APRIL 09 2013

Preboundary lengthening and preaccentual shortening across syllables in a trisyllabic word in English

Taehong Cho; Jiseung Kim; Sahyang Kim

J. Acoust. Soc. Am. 133, EL384–EL390 (2013)
https://doi.org/10.1121/1.4800179

Preboundary lengthening and preaccentual shortening across syllables in a trisyllabic word in English

Taehong Cho[a] **and Jiseung Kim**
Hanyang Phonetics and Psycholinguistics Lab, Department of English Language and Literature, Hanyang University, Seoul, South Korea
tcho@hanyang.ac.kr, jiseungkim@gmail.com

Sahyang Kim
Department of English Education, Hongik University, Seoul, South Korea
sahyang@hongik.ac.kr

Abstract: This study demonstrates some new aspects of preboundary lengthening and preaccentual shortening on a test word *banana* in American English. Preboundary lengthening was found to be extended to the initial unstressed syllable beyond the main-stressed syllable, presenting more complexity than has previously been assumed. Preaccentual shortening was observed regardless of boundary strength or the stress pattern (trochaic vs iambic) of the following context word, suggesting that it operates globally at an utterance level. The locus of preaccentual shortening, however, was modulated by prosodic boundary: It is realized on the final vowel IP-finally but on the non-final stressed vowel IP-medially.

PACS numbers: 43.70.Fq [AL]
Date Received: January 28, 2013 **Date Accepted:** March 22, 2013

1. Introduction

Recent years have witnessed a growing body of research on the nature of prosodically conditioned variation in segmental duration along with increasing awareness that it is closely linked to the constituent structure of an utterance in a linguistically significant way. The more we study it, however, the more questions we seem to be left with (see Fletcher, 2010; Cho, 2011 for a recent review). The purpose of the present study is to build on previous findings by exploring how temporal organization of segments in one particular trisyllabic word *banana* in American English is conditioned by two prosodic contextual factors: Prosodic boundary and prominence (accent/stress) of the (following) postboundary word.

The temporal effect of prosodic boundary on a phrase-final word has been extensively documented in the literature as a phenomenon called "phrase-final lengthening" or "preboundary lengthening"—i.e., segments in a phrase-final word (e.g., before an intonational phrase boundary) are longer than the same segments of the word that occurs in a phrase-medial position. One of the important issues regarding this process concerns its domain—i.e., how the preboundary lengthening is distributed across syllables in a phrase-final word (e.g., Kohler, 1983; Silverman, 1990; Cambier-Langeveld, 2000; White, 2002; Byrd *et al.*, 2006; Turk and Shattuck-Hufnagel, 2007). In a small acoustic study in German, Silverman (1990) noted that phrase-final lengthening can be distributed over the entire phrase-final word, even to the left beyond the non-initial stressed syllable. A recent acoustic study on phrase-final lengthening in

[a]Author to whom correspondence should be addressed.

American English by Turk and Shattuck-Hufnagel (2007), however, revealed that while preboundary lengthening was extended to the initial stressed syllable in a trisyllabic word, the region between the stressed syllable and the final syllable was skipped or lengthened less, which led them to propose a model of multiple targets of preboundary lengthening—i.e., the final syllable rime and the (non-final) main-stressed syllable rime. While it is not clear how the multiple target effect can be incorporated into current models of speech production (e.g., Byrd and Saltzman, 2003), what has emerged from previous studies is that the leftward extension of preboundary lengthening is bounded by the main-stressed syllable in American English. [Note that in an articulatory study in American English, Byrd and Riggs (2008) reported no consistent preboundary lengthening of the segments in a non-final stressed syllable, although their results were limited to consonantal data.] The present study, however, reports a new case that shows a leftward extension of preboundary lengthening even beyond the non-final main-stressed syllable to the initial unstressed syllable in the test word *banana* with implications for theories of boundary-related lengthening.

The present study also examines how the temporal organization of the preboundary test word *banana* is conditioned by the prominence (accent/stress) factor of postboundary context words. The origin of this question may be traced back as early as Jones (1956) and Bolinger (1965), who recognized that a monosyllabic word is lengthened when followed by another monosyllabic word. While Bolinger (1965) and Dasher and Bolinger (1982) considered the full vowel quality as the primary cause, Liberman (1975) attributed it to the rhythmic structure of the two word sequence—i.e., the influence of prominence (accent) of the second word on the first word. This "preaccentual lengthening" (Dasher and Bolinger, 1982), however, has not been extensively explored or supported by later studies, presumably because of the following reasons. First, studies on accentual lengthening in English (see Turk and White, 1999; Cambier-Langeveld, 2000, and references therein) have shown that it is not easily extended to a preceding word. Second, a word before a focally accented word is often reported to be shortened rather than lengthened (e.g., Erickson and Lehiste, 1995; Fougeron and Jun, 1998). Third, perhaps most importantly, early studies on preaccentual lengthening (e.g., Dasher and Bolinger, 1982) did not seem to control for the prosodic boundary between the two successive test words and for the accent condition on the target word.

The present study re-examines the effect of accent of the following context word on the preboundary test word by controlling for both the accent and the boundary factors. In the current experimental setting, the test word *banana* was always unaccented, so that any temporal effect to be found would not be due to its own prominence; the intervening boundary was systematically varied with an intonational phrase (IP) boundary versus a prosodic word (Wd) boundary; and the postboundary context word was either trochaic (e.g., *bánner*) or iambic (e.g., *banál*), varying in terms of its stress and accent distribution. By manipulating the prominence distribution of the context word along with the varying boundary size, the present study also tests whether any arising temporal effect could be characterized as a local phonetic effect just between adjacent segments or syllables or as a process that operates more globally between adjacent words regardless of the stress pattern of the context word and the size of the intervening prosodic boundary.

2. Method

2.1 Subjects and recording

Eleven native speakers of American English (6 female, 5 male) were paid to participate in the experiment. They were either exchange students at Hanyang University or English teachers working in Seoul, all in their 20's at the time of recording. Although the dialectal differences are not relevant for the purposes of the present study, we limited our subject pool to those from the Midwest and the West Coast to minimize potential differences. The recording was made with a SHURE KSN 44 dynamic microphone and a Tascam HD-P2 digital recorder at a sampling rate of 44 kHz in a sound-attenuated booth at the Hanyang Phonetics and Psycholinguistics Lab.

2.2 Speech materials and procedure

Various sentences were created in which the preboundary test word *banana* was followed by eight critical context words, which were all disyllabic with four different initial stops (/p,b,t,d/), varying with lexical stress—i.e., trochaic: *Bánner, Dániel, pánel, tánner;* iambic: *Banál, Deníse, panáche, Teníse.* The critical two-word sequences (e.g., *banána # bánner*) were produced in sentences with two prosodic boundaries (IP vs Wd) and two postboundary accent conditions (accented vs unaccented).

An example set is given in Table 1. For each condition, two sentences were constructed so that the second sentence in the pair was always the target-bearing test sentence while the first sentence was used to induce the intended prosodic conditions. The accent condition was created by inducing a contrastive focus on the target words, and the unaccented condition bore a contrastive focus somewhere else in the sentence, as marked in bold upper case in Table 1. In addition, to induce an IP boundary, syntactically complex sentences were used (Table 1, a and b), so that the test word *banána* became the final of the preceding subordinate clause (e.g., *But after John says "banana"*), and the critical context word appeared in the initial position of the following main clause (#*"panel again" will be*…). For a Wd-boundary condition, the two word sequence formed a single object NP within the same syntactic phrase as in Table 1, c and d (e.g., *To say "banana panel again" with me*…) to increase the likelihood for the speaker to pronounce them as a chunk phrase-internally.

In the experiment, the subjects were presented with test sentences on a computer screen. For each trial, speakers were asked to read each set of two sentences aloud by paying attention to the meaning contrast of the highlighted words in the first and the second sentence. To help the speakers to understand the discourse situation of the experimental sentences, they were told that the sentences are used to explain some kind of language game.

The entire corpus was repeated four times in a randomized order. In total, 1408 tokens were collected: 2 prosodic boundaries × 2 lexical stress patterns × 2 accent

Table 1. Sample test sentences with the test word *banána* and the critical context word *pánel* with four different following prosodic conditions.

Prosodic	Conditions	Test Sentences
IP-Boundary	Accented (focus)	*(a) After **I** say 'banána,' '**BÁNNER** again' will be the next phrase to say.*
		*But after **JOHN** says '<u>banána,</u>' # '<u>**PÁNEL**</u> again' will be the next phrase to say.*
	Unaccented (nonfocus)	*(b) After **I** say 'banána,' 'pánel again' will be the **NEXT** phrase to say.*
		*But after **JOHN** says '<u>banána,</u>' # '<u>pánel</u> again' will be the **FINAL** phrase to say.*
Wd-boundary	Accented (focus)	*(c) To say 'banána # **BÁNNER** again' with me is going to be difficult.*
		*But to say '<u>banána</u> # '<u>**PÁNEL**</u> again' with me is going to be easy.*
	Unaccented (nonfocus)	*(d) To say 'banána # pánel again' with **JOHN** is going to be difficult.*
		*But to say '<u>banána</u> # <u>pánel</u> again' with **ME** is going to be easy.*

(focus) conditions × 4 initial consonants × 11 speakers × 4 randomized repetitions. The prosodic boundary and the prominence distribution in the critical two word sequences were checked by three trained ToBI (Tones and Break Indices) transcribers. Only those tokens whose prosodic patterns were agreed upon by all three transcribers (1059 tokens of 1408) were further analyzed in the present study—i.e., about 25% of the tokens were abandoned, a large portion of which was due to the fact that the preboundary target word *banana* was not completely deaccented as intended.

2.3 Measurements

Acoustic duration of six dependent variables were measured: C1(/b/), V1(/ə/), C2(/n/), V2(/ǽ/), C3(/n/), V3(/ə/). For C1 duration (/b/), closure duration and VOT were combined; the acoustic onset and the offset of the nasals (C2, C3) were detected by a close examination of both the waveform and its accompanying wide spectrogram.

3. Results

Repeated measures analysis of variance (RM ANOVA) tests were conducted on the data pooled across consonant types and repetitions. Three contextual prosodic factors were tested: Boundary (IP/Wd), (focal) accent (ACC/UNA) (of the following context word), and stress (STR/UNS) (of the following context word). Because the stress factor was included only to see whether it would interact with accent, results regarding main effects of stress will not be reported here.

3.1 Effects of boundary

RM ANOVAs returned significant main effects of boundary on V1, V2, C3, and V3: They were significantly longer before an IP than before a Wd boundary [see the statistical summary in Fig. 1(a)]. Among the four measures, V3 showed, by far, a greater

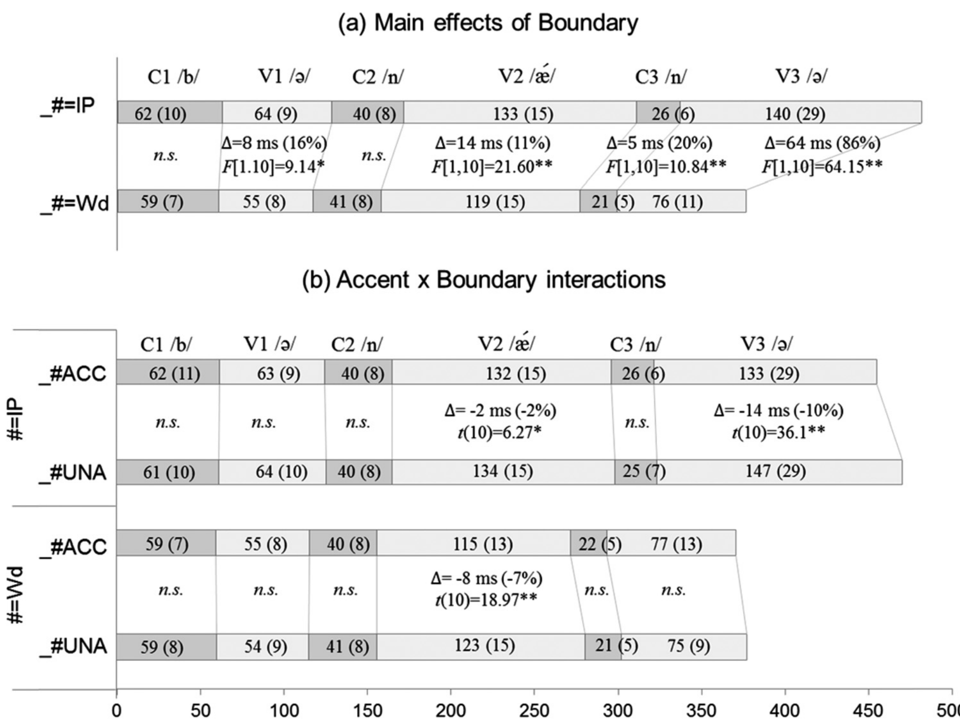

Fig. 1. A statistical summary of (a) effects of boundary (b) effects of accent interacting with boundary on the preboundary test word *banana.* Values in each box refer to the mean and the standard deviation for each condition; * and ** refer to $p < 0.05$ and $p < 0.01$, respectively.

magnitude of lengthening than the other three measures. The results in absolute terms show a pattern of V3 (64 ms) > V2 (14 ms) > V1 (8 ms) > C3 (5 ms) as if the effect became progressively attenuated across the three vowel measures. However, in relative terms (expressed by percent increase in duration from Wd to IP), the order of magnitude is V3 (86%) > C3 (20%) > V1 (16%) > V2 (11%), indicating that the leftmost V1 (/ə/) was not necessarily lengthened less than V2 (/æ/). [Additional RM ANOVAs with V position (V1, V2, V3) as a factor were performed on both the absolute and the relative increases (from Wd to IP), which returned significant main effects ($F[2,20] = 39.78$, $p < 0.001$; $F[2.30] = 31.95$, $p < 0.001$, respectively]. However, *post hoc* pairwise comparisons (with Bonferroni correction) revealed that while V3 (at the right edge) was significantly different from either V2 or V1 (both at $p < 0.001$), the difference between V1 and V2 was not significant on both the absolute and the relative measures (both at $p > 0.1$), showing no evidence for temporal attenuation from V2 to V1.

With respect to interactions between boundary and other factors, RM ANOVAs returned just three significant cases with C3, V3, and V2. C3 showed a three-way interaction among boundary, accent, and stress ($F[1,10] = 9.01$, $p < 0.05$), but the lengthening pattern remained the same in all four *post hoc* comparisons. The remaining two interaction effects on V2 and V3 did not modify the general preboundary lengthening pattern either, but they turned out to be more relevant for accent effects, which will be reported in the next section.

3.2 Effects of (focal) Accent of the postboundary context word

RM ANOVAs returned a significant main effect of accent not only on the immediately preceding V3 (/ə/) ($F[1,10] = 11.66$, $p < 0.01$) but also on the non-adjacent penultimate stressed V2 (/æ/) ($F[1,10] = 19.59$, $p < 0.001$): They were significantly *shorter* when the following word was accented than when it was unaccented (by 5 ms/4% and by 6 ms/5%, respectively), showing both a local (V3) and a non-local (V2) *preaccentual shortening* (rather than lengthening) effect. However, the shortening effect was further modulated by prosodic boundary. There was a significant accent × boundary interaction for both V3 ($F[1,10] = 30.36$, $p < 0.001$) and V2 ($F[1,10] = 11.07$, $p < 0.01$). The interactions, seen in Fig. 1(b), were in large part due to different loci of preaccentual shortening as a function of boundary strength. Before an IP boundary, preaccentual shortening was realized mostly on the final /ə/ (V3, by 14 ms/10%, $t[10] = 36.1$, $p < 0.001$) while V2 (/æ/) showed a significant shortening effect with a minuscule difference (by 2 ms/2%, $t[10] = 6.27$, $p < 0.05$). Before a Wd boundary, on the other hand, the reverse held true—i.e., it was not the final /ə/ but the penultimate stressed /æ/ (V2) that underwent a significant shortening (by 8 ms/7%, $t[10] = 18.97$, $p < 0.001$).

The effect of accent did not show any significant interaction with stress: Neither a two-way (accent × stress) nor a three way (accent × stress × boundary) interaction was observed. In other words, the observed preaccentual shortening pattern was irrespective of whether the postboundary initial syllable was stressed (with a full vowel as in *bánner*) or unstressed (with a reduced vowel as in *banál*).

4. Discussion and conclusion

The results of the present study revealed new aspects of preboundary lengthening and preaccentual shortening on the test word *banana* in American English. Contrary to the previous assumption that preboundary lengthening can be extended to the non-final syllable only if the main stress falls on that syllable (Cambier-Langeveld, 1997; White, 2002; Turk and Shattuck-Hufnagel, 2007), the present study demonstrated that it can be extended even beyond the non-final stressed syllable to an unstressed first vowel. Furthermore, contrary to a common assumption that the magnitude of lengthening tends to be progressively weakened as the syllable is displaced farther away from the boundary (e.g., Byrd *et al.*, 2006), it was found to be only partially true for the test word *banana.* The seemingly progressive attenuation of preboundary lengthening (V1 < V2 < V3) in absolute terms was not statistically supported in that no difference between V1 and V2 was found, and it became even less evident in relative terms (as measured by percentage increase). In fact, the difference in its relative magnitude between V1 and V2 suggested the opposite if there was any effect at all—i.e., V1 was lengthened more than V2 (16% vs 11%), although the difference turned out to be statistically negligible.

These new findings have implications for theories of boundary-related speech production. Turk and Shattuck-Hufnagel (2007) suggested that the mechanism of preboundary lengthening is more complex than the existing speech production models propose by showing that preboundary lengthening has dual targets (the final syllable rime and the non-final stressed syllable rime). The results of the present study, however, added further complexities in two aspects (i.e., its extension to the initial non-stressed syllable and its non-attenuated magnitude relative to the penultimate stressed vowel). These findings challenge any theory of speech production that assumes a gradual and continuous effect of preboundary lengthening (e.g., Byrd and Saltzman, 2003); moreover, the mechanism seems even more complex than the multiple target model proposes. Given the limited data presented here and the limited space allowed for the paper, however, it may be premature and impractical to provide any speculative thoughts, but it remains to be seen how these findings may be generalizable over different types of words, stress patterns, and languages and how they can be incorporated into existing theories concerning temporal variation in the vicinity of prosodic juncture.

As for the accent effect of the context word, the observed preaccentual shortening pattern stands in sharp contrast with the preaccentual lengthening effect reported in earlier studies (e.g., Bolinger, 1965; Liberman, 1975; Dasher and Bolinger, 1982). Given that the type of accent employed in the present study arises with a contrastive focus, preaccentual shortening could be viewed as a backgrounding effect. That is, shortening of the immediately preceding word may have a perceptual effect of making the following focused word more prominent or more foregrounded (e.g., Jensen, 2004), although it remains to be corroborated whether the observed small magnitude of preaccentual shortening could be indeed exploited by the listener in a linguistically meaningful way.

The results also have implications for the domain of preaccentual shortening. Although focus-driven preaccentual shortening has been previously observed (e.g., Erickson and Lehiste, 1995; Fougeron and Jun, 1998), it has been less clear how the effect is distributed across syllables in a polysyllabic word. At least for the test word *banána,* preaccentual shortening appears to be effective up to the penultimate stressed vowel (/æ/). Most importantly, its distribution was found to be modulated by boundary strength. The locus of preaccentual shortening was the final unstressed /ə/ (V3) (with only a negligible shortening of V2) across an IP boundary, but it was the non-final stressed vowel /æ/ (V2) across a Wd boundary. We propose that this is due to the phonetic content of the final vowel that varies as a function of boundary strength. Although the final vowel /ə/ is unstressed/reduced, it undergoes preboundary lengthening IP-finally; and the expanded schwa can have some room for shortening. On the other hand, a reduced word-final vowel is already short enough when it occurs phrase-internally (before a prosodic word boundary); therefore, the syllable may not be further compressed to accommodate an adequate amount of preaccentual shortening. In such a case, preaccentual shortening appears to be extended to the preceding stressed vowel (/æ/ in *banána*).

Finally, preaccentual shortening was consistently observed regardless of boundary strength and the stress pattern of the postboundary context word. This implies that preaccentual shortening is not a merely local phonetic effect, but a process that operates at an utterance level, in line with the view that a prosodic structure of a given utterance is constructed as a whole in speech planning (Keating and Shattuck-Hufnagel, 2002).

In conclusion, although the data reported here are rather limited (with one particular test word *banána* in American English), the present study has opened up new insights into temporal variation of speech with respect to distribution of preboundary lengthening and preaccentual shortening; hopefully this inspires future research on developing theories of speech production that model prosodically conditioned speech timing.

Acknowledgment

The authors wish to thank the 11 American English speakers for recording our speech materials and two anonymous reviewers for helpful comments. This work was supported by the research fund of Hanyang University (HY-2011-N).

References and links

Bolinger, D. (**1965**). *Forms of English: Accent, Morpheme, Order* (Harvard University, Cambridge, MA), pp. 1–334.
Byrd, D., Krivokapić, J., and Lee, S. (**2006**). "How far, how long: On the temporal scope of prosodic boundary effects," J. Acoust. Soc. Am. **120**, 1589–1599.
Byrd, D., and Riggs, D. (**2008**). "Locality interactions with prominence in determining the scope of phrasal lengthening," J. Int. Phonetic Assoc. **38**, 187–202.
Byrd, D., and Saltzman, E. (**2003**). "The elastic phrase: Modeling the dynamics of boundary-adjacent lengthening," J. Phonetics **31**, 149–180.
Cambier-Langeveld, T. (**1997**). "The domain of final lengthening in the production of Dutch," in *Linguistics in the Netherlands*, edited by H. de Hoop and J. Coerts (John Benjamins, Amsterdam), pp. 13–24.
Cambier-Langeveld, T. (**2000**). "Temporal marking of accent and boundaries," Ph.D. dissertation, University of Amsterdam (LOT series 32). It is also available at http://dare.uva.nl/document/84163 (Last viewed March 31, 2013).
Cho, T. (**2011**). "Laboratory phonology," in *The Continuum Companion to Phonology*, edited by N. C. Kula, B. Botma, and K. Nasukawa (Continuum, London/New York), pp. 343–368.
Dasher, R., and Bolinger, D. (**1982**). "On pre-accentual lengthening," J. Int. Phonetic Assoc. **12**, 58–71.
Erickson, D., and Lehiste, I. (**1995**). "Contrastive emphasis in elicited dialogue: Durational compensation," in *Proceedings of the 13th International Congress of Phonetic Sciences*, Stockholm, Sweden, edited by K. Elenius and P. Branderud, Vol. 4, pp. 352–355.
Fletcher, J. (**2010**). "The prosody of speech: Timing and rhythm," in *The Handbook of Phonetic Sciences*, 2nd ed., edited by W. J. Hardcastle, J. Laver, and F. E. Gibbon (Blackwell, Oxford), pp. 523–602.
Fougeron, C., and Jun, S.-A. (**1998**). "Rate effects on French intonation: Prosodic organization and phonetic realization," J. Phonetics **26**, 45–69.
Jensen, C. (**2004**). "Stress and accent: Prominence relations in Southern Standard British English," Ph.D. dissertation, University of Copenhagen, pp. 1–192.
Jones, D. (**1956**). *An Outline of English Phonetics* (Dutton, New York), pp. 1–362.
Keating, P. A., and Shattuck-Hufnagel, S. (**2002**). "A prosodic view of word form encoding for speech production," UCLA Working Papers in Phonetics 101, pp. 112–156. It is also available at http://escholarship.org/uc/item/1qf5f44k#page-114 (Last viewed March 31, 2013).
Kohler, K. J. (**1983**). "Prosodic boundary signals in German," Phonetica **40**, 89–134.
Liberman, M. (**1975**). "The intonational system of English," Ph.D. dissertation, MIT, pp. 1–319.
Silverman, K. (**1990**). "The separation of prosodics: Comments on Kohler's paper," in *Papers in Laboratory Phonology I: Between the Grammar and the Physics of Speech*, edited by J. Kingston and M. E. Beckman (Cambridge University Press, Cambridge, UK), pp. 139–151.
Turk, A. E., and Shattuck-Hufnagel, S. (**2007**). "Multiple targets of phrase-final lengthening in American English words," J. Phonetics **35**, 445–472.
Turk, A. E., and White, L. (**1999**). "Structural influences on accentual lengthening in English," J. Phonetics **27**, 171–206.
White, L. S. (**2002**). "English speech timing: A domain and locus approach," Ph.D. dissertation, University of Edinburgh, pp. 1–336.