = -2.39$, $z = -20.05$, $p < 0.001$; for H-H% vs. L-, $\beta = 2.02$, $z = 11.27$, $p < 0.001$; for H-H% vs. L-L%, $\beta = 0.32$, $z = 1.83$, n.s.; for L- vs. L-L%, $\beta = -1.70$, $z = -14.94$, $p < 0.001$). In comparison, Korean learners of English (right panel) showed a substantial difference in the likelihood between all the pairs of boundary types (for prosodic word vs. H-, $\beta = -4.62$, $z = -30.28$, $p < 0.001$; for prosodic word vs. H-H%, $\beta = -8.83$, $z = -22.75$, $p < 0.001$; for prosodic word vs. L-, $\beta = -5.33$, $z = -34.74$, $p < 0.001$; for prosodic word vs. L-L%, $\beta = -7.73$, $z = -43.38$, $p < 0.001$; for H- vs. H-H%, $\beta = -4.21$, $z = -11.18$, $p < 0.001$; for H- vs. L-, $\beta = -0.72$, $z = -5.61$, $p < 0.001$; for H- vs. L-L%, $\beta = -3.12$, $z = -20.24$, $p < 0.001$; for H-H% vs. L-, $\beta = 3.49$, $z = 9.30$, $p < 0.001$; for H-H% vs. L-L%, $\beta = 1.10$, $z = 2.87$, $p < 0.05$; for L- vs. L-L%, $\beta = -2.40$, $z = -15.83$, $p < 0.001$).

In summary, the two groups of listeners differed in their estimates of the pair H-H% and L-L%, as shown in Figure 5. In the left panel, native English speakers had a non-significant perceptual difference between H-H% and L-L% ($\beta = 0.32$, $z = 1.83$, n.s.). However, Korean learners of English in the right panel showed significantly higher likelihood of perceived boundary for H-H% than for L-L% ($\beta = 1.10$, $z = 2.87$, $p < 0.05$).

In other words, the two groups of listeners showed similar but not identical perceptions of prosodic boundaries. Korean learners of English paid attention to tonal differences in intonational boundaries (low tone vs. high tone), while native English speakers did not. Native English speakers showed the likelihood of perceived prominence in the following increasing order: (a) prosodic word < (b) H- < (d) L- < (e) L-L% = (c) H-H%. Korean learners of English had a more gradient likelihood of perceived prominence than native English speakers in the following increasing order: (a) prosodic word < (b) H- < (d) L- < (e) L-L% < (c) H-H%.

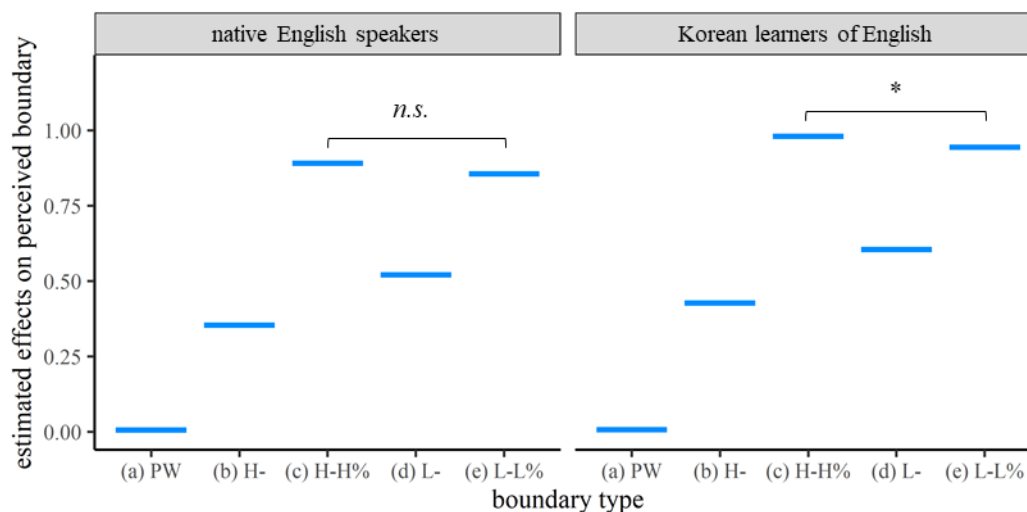


Figure 5. Estimated Effects on Perceived Boundary by Boundary Type (PW for Prosodic Word) and Listeners' Group

4. Discussion

In Section 4.1, we discuss the results of the production of boundary types by TED talk speaker in speech materials. In Section 4.2, we discuss the results of the perception of prosodic boundaries by Korean learners of English compared to native English speakers. We also provide pedagogical suggestions for the acquisition of L2 prosodic boundaries.

4.1 Production of Prosodic Boundaries in Public Speech

We examined the prosodic boundaries produced by the TED talk speaker in the speech materials. The speech style of the speaker in the speech materials might have influenced listeners' perception of prosodic boundaries in the perception experiment. Our casual observation was that the speaker of this public speech tended to speak clearly and slowly in order to convey information to an audience that does not share background knowledge. In addition, the speaker tended to speak lively and enthusiastically in order to engage with the audience. For a closer examination, we investigated the annotation of prosodic boundaries by linguistic experts following the ToBI Convention (Veilleux et al. 2006). Five types of prosodic boundaries were observed in the speech materials: (a) prosodic word, (b) high intermediate boundary tone (H-), (c) high intonational boundary tone (H-H%), (d) low intermediate boundary tone (L-), and (e) low intonational boundary tone (L-L%). We have a couple of notes to make. First, in this public speech, the speaker tended to create prosodic boundaries frequently. Results showed that one-fourth of all the words in the speech material (24.37%) had either an intermediate phrase (10.36%) or an intonational phrase (14.01%). In other words, one of the four words conveyed a rhythmic juncture (ips or IPs) in this public speech. In comparison, Choe (2016) showed that approximately one out of 13 words (in one sentence) delivered a prosodic juncture in stories or news articles for children. The comparison between Choe (2016) and the present study may indicate that the TED talk speaker in the current study tended to make frequent pauses, perhaps to convey messages more clearly and slowly to the audience without shared background knowledge.

Second, the speaker in this public speech tended to produce high tones frequently. The results showed that one-fourth of all words in the speech materials (24.37%) had either a high or low tone, indicating that one out of four words conveyed a boundary tone. In addition, the results showed that the high tones (8.12%) were half of the low tones (16.25%), suggesting that one out of the three boundary tones was a high tone. In comparison, Choe (2016) found that native English speakers were more likely to exploit low tones than high tones for sentence-final position (approximately 90% of the low tones and 10% of the high tones) and sentence-internal positions (approximately 60% of the low tones and 40% of the high tones). In comparison with Choe (2016), the native English speaker in the present study seemed to use high tones frequently. Considering that the public speech in the current study is a monologue, one may wonder why the speaker frequently used high tones. In this public speech, the speaker seemed to exploit the high tone for continuation rise or rhetorical questions. The continuation rise is used to inform the listeners that the speaker's message (or turn) is incomplete. The speaker in the present study seemed to exploit this continuation rise to attract the audience's attention to upcoming messages. Also, the speaker in the current study seems to use rhetorical questions to engage audience and invite them to think about the questions. Overall, the speaker in the present study showed two aspects of public speech: (i) frequent prosodic boundaries and (ii) frequent high boundary tones. These two aspects made the entire speech clear and engaging.

4.2 Perception of Prosodic Boundaries in Public Speech

Next, we examined the perceptions of prosodic boundaries of native English speakers and Korean learners of English. The main effect of our model was that Korean learners of English had broadly similar perceptions as native English speakers. However, the interaction effects of our model showed that the two groups of listeners differed in that Korean learners of English were more likely to mark rhythmic junctures for intonational boundaries than native English speakers, especially those with a high boundary tone.

In the production of the TED talk speaker, we observed that intonational boundary tones had more extreme pitch changes than intermediate boundary tones, which is consistent with Wang and Hirschberg (1992). In Figure 2, for high tones, the intonational boundary tone showed a much steeper increase than the intermediate boundary tone. For low tones, the intonational boundary tone had earlier and steeper falls than the intermediate boundary tone. In the perception of the TED talk, we found that Korean learners of English made a perceptual distinction between high and low intonational boundary tones, while native English speakers did not. For native English speakers, the likelihood of perceived prominence significantly increased between high and low intermediate boundary tones, but not between high and low intonational boundary tones. In comparison, Korean learners of English showed a more gradient increase in the likelihood of perceived prominence than native English speakers. For Korean learners of English, the likelihood of perceived prominence significantly increased between high and low intermediate boundary tones and between low and high intonational boundary tones. The likelihoods of perceived prosodic boundaries for native English speakers and Korean learners of English are recapitulated in (6) and (7). Overall, these results support our predictions P1-P3: Korean learners of English, compared to native English speakers, have a greater likelihood of perceiving prosodic boundaries (P1), greater attention to intonational boundaries (P2), and greater sensitivity to high tones (P3).

(6) Native English speakers: prosodic word < H- < L- < H-H%, L-L%

(7) Korean learners of English: prosodic word < H- < L- < L-L% < H-H%

One may argue that Korean learners of English could have made more frequent judgment of prosodic boundaries than native English speakers, leading to a difference in the perception of intonational boundaries between native English speakers and Korean learners of English. However, this seems not likely to be the case because Korean learners of English do not make identical judgment for all types of prosodic boundaries. Korean learners of English differed from native English speakers in their judgment of intonational boundaries but not in their judgment of intermediate boundaries.

One possible explanation is that Korean learners of English are more likely to rely on a bottom-up process than native English speakers. In the production of the TED talk, the speaker frequently exploited prosodic boundaries and high tones to convey paralinguistic information (e.g., speech style and emotion), rather than delivering linguistic information (e.g., completing utterances and seeking information). In the perception of the TED talk, native English speakers could have known that the frequent use of prosodic boundaries and high tones is associated with a paralinguistic (or stylistic) purpose rather than a linguistic purpose. More specifically, native English speakers could have considered the high intonational boundary tone similarly with the low intonational boundary tone as an indication of the end of utterance, considering that a question in public speech is a rhetorical question, not a “real” question seeking information from listeners. Therefore, it is possible that native English speakers may not have paid attention to the details of prosodic boundaries in this public speech, knowing that prosodic boundaries and high tones have little linguistic information. However, Korean learners of English may have paid attention to the details of the prosodic boundaries in this public speech. Language learners are more likely to rely on the bottom-up process rather than the top-down process than native English speakers because of their lack of background knowledge (or prior experiences) of L2 (Clarke 1980, Cummins 1979, Cziko 1980). It is possible that Korean learners of English paid attention to the details of prosodic boundaries in their speech without considering the particular speech style of the speaker.

Another possible explanation is that the Korean learners of English transferred L1 prosody to L2 prosody in perception. Regarding the perception of L1, Kim and Cho (2009) showed that native Korean speakers relied on a high boundary tone for segmentation, whereas native Dutch speakers did not. Regarding the perception and production of L2, previous studies (Choe 2016, Im and Ahn 2019) showed that Korean learners of English preferred a rising intonational boundary tone, while native English speakers did not. Overall, these results indicate that high boundary tones play an important role in the segmentation of L1 and/or L2 by native Korean speakers. We believe that the Korean learners of English in the present study showed high sensitivity to the tonal distinction of intonational boundaries in L2 English because they have been considering high tone as an important cue for speech segmentation from their prior experiences in L1 Korean and could have transferred their L1 experiences (or knowledge) to process L2 information. This can be considered supporting evidence of (positive) L1 transfer.

Our results show that Korean learners of English are super-annotators (Cole et al. 2017). They made a distinction between the low intonational boundary tone vs. the high intonational boundary tone, as the ToBI experts did in the current study. This is surprising given that even native English speakers differed from ToBI experts in judging intonational boundaries. Korean learners of English accurately perceived tonal distinctions of intonational boundaries, even though they were neither native English speakers nor linguistic experts. Does this imply that Korean learners of English have acquired English prosodic boundaries? In the present study, Korean learners of English did not seem to have difficulties perceiving prosodic boundaries, but they might have been slightly oversensitive compared to native English speakers. In this public speech, the speaker showed frequent use of continuation rise and rhetorical question for the audience’s attention and did not seem to rely on boundary tones to convey much semantic or pragmatic information, as discussed above. Considering this, it is perhaps cost-effective to “neglect” some details of tonal information associated with prosodic boundaries in perception of public

speech. Native English speakers must have had extensive prior experience with various speech styles, including a clear and engaging speech style, and exploited their top-down knowledge to filter out (or neglect) linguistically unimportant prosodic information in this public speech. However, this was not the case for Korean learners of English. Korean learners of English paid attention to the details of the acoustic signals at the end of each prosodic boundary.

What seems necessary for Korean learners of English based on the present study is the balance between the top-down process and the bottom-up process. Korean learners of English are in need of more exposure to various speech styles when learning English prosody. Various speech styles differ in their content, relationship between interlocuters, register, emotion, context, etc. In this public speech, the speaker must have had (at least) a couple of goals to achieve: (a) content delivery and (b) audience engagement. For this, as we have seen earlier in the present study, the speaker exploited prosody to convey not only linguistic (semantic and pragmatic) information, but also paralinguistic (attentional and emotional) information. The use of prosody must differ between public speech and conversational speech even by the same speaker. In the present study, Korean learners of English paid attention to the very details of prosodic boundaries to a higher degree than native English speakers, suggesting that they might not have considered the characteristics of speech style. This is interesting because they must have had experiences of varying speech styles in their L1 Korean and could have transferred their L1 experiences to process L2 speech, if possible. This raises a question why Korean learners of English were not able to activate their prior knowledge. It is possible that Korean learners of English must have known the difference between speech styles but they were not able to take it into account due to limited attentional resources in L2 processing. Therefore, Korean learners of English need to have explicit or implicit instruction of various speech styles so that they can make the positive transfer of L1 experience to process L2, and more importantly, make an effective use of attentional resources in the cognitive processes involved in L2.

The present study has a limitation of examining only one public speech. The ToBI annotation requires tremendous time and efforts from two linguistic experts to achieve consensus. For this reason, it was not conceivable to include and analyze more authentic, non-controlled speeches in the present study. In future research, we attempt to expand our knowledge of L2 prosody by comparing perception vs. production, and public vs. conversational speech with more authentic, non-controlled speeches.

5. Conclusion

This study investigated how Korean learners of English perceive prosodic boundaries in public speech compared with native English speakers. For this purpose, we first examined the production of prosodic boundaries by a native English speaker using speech materials. Five types of prosodic boundaries were found in this TED talk: (a) prosodic words, (b) high intermediate boundary tones, (c) high intonational boundary tones, (d) low intermediate boundary tones, and (e) low intonational boundary tones. The TED talk speaker was likely to use earlier and more dynamic pitch changes for the intonational boundary tones (c, e) than for the intermediate boundary tones (b, d), which turned out to have more dynamic pitch movement than for the prosodic word (a). In addition, the speaker in this public speech tended to show frequent use of prosodic boundaries and boundary tones (especially high boundary tones) seemingly to attract the audience's attention. Next, we examined the perceptions of prosodic boundaries of native English speakers and Korean learners of English. The results showed that both groups of listeners had broadly similar judgment regarding prosodic boundaries. However, compared to native English speakers, Korean learners of English showed a significantly higher likelihood of perceiving prosodic boundaries

as intonational boundaries, especially those with a high tone. Specifically, native English speakers made tonal distinctions for intermediate boundaries but not for intonational boundaries. However, Korean learners of English made tonal distinctions for both intermediate boundaries and intonational boundaries. In other words, Korean learners of English made a more gradient perceptual judgement of prosodic boundaries than did native English speakers. These results suggest that Korean learners of English may (a) rely on the bottom-up process involved in language, and (b) transfer L1 Korean prosody to L2 English prosody. More extensive exposure to various speech styles in English is recommended for Korean learners of English in the acquisition of English prosody.

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Examples in: English

Applicable Languages: English

Applicable Level: Tertiary