DURATIONAL EVIDENCE FOR WORD-BASED VS. PROMINENCE-BASED CONSTITUENT STRUCTURE IN LIMERICK SPEECH

Stefanie Shattuck-Hufnagel[a] *& Alice Turk*[b]

[a]M.I.T., USA; [b]University of Edinburgh, UK
sshuf@mit.edu; turk@ling.edu.ac.uk

ABSTRACT

In this paper we present an experiment to determine the types of constituents that influence polysyllabic shortening. Materials were designed to encourage the use of rhythmic, prominence-based, cross-word (Abercrombian) feet. Our preliminary results suggest that when polysyllabic shortening occurs, it operates preferentially within word-based constituents of the prosodic hierarchy (Selkirk [9], Nespor & Vogel [7]), rather than within cross-word feet that contain word fragments. In spite of the highly rhythmicized nature of our materials, only one of the three speakers analyzed so far showed any evidence at all of polysyllabic shortening within Abercrombian feet. Even this speaker showed stronger evidence of word-based constituent polysyllabic shortening, as well as other types of word-boundary correlates, such as initial vowel glottalization. Data from additional speakers will be presented at the conference.

Keywords: polysyllabic shortening, Abercrombian feet, prosodic hierarchy, syllable duration, speech timing

1. INTRODUCTION

A growing body of evidence suggests that a hierarchy of word-based constituents influences the phonetic shape of utterances. These constituents include word-sized and larger constituents, e.g. prosodic words, clitic groups, phonological phrases, and intonational phrases. Previous experiments have shown that rhyme durations in primary-stressed syllables of phrasally-stressed words depend on the number of syllables in the word (e.g. *–un-* in *tuna* shorter than *–un* in *tune*), Beckman & Edwards [2], Turk & Shattuck-Hufnagel [11], Kim [5], White & Turk [12]). Polysyllabic shortening is one of the mechanisms proposed to account for shorter durations in words with more syllables.

Other findings in the literature suggest that polysyllabic shortening may also operate in some types of larger units (Lehiste [6], Huggins [4], Williams & Hiller [13], Kim [5]. One of the units proposed to govern polysyllabic shortening is the cross-word, or Abercrombian foot (Abercrombie [1]). Abercrombian feet consist of a phrasally prominent syllable followed by non-phrasally stressed syllables up to, but not including the following phrasally prominent syllable. Table I shows that for some word sequences containing phrasal prominences on both content words, word-based constituents and prominence-based Abercrombian feet are isomorphic. However, for e.g. *bake elixirs* and *bake avocadoes*, Abercrombian feet include word fragments but word-based constituents do not.

Table 1: Example parsings: 1) Word-based constituents and 2) Prominence-based constituents.

Word-based constituents	Prominence-based constituents
Bake][apples	Bake][apples
Baking][apples	Baking][apples
Bake us][apples	Bake us][apples
Bake][avocados	Bake avo-][-cados
Bake][elixirs	Bake e-][-lixirs

Several findings in the literature are consistent with the view that cross-word feet govern polysyllabic shortening. For example, Williams & Hiller's [13] large scale study shows that a strong syllable is shorter when followed by 1 or more weak syllables. However, their data don't distinguish among possible governing units, i.e. words (e.g. *bake*), word combinations e.g. *bake us an*, or cross-word feet containing word fragments. Kim's [5] study of radio news speech showed that polysyllabic shortening of stressed syllables (phrasal and otherwise) occurs within words, as well as larger units, but again doesn't distinguish between word combinations vs. cross-word feet. Suggestive evidence that cross-word feet may play a role can be found in Huggins [4], where polysyllabic shortening was observed within a verb phrase-internal cross-word foot, i.e. *bound* in *bound about* was shorter than *bound* in *bound out*, but polysyllabic shortening did not occur across a

NP-VP boundary: *cheese* in *cheese abounded* was no shorter than *cheese* in *cheese bounded.*

Our experiment was designed to determine the types of constituents that influence polysyllabic shortening. Because Abercrombian feet were of particular interest, we designed our materials to encourage the use of prominence-based, rhythmic constituents. In addition, we tested whether the syntactic affiliation of function words plays a role in the implementation of polysyllabic shortening, as in e.g. *[bake us] apples* vs. *bake [an apple]*.

2. METHOD

Materials consisted of phrases like those in Table 1, created from 10 monosyllabic verb stems (*bake, pick, cook, tab, bag, stop, track, grab, crib, catch)* and recorded by six speakers of a variety of American English. We embedded each phrase in the 4th line of a limerick, to ensure reliable placement of phrasal prominences on each content word in the target sequence, and to encourage the production of near-isochronous inter-stress intervals. In the example given below, the test sequence is in bold, although the test sequence was not highlighted in any way for the participants. Different limerick frames were created for each verb stem.

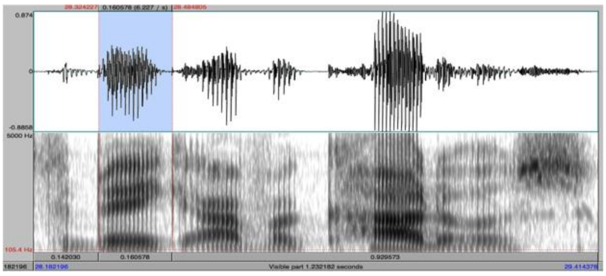
There once was a boy from St. Paul;
Who loved to bake fruit in the fall;
He'd give up his Snapple;
To ***bake apples***;
With butter and sugar and all.

One repetition of each limerick was recorded in verb-stem blocks, in the following order: 1) e.g. *bake us an apple*, 2) e.g. *baking apples* 3) e.g. *bake avocadoes*, 4) *bake elixirs*, 5) e.g. *bake us apples*, 6) e.g. *bake an apple*, 7) e.g. *bake apples*, and 8) e.g. *bake us an apple*. Each verb stem followed this same order, with e.g. *bake us an apple* occurring twice, both first and last, in order to assess whether speech rate affected target durations.

2.1. Acoustic analyses

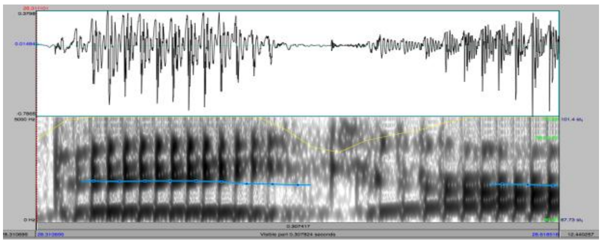
Measurements were made on the basis of the acoustic waveform and spectrograms, following guidelines in Turk, Nakai & Sugahara [10]. The interval of interest was the rhyme duration of the base verb. This interval extended from the release of the first onset consonant to the release of the base verb coda consonant, as illustrated in Figure 1 for *–ake* in *bake avocadoes.* Note that we included aspiration of the /p/ in *pick* as part of the rhyme. The /r/s of *track*, *grab*, and *crib* were also included in the "rhyme" because of segmentation reliability issues.

Figure 1: An example rhyme interval (*–ake* in *bake avocadoes*), highlighted.



In addition to durational measurements, we also evaluated other boundary correlates within our test materials. These included silence and/or irregular pitch periods at word-onset vowels. These have been observed at the onset of other prosodic constituents (Pierrehumbert & Talkin [8], Dilley, Shattuck-Hufnagel & Ostendorf [3]). Of particular interest was whether these correlates might occur at the onset of foot-internal words (e.g. at the onset of *elixir* in the foot *bake e-(lixir)*, where they would indicate a constituent boundary.

Figure 2: Acoustic waveform and spectrogram illustrating initial vowel-onset glottalization in one token of *bake avocadoes*. *Bake a-* is illustrated here.



2.2. Statistical analyses

By-items repeated measures ANOVAs were used to analyze data separately for each participant.

2.3. Results

2.3.1. Assessment of possible speech rate differences across conditions

To test whether speakers systematically sped up during the course of a verb-stem block, we compared verb stem rhyme durations from the first vs. second repetitions of e.g. *bake us an apple*, recorded first and last (8^{th}) in each verb-stem block respectively. No significant differences were found for Speakers 1 and 2, but we did observe a tendency towards a significant increase in rate for Speaker 3 ($F(1,8) = 4.92$, $p < .1$, 20 ms, 10% difference). Although our results suggest comparability of speech rate throughout each block, especially for Speakers 1 and 2, it is nevertheless possible that speech rate differences influenced our target measurements to some extent, since later repetitions in an experimental session are expected to be faster. Our experiment was designed to safeguard against attributing a difference to polysyllabic shortening within a constituent when in fact it should be attributed to a difference in speech rate. That is, materials that might be influenced by polysyllabic shortening (e.g. *bake us an apple, baking apples, bake avocadoes, bake elixirs, bake us apples, bake an apple*) were recorded earlier in the block, where their rates would be slower, than e.g. *bake apples* which is not expected to undergo polysyllabic shortening. For example, e.g. *baking apples* was expected to undergo polysyllabic shortening and therefore to have a shorter verb stem rhyme duration than e.g. *bake apples*. If we had recorded *baking apples* after *bake apples*, we wouldn't have known if a shorter verb stem in *baking apples* were due to polysyllabic shortening, or to a difference in speech rate expected to occur for materials recorded later in the block. Instead, e.g. *baking apples* was recorded earlier in the verb stem block (2nd), where its speech rate would be expected to be slower as compared with *bake apples* (recorded 7th). A shorter verb stem in e.g. *baking apples* as compared to e.g. *bake apples* can therefore be reliably attributed to polysyllabic shortening.

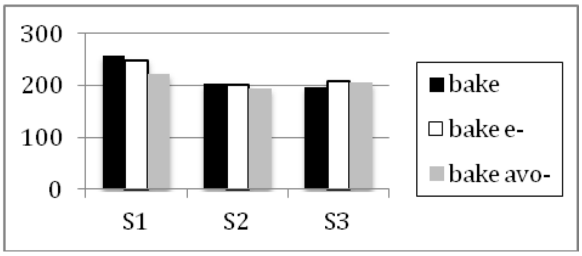
2.3.2. Boundary correlates occur at word onsets within Abercrombian feet, for all 3 speakers

All three speakers showed evidence of word-onset glottalization, even within Abercrombian feet. For example, e.g. e.g. *bake e-(lixirs)* and *bake avo-(cadoes)* contained word-onset glottalization at the onset of the second content word in over half of all cases.

2.3.3. Polysyllabic shortening occurs rarely within Abercrombian feet, and only for 3-syllable feet

The crucial test for Abercrombian-foot-related polysyllabic shortening came from feet containing word fragments, e.g. *bake e-(lixirs)* and *bake avo-(caodoes)*, as compared to monosyllabic feet (e.g. *bake (apples)*). Only one speaker showed Abercrombian-foot related polysyllabic shortening; and then only for feet containing 3 syllables. Speaker 1 showed a difference in stem rhyme duration in e.g. *bake apples vs. bake avocadoes* ($F(1,8) = 25.68$, $p < .001$; 35 ms, 16% difference). No speakers showed polysyllabic shortening in 2 syllable feet. That is, e.g. *–ake* in *bake e-(lixirs)* was not shorter than in *bake (apples)*.

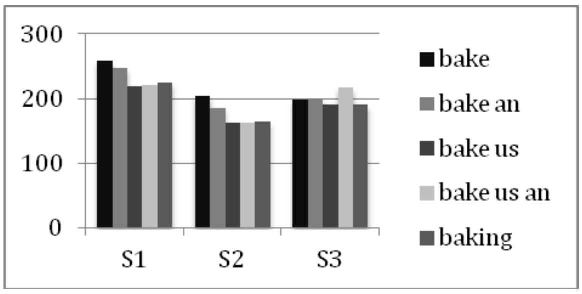
Figure 3: Mean stem rhyme durations in ms for feet consisting of the stem only (e.g. *bake*), and for feet containing word fragments (e.g. *bake e-(lixirs), bake avo-(cadoes)*.



2.3.4. Polysyllabic shortening occurs preferentially within word-based units

Figure 4 shows mean stem rhyme durations for feet consisting of words and word combinations. Speaker 1 and Speaker 2 both showed polysyllabic shortening: both showed effects of Number of Syllables (1 vs. 2 vs. 3) on Stem rhyme durations in by-items repeated measures ANOVAS: Spkr 1: $F(2,18) = 7.42$, $p = .0045$, Spkr 2: $F(2,18) = 22.42$, $p = .000013$. Spkr 3 showed no evidence of polysyllabic shortening within these units.

Figure 4: Mean stem rhyme durations in ms for feet consisting of words and word combinations.



We conducted analyses to determine whether the polysyllabic shortening of Speakers 1 and 2 occurred preferentially within feet containing words or word combinations as opposed to within feet containing word fragments. Stem rhyme durations in 2-syllable feet with word (combinations) only e.g. *baking/bake us/bake an* were compared with stem rhyme durations in feet with word fragments (e.g. *bake e-(lixirs))*, for both of the speakers showing polysyllabic shortening within word-based units. Stem rhyme durations in two types of word (combination) feet (e.g. *baking* and *bake us*) were shorter than stem rhyme durations in feet with word fragments (e.g. *bake e-(lixirs)*. E.g. *Bake e-(lixirs)* vs. *baking (apples)*: Sp. 1: $F(1,9) = 10.73$, $p < .01$, Sp. 2: $F(1,9) = 56.19$, $p < .01$. e.g. *Bake e-(lixirs)* vs. *bake us (apples)*: Sp. 1: $F(1,9) = 7.11$, $p < .05$, Sp. 2: $F(1,9) = 22.37$, $p < .01$. In contrast, stem rhymes followed by *an* had durations more similar to those followed by a word-fragment (e.g. *bake an (apple) vs. bake e-(lixirs*), i.e. no significant difference for for Speaker 1, and only a tendency for Speaker 2: $F(1,9) = 4.86$, $p < .1$, (15 ms difference).

Comparisons of 3-syllable feet, e.g. *bake avo-(cadoes)* vs *bake us an (apple)*, showed a significant difference for Speaker 2 only ($F(1,9) = 21.17$, $p = .00129$, 35 ms, 22% difference). The lack of a significant difference for Speaker 1 suggests that the magnitude of polysyllabic shortening within this speaker's 3-syllable feet was similar whether these contained word fragments (e.g. *bake avo-*) or not (e.g. *bake us an*).

2.3.5. Syntactic groupings influence the magnitude of polysyllabic shortening, for 2 speakers

Stem rhymes followed by the direct object pronoun *us* (e.g. *bake us*] *apples*) were shorter than stem rhymes followed by the determiner *an* (e.g. *bake* [*an apple*), for 2 of 3 speakers. Speaker 1: $F(1,9) = 6.36$, $p < .05$, 28 ms, 13% difference, Speaker 2: $F(1,9) = 15.47$, $p < .01$, 23 ms, 14% difference.

3. CONCLUSION

This study provides preliminary evidence that highly rhythmicized speech contains correlates of the word-based hierarchy of prosodic constituents. Polysyllabic shortening operated preferentially within word-based constituents, but only weakly within rhythmic constituents. In addition, word-boundary cues were often observed within rhythmic feet. Results suggest that syntax influences the formation of constituents used in speech production: the syntactic affiliation of function words (e.g. *us* vs. *an*) influenced the likelihood of polysyllabic shortening within a content + function word sequence. We emphasize the interspeaker variation in our data: one of the three speakers failed to show any evidence of polysyllabic shortening at all, and only one of the other two speakers showed significant polysyllabic shortening in feet containing word fragments.

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