The origins and scope of final lowering in English and Greek

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ABSTRACT

Two experiments were designed to examine final lowering in English and Greek. In both, the number of unstressed syllables between the last two accents varied between two and three syllables (English), and two and four syllables (Greek). In English the final accent was one or three syllables from the end of the utterance; in Greek the distance was zero, one or two syllables. Final lowering was evident in both languages, while the extra syllables between the last two accents did not produce additional lowering, clearly showing that final lowering is independent of declination. In both languages the final accent was scaled lower when closer to the end of the utterance, though the effect was not consistent across speakers. This result suggests that final lowering is not phonologically controlled, but more research is necessary to draw a firm conclusion on this point.

1. INTRODUCTION

Final lowering, the lower than expected scaling of the final peak in a series of downstepping Hs, was first investigated in [1]. Since then similar experimental results have been presented for Japanese [2], Igbo [3], Kipare [4], and Spanish [5]. Nevertheless, the origins and scope of final lowering remain unclear. In [1] it is suggested that final lowering could be either phonologically controlled or the result of lower subglottal pressure at the end of an utterance, resulting in slower vocal fold vibration. To our knowledge, this point has not been addressed experimentally before.

Furthermore, the existence of final lowering has been disputed by Grabe [6], whose results in a series of experiments similar to that in [1] suggested that it may be an epiphenomenon of declination. Specifically, in [1] the last two items in word lists were separated by *and* which added an extra syllable between the last two accents; in [6], final lowering disappeared, when this extra syllable was eliminated. However, the materials in [6] did not take the form of a list, so they could have elicited a different intonation pattern. To test this interpretation, an experiment was designed in which the problem of the extra syllable in the original experiment in [1] was addressed. Similar materials were also used for Greek to test whether similar effects would be found in an unrelated language for which no previous data on final lowering have been reported.

2. EXPERIMENT 1: METHOD

Materials: The materials were similar, though not identical, to those in [1]. First, bean names (rather than berry names, as in [1]) were used, because they offer some advantages: many bean names consist largely of sonorants thus ensuring fewer perturbations of the F0 contour, while it is possible to vary the number of syllables in the first member of bean compounds (thereby changing the syllable count between accents). Seven bean names were used to create lists with two to five items: *lima beans*, *yellow beans*, *fava beans*, *navy beans*, *haricot beans*, *green beans* and *long beans*.

Second, unlike [1], we used the order of list items to control syllable count. Specifically, the number of unstressed syllables between accents ("inter-accent interval") was two in all positions, except between the penultimate and final accent. As shown in (i) and (ii), in penultimate position either *green beans* or *navy beans* was used. In (i), *and* does not add an extra syllable between the last two accents, but in (ii), it does (cf. underlined part of (i) and (ii)). If final lowering is due to declination, then only lists with *navy beans* in penultimate position should show final lowering.

(i) Lima beans, green beans and long beans.

(ii) Lima beans, navy beans and long beans.

(iii) Lima beans, green beans and haricot beans.

Finally, we used *long beans* and *haricot beans* for the final item in the list. If final lowering targets the last accent, then sentences ending in either word should have final peaks of similar scaling. If final lowering targets the last portion of the utterance, then sentences ending in *haricot beans* should have higher final peaks, provided the inter-accent interval is the same, as in (i) and (iii).

Speakers: There were five speakers, all in their twenties and thirties. The female speakers, EF1 and EF2, were from

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Wisconsin and upstate New York respectively; the male speakers, EM1, EM2 and EM3, were from Pennsylvania, Boston and Boise respectively.

Procedure: The data were recorded on DAT tape in the recording studio of the Linguistics Department of UCSD, and were later re-digitized at 16 KHz for analysis. The materials were typed on flashcards (one list per card). The speakers read the materials ten times in random order. For EF1 and the male speakers, on average eight of these repetitions were used for measurement; for EF2 seven repetitions were used. Tokens were discarded if they contained a phrase boundary, the wrong intonation contour altogether, or so much creak that measurement of the last peak and the final low value were impossible to make.

Measurements and statistical analysis: The measurements included the final (and lowest) F0 value (FL), and the F0 of all peaks. The data were analyzed using between subjects Analyses of Variance in which the F0 value of the final and penultimate accent in the lists was the dependent variable; SPEAKER, LAST ACCENT (*haricot beans* or *long beans*), (final) INTER-ACCENT INTERVAL (two or three syllables), and LIST LENGTH (two, three, four or five items) were used as independent variables. Reported results are significant at (at least) $p<0.001$ unless otherwise stated. Interactions were investigated using the Tukey HSD *post-hoc* test.

3. EXPERIMENT 1: RESULTS

First, it was necessary to establish that the speakers used a relatively stable pitch range during the recording. In order to do so, the difference in Hz was calculated between H1 (the first peak in each utterance and highest F0 value) and FL. Results, presented in Table 1, suggest that the ranges were relatively stable for each speaker. It should be noted, however, that some standard deviations were somewhat large, especially for EF1 and EF2, due to regions of creak towards the end of utterances, which made locating FL less reliable than locating the other measured points.

Speaker	H1 Mean	H1 s.d.	FL Mean	FL s.d.	Range Mean	Range s.d.
EM1	154	20	87	4	67	21
EM2	166	14	89	14	77	19
EM3	135	7	100	13	35	14
EF1	265	15	150	22	115	22
EF2	260	13	145	32	115	29

Table 1: Means and standard deviations for H1, FL and pitch range, for each English speaker separately.

Second, it was essential to see if final lowering took place. To this effect, ANOVAs were run comparing the scaling of the final peak in word lists with *n* accents to the penultimate peak of word lists with *n*+1 accents: if final lowering took place, then the former would be lower than the latter. This is indeed what our results showed (see Figure 1): for two-word vs. three-word lists, $F(1, 272)=769.47$; for three-word vs. four-word lists, $F(1, 272)=451.3$; for four-word vs. five-word lists, $F(1, 272)=175.27$.

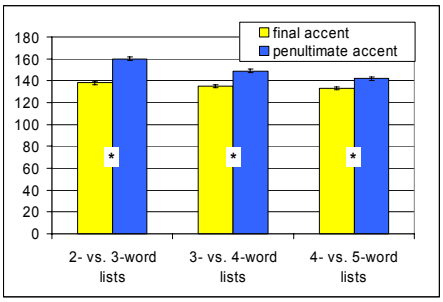

Figure 1: Mean and standard error values for final accents in two-, three- and four-word lists compared to penultimate accents in three-, four- and five-word lists respectively (English data). Asterisks indicate a statistically significant difference between adjacent bars.

Yet, it is possible that there is an effect of declination on the scaling of final accents, even if final lowering does take place in all cases. To test for this possibility, we compared the scaling of final accents in lists of the same length but with different inter-accent intervals. The results showed that inter-accent interval did not affect final accent scaling (results for all list lengths were non significant).

Finally, comparisons between sentences with the same final inter-accent interval but ending in a different word showed that the position of the last accent did influence accent scaling. However, this factor always interacted with SPEAKER (for two-word lists, $F(4,137)=10.8$; for three-word lists, $F(4,137)=16.5$; for four-word lists, $F(4,134)=6.6$; for five-word lists, $F(4,129)=9.6$). Investigation of these interactions showed that only EF1 had consistently higher scaling of the final accent when this accent appeared earlier (i.e. when the lists ended in *haricot beans*); EF2 showed the same effect in lists of four and five words, but the other three speakers did not show any effect at all (see Figure 2).

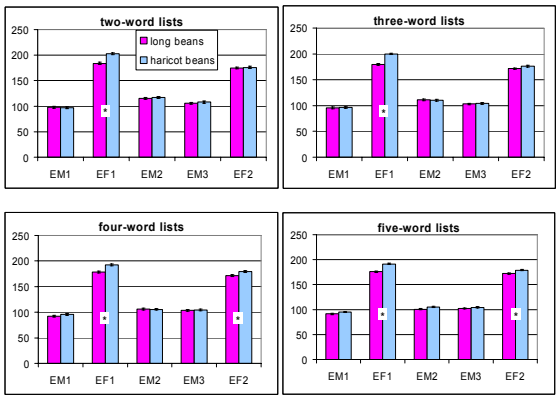

Figure 2: Means and standard errors for final accents in two-, three-, four- and five-word lists ending in either *haricot beans* or *long beans*; results for each speaker separately. Asterisks indicate a statistically significant difference between adjacent bars.

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4. EXPERIMENT 2: METHOD

Materials: Materials similar to those used for English were constructed for Greek. The main difference was that in the Greek case the sentences used were not lists (since these show an intonational pattern unsuitable for the purposes of this investigation; c.f. [7]); rather, simple sentences that would typically be pronounced with declarative intonation (see [8]) were used instead. As in English, the distance between all accents apart from the last two was two syllables. The last two accents, however, were separated by either two or four syllables (cf. the underlined part in (iv) and (v) below) to see if the extra segmental material would result in greater lowering of the final accent in sentences like (v), where the final accent is separated from the penultimate accent by more segmental material. In addition, sentences with even inter-accent intervals were constructed, similar to example (iv); in these, the last accent was either on the final syllable, as in (vi), or the antepenult, as in (vii); the aim was to see if moving the last accent closer to the end of the utterance would result in greater final lowering.

(iv) [i meˈlina θaˈrθi me ti ˈlina]
"Melina will come with Lina"
(v) [i meˈlina θaˈrθi me ti mariˈlina]
"Melina will come with Marilina"
(vi) [i meˈlina θaˈrθi apti ˈro]
"Melina will come from Ro (Greek island)"
(vii) [i meˈlina θaˈrθi apti ˈflorina]
"Melina will come from Florina (Greek town)"

Speakers: Two females in their thirties (GRF1 and GRF2), and one 22 year old male (GRM3) were recorded. GRF1 and GRM1 are speakers of Athenian Greek, while GRF2 is from Thessaloniki.

Procedure: The procedure described for English was used, except in two respects: (a) in the Greek materials each test sentence was preceded by a question that provided a plausible context for it; (b) GRM1 was recorded directly to disk, using an A/D converter, at a sampling rate of 44.1 KHz. GRF1 and GRF2 read the sentences eight times in random order, while GRM1 read the sentences nine times (the speakers did not read the questions). All repetitions were used for measurement. The same measurements were taken as for the English experiment, and the data were statistically analyzed in the same manner.

5. EXPERIMENT 2: RESULTS

Like the English data, the Greek data showed that the speakers used a relatively constant pitch range; in fact, as can be seen in Table 2, the Greek speakers showed somewhat less variation than the English speakers.

On the other hand, the Greek speakers were less consistent in showing final lowering. Specifically, we ran ANOVAs on two subsets of the data to test for the presence of final lowering (see Figure 3). The first subset (panel (a) in Figure 3) included sentences with final accent in penultimate position and differing in inter-accent interval. An ANOVA on these data showed that final lowering did take place and was not affected by differences in inter-accent interval (for two-word vs. three-word sentences, $F(1,88)=27.6$; for three-word vs. four-word sentences, $F(1,88)=149.3$; for four-word vs. five-word sentences, $F(1,88)=111.8$). The second subset (panel (b) in Figure 3) included sentences with even inter-accent intervals but differing in the position of the final accent. This subset showed similar results to the first one: final lowering was evident in all comparisons and was not affected by the position of the final accent. However, in both subsets SENTENCE LENGTH interacted with SPEAKER. *Post-hoc* tests showed that final lowering was consistently present only in the data of GRF1 and GRF2; for GRM1 final lowering was present only in the comparison between three-word and four-word sentences in the second subset of data ($p<0.04$).

Speaker	H1 Mean	H1 s.d.	FL Mean	FL s.d.	Range Mean	Range s.d.
GRF1	235	8	160	11	75	14
GRF2	242	18	140	6	102	18
GRM1	128	5	94	5	34	6

Table 2: Means and standard deviations of H1, FL and pitch range, for each Greek speaker separately.

Further, ANOVAs within sentences of the *same* length but with different inter-accent intervals yielded mixed results. As illustrated in Figure 4a, having more syllables between the last two accents resulted in greater final lowering in four- and five-word sentences ($F(1,44)=5.6$, $p<0.02$, and $F(1,44)=5.3$, $p<0.03$ respectively). In two-word sentences, however, the opposite effect was observed ($F(1,44)=4.3$, $p<0.04$), while results were non significant for three-word sentences.

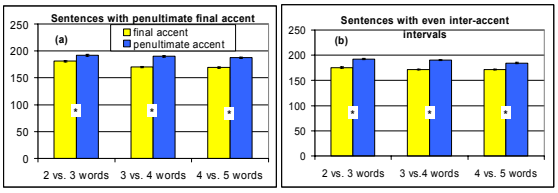

Figure 3: Mean and standarsd error values for final accents in two-, three- and four-word sentences compared to penultimate accents in three-, four- and five-words sentences respectively in two subsets of the Greek data. Asterisks indicate a statistically significant difference between adjacent bars.

Finally, our results showed a significant effect of LAST ACCENT, illustrated in Figure 4b (for two-word sentences, $F(2,66)=3.64$, $p<0.03$; for three-word sentences, $F(2,66)=10.4$; for four-word sentences, $F(2,66)=9.08$; for five-word sentences, $F(2,66)=6.8$, $p<0.02$). Planned comparisons between levels of LAST ACCENT suggest that the later the accent is placed, the lower its scaling. However, LAST ACCENT interacted with SPEAKER in most cases.

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Post-hoc tests showed that for GRM1 there was no effect of accent location. There were some effects for the other two speakers, but these were not consistent. Concretely, in two-word sentences, GRF1 showed higher scaling for antepenultimate accent relative to final accent. The same effect was found in three- and four-word sentences for GRF1 and GRF2, and in five-word sentences for GRF2 only. All other comparisons were non significant.

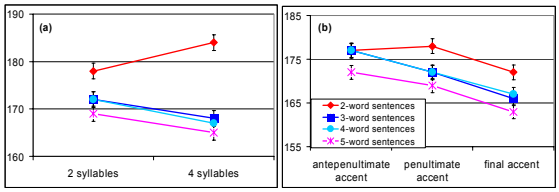

Figure 4: Mean and standard error values for final peaks; panel (a): data from sentences with penultimate final accent presented as a function of inter-accent interval; panel (b): data from sentences with even inter-accent intervals presented as a function of last accent placement.

6. DISCUSSION AND CONCLUSIONS

The results of the experiments confirm that final lowering takes place in both English and Greek: in both languages peaks in final position were significantly lower in scaling that peaks in penultimate position. This effect was present independently of whether extra segmental material was added between the last two peaks in a series. Since these results agree with German, Kipare, Igbo, Japanese and Spanish results that have been reported in the literature, they further strengthen the claim that final lowering is probably a universal phenomenon. In addition, the fact that final lowering did not become more prominent when extra syllables were added between the last two accents suggests that declination plays a small role (if any) in accent scaling (but see [9]). Even in the Greek results, which in some cases did show greater lowering when the inter-accent interval increased from two to four syllables, the differences in scaling were very small (see Figure 4a).

On the other hand, the question whether final lowering is phonologically or physiologically controlled is harder to answer on the basis of the present experiments. The Greek data show some effect of accent placement, suggesting that, in this language, the phenomenon might be physiologically controlled, while the English data point towards a phonological explanation. In both languages, however, the data show variation. In the Greek data, no effect was found for GRM1, and the effect was not robust for the other two speakers. In the English data, EF1 consistently showed greater final lowering when the last accent was closer to the end of the utterance; similar results were found in the data of EF2 for the longer sentences, but not in the data of the other three speakers. Results similar to those of EF1 and EF2 were also obtained in a pilot experiment that included four-and five-word lists elicited from a different set of four speakers. Such variation may be individual or dialectal, an issue that requires further investigation for both languages.

Finally, the English results agree entirely with those of [1], but disagree with the results of [6]. There are two possible explanations for this: first, both [1] and the present experiment used speakers of American English, while [6] used speakers of British English; thus, a dialectal difference might be at play here. Another possibility is that the materials used in [6] did not result in an intonation contour similar to that used in [1], and this is likely to have affected the outcome. More research is necessary using both British and American speakers, and materials that result in comparable contours (as much as possible) to see which of the two interpretations is more likely.

In conclusion, the data from both American English and Greek clearly show that final lowering is an independent phenomenon, and not an epiphenomenon of declination, strengthening the claim that declination is not a crucial factor in accent scaling. On the other hand, the variability observed in both languages regarding the effect that final accent position had on peak scaling suggests that more research is needed on the cross-linguistic origins of final lowering.

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