Distinguishing Phrase-Final and Phrase-Medial High Tone on Finally Stressed Words in Turkish

Canan Ipek[1], Sun-Ah Jun[2]

[1]Department of Linguistics, University of Southern California, Los Angeles
[2]Department of Linguistics, University of California Los Angeles, Los Angeles
ipek@usc.edu, jun@humnet.ucla.edu

Abstract

The goal of this paper is to investigate the nature of the high tones realized on finally stressed words in Turkish. Following Ipek & Jun's [1] AM model of intonational phonology of Turkish, it was hypothesized that the high tone realized on the last syllable of a phrase (i.e., Intermediate Phrase (ip)) is realized differently from that of a phrase-medial prosodic word (PW), reflecting the prosodic hierarchy. Acoustic data show that an ip-final High tone shows larger f0 rise than a PW-final High tone, and the ip-final syllable is longer than the PW-final syllable. Furthermore, the degree of coarticulation is weaker across an ip boundary than a PW boundary. These findings support the prosodic structure and tonal categories proposed in Ipek & Jun's [1] model of Turkish intonation.

Index Terms: Turkish intonation, pitch accent, Intermediate Phrase, boundary tone

1. Introduction

The intonational contour of a Turkish declarative sentence produced in a neutral context typically consists of a sequence of rising tones [L H], followed by a nuclear accented word in a narrower pitch range, and a low boundary tone at the end of the sentence. The domain of a rising tone is a Prosodic Word (PW) with the L tone on the first syllable of a word and the H tone on its stressed syllable, often the last syllable of the word. The primary goal of this paper is to investigate the nature of high tones on finally-stressed words in Turkish that are either (a) phrase medial, or (b) phrase final. Based on the findings, we aim to support Ipek & Jun's [1] model of the intonational phonology of Turkish being developed in the Autosegmental-metrical (AM) framework [2, 3, 4, 5].

Word-final high tones have been analyzed differently in two previous phonological models of Turkish intonation within the AM framework.. In [6], a high tone on a word-final stressed syllable was analyzed as a pitch accent regardless of whether the word is in the middle or at the end of a Phonological Phrase. On the other hand, [7], following [8],assumes that words with final stress under the traditional analysis [9, 10, 11] are lexically unstressed, and instead the High tone is analyzed as a boundary tone (H-) of a Major Phrase (or Phonological Phrase or Accentual Phrase). Since the Major Phrase included only one prosodic word in [7], it is not clear whether H- is a boundary tone of a prosodic word or of a Major Phrase. It is also not clear how a phrase-medial, word-final High tone would be analyzed in this model.

In Ipek and Jun's [3] intonation model, a High tone on a stressed syllable is analyzed as a H* pitch accent regardless of the location of stress, but when the finally-stressed word is the last word in an Intermdiate Phrase (ip), the prosodic unit above the Prosodic Word, the High tone on the ip-final stressed syllable is assumed to have a dual function. First, it marks prominence on the word (the function of a pitch accent); second, it marks the right edge of an ip (the function of a boundary tone). This tone is therefore given the label H*-.

In the present study, we will examine acoustic data from word-final syllables in the two prosodic conditions, PW-final vs. ip-final. The aim is to examine (a) whether the word-final High tones are realized differently depending on their prosodic condition and (b) whether the degrees of final lengthening and of coarticulation with a following word reflect the word-final syllable's location in the prosodic hierarchy proposed in [1]. Previous studies have shown that, compared with syllables at the edge of lower constituents, syllables at the edge of higher constituents will show higher f0 peaks [2, 12, 13], greater degrees of final lengthening [14, 15, 16, 17], and lesser degrees of trans-boundary segmental coarticulation [18]. We will therefore test the following two hypotheses: (i) There will be a higher f0 peak and more phrase-final lengthening for a word bearing a final H*- than one bearing the H*; (ii) Vowels will undergo less coarticulation across a boundary following the H*- than across a boundary following H*.

2. Experiment

2.1. Method

2.1.1. Stimuli

Five pairs (i.e., ten total) of five-word sentences were designed to examine the acoustic properties of word-final H* and H*-, and the prosodic juncture following them (see Table 1). Every sentence started with a subject noun phrase (NP), and the number of words within the subject NP differed between the two sentences in each pair. One sentence of each pair contained a three-word subject NP (Group 1), and the other contained a two-word subject NP (Group 2), but the target word was always the second word (i.e., word2).

According to [6], word2 in each Group receives a pitch accent (L+H*), but according to [7], word2 in Group 2 receives a H- boundary tone marking a Major Phrase. (The H tone of word2 in Group 1 is not analyzed in [7]). In Ipek and Jun's [1] model, the high tone realized on the final syllable of word2 in Gorup1 is in the middle of an ip (therefore, it would be marked with H*), but the final syllable of the same word in Group2 is the last syllable of an ip (corresponding to a right edge of NP), and so would be marked with H*-.

In addition, in order to measure the degree of vowel coarticulation across the boundary between the second and the

third word in each sentence, the last vowel of the second word was fixed as [a] and the first vowel of the third word was fixed as [i], maximizing the difference in the first (F1) and second formant (F2) values between the vowels.

Table 1. *A list of ten target sentences in the two groups. The second word (in bold) in Group1 is ip-medial, marked with H*, but the same second word in Gorup2 is ip-final, marked with H*-. Below each sentence, an English gloss is given word-by-word, followed by the meaning of the sentence.*

Group 1: Intermediate Phrase-medial High tone (H*) {word1 **word2**^{H*} word3}ip word4 word5
1-1. Ülkedeki **yasak** içkiler dışardan geliyor. in the country banned drinks from outside coming "Drinks banned in the country are coming from outside the country."
1-2. Yoldaki **tuzak** işaretler önümüzü kapatıyor. on the road trap signs our front blocking "Trap signs on the road are blocking our sight."
1-3. İnşaattaki **tutsak** işçiler çevreyi temizliyor. in the construction captive workers the neighborhood cleaning "Captive workers in the construction are cleaning the neighborhood."
1-4. Dergideki **korkak** içerikler tamamen kaldırılmış. in the magazine coward contents completely removed "Coward contents in the magazine were completely removed."
1-5. Camdaki **çatlak** izler önümüzü kapatıyor. on the mirror cracked traces our front blocking "Cracked traces in the mirror are blocking our sight."
Group 2: Intermediate Phrase-final High tone (H*-) {word1 **word2**$^{H*-}$}ip word3 word4 word5
2-1. Ülkedeki **yasak** içkiyi çekici kılıyor. in the country ban the alcohol attractive make "The ban in the country makes alcohol attractive."
2-2. Yoldaki **tuzak** işareti tamamıyla kapatıyor. on the road trap the sign completely blocking "The trap on the road is blocking the sign completely."
2-3. İnşaattaki **tutsak** işleri tamamen aksatıyor. in the construction captive the works completely hindering "The captive in the construction is hindering the works completely."
2-4. Dergideki **korkak** içeriği tamamen değiştirmiş. in the magazine the coward the content completely changed. "The coward in the magazine changed the content completely."
2-5. Camdaki **çatlak** izleri tamamen kapatıyor. on the mirror crack the traces completely blocking "The crack in the mirror is blocking the traces completely."

2.1.2. Participants

Data is collected from five native speakers of Turkish (2 males, 3 females) from Istanbul, Turkey, who have been living in America (Los Angeles) for less than five years. Mean age of participants was 33.8 years. None of the participants reported any speech or hearing disorders.

2.1.3. Recording Procedure

The recordings were done in a quiet room, with participants seated in front of a computer screen. A unidirectional USB microphone was placed to the left of the computer, approximately six inches from the speaker's lips. Speakers repeated twenty-five sentences (randomized between ten target and fifteen filler sentences) five times.

2.1.4. Measurements

- Peak f0, Minimum f0, and Magnitude of f0 rise: The f0-peak was measured ten ms before the end of the vowel in the final syllable of the target word (to avoid any effect of microprosody) and the minimum f0 value was measured on the preceding syllable. Each f0 value was converted into semitones and the magnitude of f0 rise was calculated by the difference between the f0 peak and the minimum f0 values.
- Rhyme Duration: Measured the duration between the beginning of the final vowel in the second word and the beginning of the first vowel in the third word. The beginning of the vowel was defined as the point where the second formant energy begins.
- Degree of V-to-V Coarticulation: Measured by the Euclidean distance in the F1 by F2 space between the final vowel of second word (V1) and the first vowel of the third word (V2), i.e., in $V_1C\#V_2$ context, where # represents a prosodic word boundary in Group 1 and an Intermediate Phrase boundary in Group 2.

2.1.5. Statistical Analysis

Statistical analyses were done in R using Linear Mixed-Effects Regression (LMER) package 'lme4' written by [19], with PROSODIC BOUNDARY (prosodic word/intermediate phrase) as the fixed effect, and SUBJECT and SENTENCE as random effects. The simplest and best fitting model for each LMER analysis was derived via model comparison.

In order to obtain *p*-values for the fixed effects, we used *pvals.func* in the 'languageR' package, which computes the relevant *p*-values using Markov chain Monte Carlo sampling (default number of samples=10,000). When the best fitting model involved random slopes, significance for fixed-effect factors was computed using likelihood-ratio test.

2. 2. Results

2.2.1. Peak f0, Minimum f0, and Magnitude of f0-rise

As predicted, the peak f0 values were higher at the Intermediate Phrase boundary (H*-) than at the Prosodic Word boundary (H*), although the difference was not significant (Intercept=13.25, β=0.73, t=1.84, p=0.07). The minimum f0 value was significantly lower before the H*- syllable than before the H* syllable (Intercept= 12.4, β= -0.71, t= -2.95,

p<0.05). Finally, the magnitude of f0 rise at an Intermediate Phrase boundary was significantly larger than that of a Prosodic Word boundary (β=1.435, t=5.925, p<0.05). Figure 1 shows the mean f0 rise in semitone at the end of the second word, i.e., the last syllable of a Prosodic Word (H*) and an Intermediate Phrase (H*-).

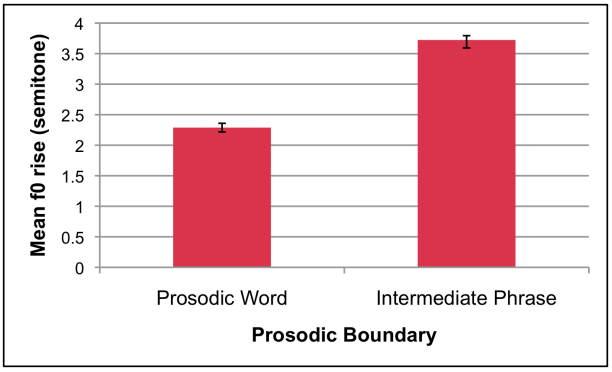

Figure 1: *Magnitude of mean f0 rise at Prosodic Word and Intermediate Phrase boundaries.*

Example pitch tracks of the sentences 1-2 and 2-2 in Table 1 are shown in Figure 2 and 3, respectively. In Figure 2, the second word (*tuzak*) is phrase-medial, thus the f0 peak at the end of the second word receives a pitch accent H*, while the f0 peak of the same word receives H*- in Figure 3 because it marks the end of an Intermediate Phrase.

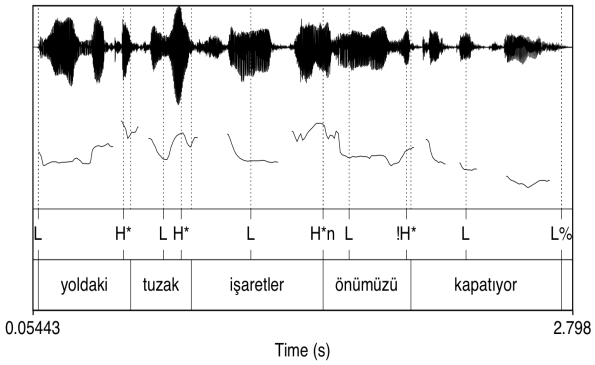

Figure 2: *Sample pitch track of the sentence 1-2 in Table 1, illustrating H* at the end of 2nd word (tuzak), i.e., Prosodic Word boundary.*

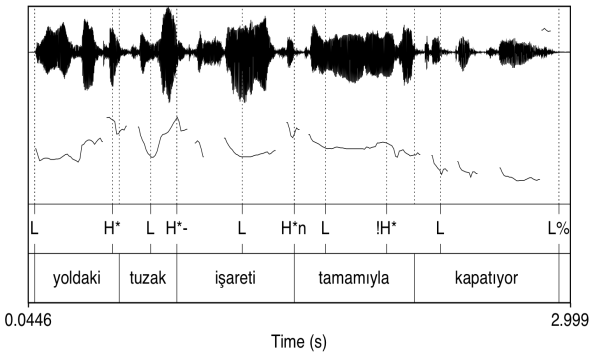

Figure 3: *Sample pitch track of the sentence 2-2 in Table 1, illustrating H*- at the end of 2nd word (tuzak), i.e., Intermediate Phrase boundary.*

2.2.2 Rhyme Duration

Figure 4 shows the mean rhyme duration of the last syllable of the second word at the Prosodic Word and Intermediate Phrase boundaries. As hypothesized, the last syllable of an Intermediate Phrase is longer than that of a Prosodic Word (β=0.067, t=8.38, p < 0.05).

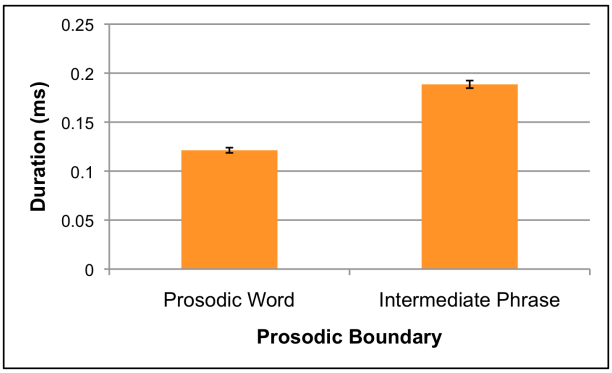

Figure 4: *Rhyme duration of the last syllable at Prosodic Word and Intermediate Phrase boundaries.*

2.3. Degree of Coarticulation

Figure 5 displays the mean Euclidean distance in the F1 by F2 space between each vowel in $V_1C\#V_2$ context. As hypothesized, there is less coarticulation (i.e., larger Euclidean distance) across the Intermediate Phrase boundary than across the Prosodic Word boundary (β=231.1, t=2.145, p<0.05).

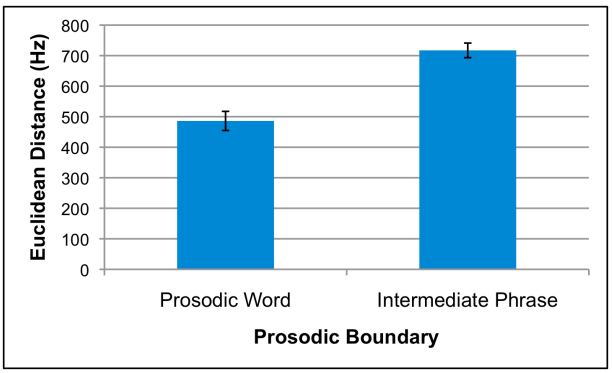

Figure 5: *Euclidean distance across Prosodic Word and Intermediate Phrase boundaries.*

3. Discussion and Conclusion

In this paper, we have shown that the phonetic realization of the high tone on finally-stressed words in Turkish differs depending on its prosodic location. The magnitude of f0 rise is larger at the end of a phrase (Intermediate Phrase/Phonological Phrase/Major Phrase) than in the middle of a phrase. The syllable carrying the high tone is longer when it is the last syllable of an Intermediate Phrase than of a Prosodic Word. Finally, the degree of V-to-V coarticulation is weaker when the two vowels are separated by an Intermediate Phrase boundary than by a Prosodic Word boundary.

The quantitative data found in the experiment therefore support the prosodic structure and tonal categories proposed in Ipek & Jun's model of Turkish intonation. In Ipek & Jun's model, the High tone on the stressed syllable of a prosodic word is labeled as H*, a pitch accent; the High tone realized on the stressed syllable at the end of an ip, however, is labeled as H*-, indicating its function, as both a pitch accent and a boundary tone.

In the experiment reported in the current paper, we only examined finally-stressed words, so an ip-final syllable is always stressed, justifying the H*- symbol. However, as shown in Ipek & Jun [1], the ip-final syllable (or Phonological Phrase/Major Phrase-final syllable in [6, 7]) was still marked by a high tone when the syllable was not stressed. For example, consider Figure 6, where the first two words are non-finally stressed and form a subject NP. Here, each word in the subject NP has a High tone on its stressed syllable (H*) and the second word has an additional High tone on its final syllable, which is also the last syllable of an Intermediate Phrase. Since there is a low f0 target between the two f0 peaks (one over the stressed syllable of the word and the other at the end of the word), and the L tone is closer to the following H tone than the preceding H tone (H*), Ipek & Jun labeled the ip-final f0 rise over an unstressed syllable as LH-. (Note also the shallow falling slope from H* in the first word, interpolating to the initial L boundary tone of the second word in Figure 6). Thus, it is clear that the end of an ip is marked by a high boundary tone regardless of whether the ip-final syllable is stressed or not. However, since the function of the ip-final High tone can differ, the High tone on the ip-final stressed syllable is labeled as H*-, indicating both the prominence marking and the boundary marking functions; the High rising tone on the ip-final unstressed syllable, however, is labeled as LH-, indicating its sole, boundary-marking function.. Further research is needed to investigate whether these tonal categories are perceptually distinct.

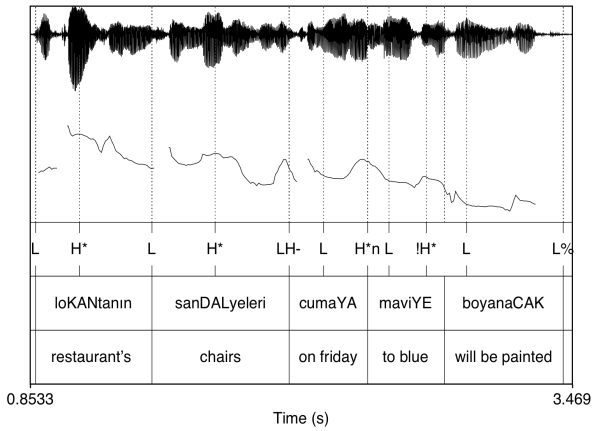

Figure 6: *Sample pitch track of the sentence "Restaurant's chairs will be painted in blue on Friday." The second word (sandalyeleri) is ip-final and is stressed on its second syllable. The second f0 rise on this word, labeled LH-, marks the right edge of ip.*

4. References

[1] Ipek, C. and Jun, S.-A., "Towards a Model of Intonational Phonology of Turkish: Neutral Intonation", in the Proceedings of Meeting on Acoustics(POMA), 9:060230-069238, 2013.

[2] Beckman, M., and Pierrehumbert, J., "Intonational structure in Japanese and English", Phonology Yearbook 3: 255–309, 1986.

[3] Ladd, D. R., "Intonational Phonology", Cambridge University Press, 1996.

[4] Ladd, D. R., "Intonational Phonology", 2nd edition, Cambridge: Cambridge University Press, 2008.

[5] Pierrehumbert, J., "The Phonology and Phonetics of English Intonation", Unpublished Ph.D. dissertation. MIT, 1980.

[6] Kan, S., "Prosodic Domains and the syntax-prosody mapping in Turkish", MA diss. Boğaziçi University, 2009.

[7] Kamalı, B., "Topics at the PF interface of Turkish", Doctoral thesis, Harvard University, 2011.

[8] Levi, S., "Acoustic correlates of lexical accent in Turkish", Journal of the International Phonetic Association 35, 73–97, 2005.

[9] Lees, R., "The phonology of Modern Standard Turkish", Bloomington, IN: Indiana University, 1961.

[10] Lewis, G., "Turkish grammar", Oxford: Oxford University Press, 1967.

[11] Sezer, E., "On non-final stress in Turkish", Journal of Turkish Studies, 5, 61-69, 1981.

[12] Jun, S.-A., "Prosodic Markings of Complex NP Focus, Syntax, and the Pre-/Post-Focus String", in the Proceedings of the 28th WCCFL, pp. 214-230, 2011.

[13] Khan, S. D., "Intonational Phonology and Focus Prosody of Bengali", Unpublished Ph.D. dissertation, University of California, Los Angeles, 2008.

[14] Jun, S.-A and Fougeron, C., "A Phonological Model of French Intonation" in A. Botinis [Ed], Intonation: Analysis, Modeling and Technology, 209-242, Kluwer Academic Publishers, 2000.

[15] Tabain, M., “Effects of prosodic boundary on /aC/ sequences: articulatory results”, Journal of the Acoustical Society of America, 113:516-531, 2003a.
[16] Tabain, M. and Perrier, P., “Articulation and acoustics of /i/ in pre-boundary position in French”, Journal of Phonetics, 33:77-100, 2005.
[17] Wightman, C. W., Shattuck-Hufnagel, S., Ostendorf, M., and Price, P. J., “Segmental durations in the vicinity of prosodic phrase boundaries”, Journal of the Acoustical Society of America, 91:1707-1717, 1992.
[18] Cho, T., “Prosodic strengthening and featural enhancement: evidence from acoustic and articulatory realization of /a,i/ in English”, Journal of the Acoustical Society of America, 117:3867-3878, 2005.
[19] Baayen, R.H., Davidson, D. J., and Bates, D. M., “Mixed-effects modelling with crossed random effects for subjects and items”, Journal of Memory and Language, 59:390-412, 2008.