ABSTRACT
This study of phrase-final vs. non-phrase-final disyllables shows the influence of prosodic structure on the spread of final lengthening in English. The greatest amount of lengthening was found on phrase-final syllable rimes, although lengthening within the rime was not uniform. Final syllable codas showed more lengthening than final syllable nuclei. In addition, lengthening was found to extend to the left of the final rime if the penultimate syllable bore primary lexical stress. The left edge of phrase-final rimes and the left edge of rimes of primary lexically stressed syllables appear to constrain the leftward spread of pre-boundary lengthening.

1. INTRODUCTION
While there are well-developed theories of constituents which influence the intonational and segmental shapes of utterances ([5],[6],[7]), it is still unclear which constituents influence durational patterns in speech, and whether these are morphosyntactic or prosodic. In this paper, we investigate the structures which constrain the spread of boundary-related durational effects. In English, intonational phrase-final lengthening is well established for the rime of the phrase-final syllable ([1]), and there is some evidence for English and other languages that the lengthening extends rightward from the boundary into the first segment of the following phrase as well ([8],[9]).

Studies of languages other than English have shown that lesser magnitudes of lengthening can extend further to the left than the final syllable, and furthermore, that the extent of this leftward spread is influenced by the linguistic structure of the final word. The purpose of this paper is therefore to determine how far to the left and right of a boundary boundary-related lengthening extends in English. We also attempt to determine whether the spread of lengthening is constrained by boundaries other than the onset of the final rime, and/or whether it is influenced by the lexical stress pattern of phrase-final words.

In the following section, we discuss structural constraints on lengthening patterns in German, Hebrew, Dutch, and Estonian, before discussing the English experiment.

1.1. German
Kohler’s [10] and Silverman’s [11] comparisons of German phrase-final vs. non-phrase-final words in comparable phrasal stress positions show that final lengthening can extend leftward at least as far as a primary lexically stressed syllable within a phrase-final word. In Kohler’s study of phrasally stressed words like *eine* and *einige* in phrase-final vs. non-phrase-final positions, the magnitude of lengthening on the final syllable (–e and –ge) was the greatest, ranging from 87% to 176%, and lengthening on pre-final syllables ranged from 15% to 31%. Silverman’s study included words with a single syllable to the left of the primary lexical stressed syllable within a word; these syllables showed a smaller degree of lengthening (6-7%) than other non-final syllables within the final word (11-17%).

1.2. Hebrew
Berkovits [2] showed that in Hebrew disyllables, most phrase-final lengthening occurs on the phrase-final rime (71% on words with initial stress, and 57% on words with final stress), and that final syllable codas show proportionally more lengthening than final syllable nuclei. Berkovits [3] also shows significant amounts of lengthening on lexically stressed penultimate syllables (23%). Lengthening on lexically unstressed penultimate syllables was insignificant.

1.3. Estonian
Krull [12] investigated preboundary lengthening in Estonian disyllables where the first syllable was either short, long, or overlong (quantities 1, 2, or 3), and the second syllable was short. She found an interesting interaction between the quantity of the first syllable and the leftward spread of final lengthening. In this study, the second syllable of disyllables was consistently lengthened across conditions and subjects, but the first syllable of disyllables was lengthened across subjects only if it was overlong (quantity 3), and was not lengthened if short.

1.4. Dutch
Cambier-Langeveld’s [4] study of final lengthening in Dutch shows yet another type of structurally conditioned pattern. Again, as seems to be the norm, most lengthening of phrase-final words occurred on the final syllable rime, and more lengthening was found on the final syllable coda than on the nucleus. Lengthening further to the left than the final syllable occurred only in words whose final syllable was reduced, as in *mode* and *tandem*, but did not occur on words whose final syllable was full, such as *yucca* and *harmonika*.

1.5. The current study
In all of these languages, preboundary lengthening was found to occur further to the left than the phrase-final rime, and moreover, this leftward spread of lengthening appears to be influenced by structural properties of words in each language. Interestingly, the linguistic structure relevant to the spread of final lengthening appears to be different in Estonian vs. Dutch vs. Hebrew/German.

In the current study of English disyllables, we therefore test the influence of the location of primary stress, and of the type of non-primary stressed syllable (full vs. reduced) on the spread of boundary-related lengthening.

2. EXPERIMENT

2.1 Methods
2.1.1. Materials. Materials consisted of ambiguous sentence pairs, such as *Please say ‘Thomas or Kenneth and Lucas will...*
stay’ which were to be disambiguated by subjects as e.g. Please say ‘(Thomas or Kenneth) and (Lucas) will stay’, and Please say ‘(Thomas) or (Kenneth and Lucas) will stay’. Target words were chosen to systematically vary in type (full vs. reduced), and in the location of main stress. Sentences containing the two-syllable target words analyzed in this paper are listed below. Additional utterances with one-syllable, three-syllable, and four-syllable target words were also recorded for further analysis.

**Table I. Test materials.**

<table>
<thead>
<tr>
<th>Primary lexical stress on first syllable, reduced second syllable:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please say ‘Thomas or Kenneth and Lucas will stay’.</td>
</tr>
<tr>
<td>Please say ‘Kansas or Texas and Boston will play’.</td>
</tr>
<tr>
<td>Primary lexical stress on first syllable, full second syllable:</td>
</tr>
<tr>
<td>Please say ‘Charlestown or Brookline and Woodstock will play’.</td>
</tr>
<tr>
<td>Please say ‘Fairbanks or Plattsburg and Fairmont will play’.</td>
</tr>
<tr>
<td>Please say ‘Stockholm or Frankfurt and Potsdam will play’.</td>
</tr>
<tr>
<td>Primary stress on second syllable, reduced first syllable:</td>
</tr>
<tr>
<td>Please say ‘Tibet or Japan and Detroit will play’.</td>
</tr>
<tr>
<td>Please say ‘Milan or dePaul and Macau will play’.</td>
</tr>
<tr>
<td>Please say ‘Corinne or Selene and Burgoyne will stay’.</td>
</tr>
<tr>
<td>Primary stress on second syllable, full first syllable:</td>
</tr>
<tr>
<td>Please say ‘Suzette or Babette and Suzanne will stay’.</td>
</tr>
<tr>
<td>Please say ‘Bangkok or Rangoon and Carmel will play’.</td>
</tr>
<tr>
<td>Please say MoDeen or Doreen and Rudan will stay’.</td>
</tr>
</tbody>
</table>

2.1.2. Subjects. Subjects were 2 native speakers of a standard variety of American English, one female and one male. Neither had any speaking/hearing difficulties. Two additional subjects were also recorded, but their data are not reported in this paper.

2.1.3. Recording. The ambiguous test sentences were typed on notecards, along with an indication of how they were to be disambiguated, e.g. as (A B) C or as (A) (B C), where A, B, and C represent the first, second, and third target words of the test sentences. The cards were shuffled, and subjects were asked to read the indicated disambiguation of each sentence, followed by its reiterant imitation, e.g. ‘ma ma (mama ma ma) ma (mama) ma ma’. If subjects stumbled, which often happened during the reiterant imitation, they were asked to repeat the utterance. Subjects read through the set of notecards twice, giving two repetitions of each utterance, along with two reiterant imitations. There were therefore 11 sentence types X 2 groupings ((AB) C vs. (A) BC) X 2 repetitions = 44 natural renditions available for analysis, in addition to their reiterant imitations.

2.1.4. Measurements. Where possible, measurements of onset, nucleus, and coda duration were made for each syllable in the ‘A or B and’ sequence of each test sentence, according to standard segmentation criteria. Nucleus and coda durations were combined into rime durations, and onset and rime durations were combined into syllable durations. Word duration was computed for the third word (Word C). In cases where segmentation could not be made reliably for one or more renditions of a particular word for a particular speaker, (e.g. the offset of the [l] in Plattsburg), the relevant segment durations (in this example, the onset and rime durations) were excluded from further analysis for all renditions of that utterance by the same speaker. Note that in cases like the first syllable of Plattsburg, although we had no reliable onset and rime durations, we did have reliable coda and syllable durations. The conjunctions or and and were not divided up into subsyllabic constituents.

2.1.5. Analyses. The B words in (A B) C groupings, and the A words in the A (B C) groupings were considered to be boundary-adjacent, and the A words in the (A B) C groupings and the B words in the A (B C) words were considered to be non-boundary-adjacent. Boundary-adjacent target words always preceded a boundary, and therefore any lengthening observed on boundary-adjacent words can be considered pre-boundary lengthening. Boundary-adjacent conjunctions could have been either pre- or post-boundary, depending on whether subjects decided to put a boundary before or immediately after or and.

Comparisons were then made between segments in boundary-adjacent vs. non-boundary-adjacent words. Results for natural renditions are presented in Section 2.2. Results for reiterant imitations are not presented in this paper.

2.2. Results.

2.2.1. Syllable Type doesn’t appear to affect the leftward spread of lengthening. In order to determine whether syllable type had an influence on the leftward spread of final lengthening, we tested for an interaction of Syllable Type (full vs. reduced) and Boundary Condition (boundary-adjacent vs. non-boundary-adjacent) on first and second syllable duration for words with primary lexical stress on the first syllable, and for words with primary stress on the second syllable. ANOVA’s with fixed factors of Syllable Type and Boundary Condition, and Target Word within Syllable Type as a random factor were conducted separately for each speaker. The only significant effect that emerged was for the first syllable of Subject ES’ words with primary stress on the second syllable (F(1,6) = 6.788, p < .05). For this speaker, words with reduced first syllables showed boundary-adjacent shortening, whereas words with full syllables showed boundary-adjacent lengthening. Further examination of this subjects’ onset and rime durations showed that the significant difference we observed was entirely due to differences on the first syllable onset, not on the rime. It was therefore not the case that the leftward spread of boundary-related lengthening was differentially affected for words with full vs. reduced syllables. We have no satisfactory explanation for the effect on the onset. Because we found no evidence that Syllable Type influences the leftward spread of lengthening, we included words with full and reduced non-main stressed syllables in all subsequent analyses.

2.2.2. Onset and rime durations in boundary-adjacent vs. non-boundary-adjacent words. Figures 1 and 2 show boundary-adjacent vs. non-boundary-adjacent onset and rime durations for ES’ and HH’s words with primary stress on the first syllable (e.g. Thomas, Charlestown), and Figures 3 and 4 show onset and rime durations for words with primary stress on the second syllable (e.g. Tibet, Bangkok). ANOVA’s with Boundary Condition (boundary-adjacent vs. non-boundary-adjacent) as a fixed factor, and Target Word as a random factor, were conducted for each segment for each subject and stress-type separately.
Figure 1. Subject ES. Mean onset and rime durations (and standard deviations) for boundary-adjacent vs. non-boundary-adjacent syllables in words with primary stress on the first syllable e.g. Thomas, Charlestown.

Significant effects of Boundary Condition for ES’ comparisons of words like Thomas and Charlestown (Fig. 1) were found on the rimes of both first and second syllables, as well as on the conjunctions (or and and). (Rime of first syllable: $F(1,6) = 23.9, p < .01$; rime of second syllable: $F(1,8) = 48.5, p < .01$; conjunction: $F(1,9) = 9.134, p < .05$.)

Figure 2. Subject HH. Mean onset and rime durations (and standard deviations) for boundary-adjacent vs. non-boundary-adjacent syllables in words with primary stress on the first syllable, e.g. Thomas, Charlestown.

Likewise, for HH, significant effects of Boundary Condition were found for the rimes of both syllables (cf. Figure 2). (First syllable rime: $F(1,6) = 17.403, p < .01$; Second syllable rime: $F(1,6) = 18.781, p < .01$). Unlike ES, HH showed a significant effect on the onset of the second syllable ($F(1,8) = 10.1, p < .05$), and showed no effect of Boundary Condition on the conjunction.

Figure 3. Subject ES. Mean onset and rime durations (and standard deviations) for boundary-adjacent vs. non-boundary-adjacent syllables in words with primary stress on the second syllable, e.g. Tibet, Bangkok.

In contrast, for words like Tibet and Bangkok, (cf. Figure 3), subject ES showed a small but significant shortening effect on the rime of the first syllable in boundary-adjacent words ($F(1,9) = 5.82, p < .05$.) Significant lengthening effects were found on the rime of the second syllable in boundary-adjacent words, as well as on the conjunction. (Rime of second syllable: $F(1,10) = 93.592, p < .01$; Conjunction: $F(1,11) = 5.674, p < .05$).

Figure 4. Subject HH. Mean onset and rime durations (and standard deviations) for boundary-adjacent vs. non-boundary-adjacent syllables in words with primary stress on the second syllable, e.g. Tibet, Bangkok.

HH showed no effect of preboundary lengthening on the first syllable, but a significant effect on the rime of the second syllable ($F(1,8) = 118.180, p < .01$).

Apart from differences with respect to the lengthening effects on boundary-adjacent conjunctions found for ES, the two subjects showed similar behavior. ES’ lengthening of conjunctions may indicate either that he has phrase-initial lengthening on these words, or that he has placed an additional weaker prosodic boundary after the conjunctions. It is difficult to tell from these data.

Figures 1-4 suggest that words with primary stress on the syllable behave differently with respect to pre-boundary lengthening than do words with primary stress on the second syllable. ANOVA’s with fixed factors of Boundary Condition (boundary-adjacent vs. non-boundary-adjacent), Position of
Stress (first vs. second syllable) and Word-within-Stress Position as a random factor confirmed this interaction. Significant interactions of Boundary Condition and Position of Stress were found for the first and second syllable rime durations for subject ES (first syllable rime: F(1,12) = 22.9, p < .01, second syllable rime: F(1,12) = 5.66, p < .05), and for the first syllable rime duration for subject HH (F(1,12) = 12.99, p < .01). Subject ES thus appears to show more final lengthening on the second syllable of words with primary lexical stress on the second syllable than on words with primary stress on the first syllable.

To give a better idea of the relative proportions of lengthening in these two conditions, we report percentage differences between boundary-adjacent vs. non-boundary-adjacent segments in Table II. % difference was calculated as: [(Duration of boundary-adjacent segment/duration of non-boundary-adjacent segment – 1) * 100.

Table II. Percent differences between boundary-adjacent and non-boundary-adjacent segments for ES and HH, for words with primary lexical stress on the first syllable (e.g. Thomas, Charlestown), and for words with primary lexical stress on the second syllable (e.g. Tibet, Bangkok).

<table>
<thead>
<tr>
<th>Subject</th>
<th>Position of Stress</th>
<th>Ons.1</th>
<th>Rime.1</th>
<th>Ons.2</th>
<th>Rime.2</th>
<th>Conj.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES</td>
<td>1st syl</td>
<td>-9</td>
<td>15</td>
<td>11</td>
<td>76</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>2nd syl</td>
<td>-15</td>
<td>7</td>
<td>117</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>HH</td>
<td>1st syl</td>
<td>.5</td>
<td>32</td>
<td>33</td>
<td>93</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>2nd syl</td>
<td>-2</td>
<td>9</td>
<td>110</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

2.2.3. Distribution of lengthening effects in the final syllable.
In this section, we report percentage differences in boundary-adjacent vs. non-boundary-adjacent onsets, nuclei, and rimes in the phrase-final syllable, pooled across subjects and word-types. % differences were calculated as in Section 2.2.2.

Figure 5. Percentage differences between boundary-adjacent and non-boundary-adjacent onsets, nuclei, and rimes in the phrase-final syllable. Means are pooled across subjects and word types.

This figure shows clearly that lengthening in the final rime is not uniform, but increases substantially from the final nucleus to the final coda.

3. CONCLUSION
Results reported here confirm the findings in [1] that most boundary-related lengthening effects are concentrated in the rime of the phrase-final syllable. However, lengthening within the rime is not uniform: Relatively more lengthening occurs on the coda than on the nucleus. These findings are consistent with findings for Hebrew discussed in [2], and the findings for Dutch discussed in [4].

These results also show that pre-boundary lengthening in two syllable words is not confined to the phrase-final syllable, but can occur on the rime of a syllable to its left if that syllable bears primary lexical stress. We found no evidence of boundary-adjacent lengthening on the first syllable in words with primary stress on the second syllable. The leftward spread of final lengthening thus appears to be conditioned by the primary lexical stress pattern of phrase-final words. We found no evidence of any influence of the pattern of secondary lexical stresses. The English pattern of boundary-related lengthening thus appears to be similar to that of Hebrew and German, and different from that of Estonian and Dutch. However, we add the caveat that further work is needed to make sure that lengthening to the left of the final syllable is due to pre-boundary lengthening per se, and not to lengthening related to the nuclear accented status of the phrase-final words as compared to the prenuclear status of the non-phrase-final words.

To conclude, these results suggest that at least two types of boundaries are involved in constraining the leftward spread of boundary-related lengthening in English disyllabic words: 1) the left edge of the rime of the final syllable, regardless of its lexical stress, and 2) the left edge of the rime of the primary lexically stressed syllable. Further work is needed to see if this pattern is maintained for three and four syllable words.

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REFERENCES