Variability in $F0$ Valleys: The Case of Belfast English*

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We studied the alignment of the low turning point (L) in Belfast English nuclear rises with respect to a number of factors: anacrusis, segmental structure, sentence type, gender and speech style. The study of variability in low points has been neglected due to a prevailing view that $F0$ peaks are variable whereas valleys are not (e.g. Arvaniti et al, 2000). Significant effects on the alignment of L were found in relation to almost all of the above factors. This reflects high variability of L in contrast to the stability reported elsewhere.

1 INTRODUCTION

1.1 Alignment of Peaks and Valleys

The study of alignment in phonetics involves the examination of high and low $F0$ turning points1 (‘peaks’ and ‘valleys’ respectively) in the intonation contour. The coordination of these turning points in time with respect to specific points in the segmental string (consonants, vowels, syllable edges etc) forms the dominant focus of study. Alignment has become increasingly prominent recently from a number of respects, yet is indebted to Bruce’s (1977) work on the Swedish word accents for much of its foundations. Areas of current interest include the possibility that alignment may feature highly in distinguishing phonological categories in intonation and the possibility that alignment differences may be key to intonational differences between languages/dialects. There has been considerable examination in previous literature of various factors involved in the alignment of $F0$ turning points. However, such examination has focused extensively on the peaks rather than on the valleys (e.g. Silverman and Pierrehumbert, 1990). One potential reason for this is that a number of those authors who have commented on both peaks and valleys have made a rather stark contrast between them. That is, that peaks display a tendency toward variability whereas valleys remain stable (e.g. Caspers and van Heuven, 1993; Arvaniti and Ladd, 1995; Arvaniti et al, 1998, 2000). This contrast is stated quite openly in Arvaniti et al (2000), where it is even touted as a language universal. In Arvaniti and colleagues’ own work on Modern Greek, the H tone (peak) in Greek prenuclear accents is described as being very variable whereas the stability of the L tone (valley) is such that it can be defined as being located at a very fixed segmental anchoring point, ‘approximately 5ms before the onset of the accented syllable’ (1998: 5).

However, there has been some work to suggest that the stability of valleys may not be a language universal. We refer, in particular, to observations made by Ladd (1996) on Glasgow English. Ladd (1996) specifically notes variability in the timing of both valley and peak of Glasgow English rises. Most interestingly, he notes that the low turning point had a tendency to occur before rather than within the accented syllable if ‘enough unstressed

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1 These turning points may be actual $F0$ minima and maxima but not necessarily.

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syllables’ (1996: 144) preceded the accented syllable. So we have here an account of variability in the valley region and also a factor involved in its motivation (i.e. the number of unstressed syllables). It seemed an ideal opportunity to see if Ladd’s observations might be corroborated in other English dialects. This was the starting point for our examination of variability in the valley region of Belfast rises. Belfast and Glasgow English have been related intonationally through their inclusion in a set of dialects termed ‘Urban North British’ (Cruttenden, 1995; Ladd, 1996), whose unifying characteristic is that of a high proportion of rises on statements (falls are more common in Southern Standard British English).

1.2 IViE Project

The data referred to in this article comes exclusively from the corpus of Belfast English recorded in the IViE (Intonational Variation in English) project (Grabe et al, 2001). This project made a notable foray into the study of the intonation of Irish/Northern Irish English dialects by its inclusion of Belfast and Dublin (Malahide) in the nine dialects of English that were studied in total. The phonetic issues studied in the project itself included alignment (Nolan and Farrar, 1999). Belfast was among the dialects studied for that paper. The focus of Nolan and Farrar’s (1999) work on alignment was exclusively on peaks, but discussed the interesting phenomenon of peak lag, in which the peak occurs beyond the accented syllable to which it is deemed to be associated. One of Nolan and Farrar’s (1999) notable contributions was to show that the alignment of the peak could be affected by material preceding the peak (specifically anacrusis) as opposed to being affected only by material following the peak, as had been proposed by Silverman and Pierrehumbert (1990). They found that the presence of anacrusis tends to draw the peak leftwards. This is a point to which we will refer again in section 3.1 below.

Speakers in the IViE project were originally recorded in five different speaking styles. We make reference here to data from two of these speaking styles: Read sentences and Map task.

2 Methodology

This project involved the study of alignment in the valley region of nuclear rises in two speech styles in Belfast English. The point of interest was the low turning point at the beginning of the rise (henceforth L). Analysis was conducted using PRAAT (Boersma and Weenink, 2005). This involved the use of a number of PRAAT scripts and one R script (R Development Core Team, 2006). The R script had the specific function of locating L by means of a line fitting procedure (for further details see Welby and Loevenbruck (in press)). Non-parametric statistical tests were used exclusively in the present study. There were 264 Read sentences in total, of which 193 were analysed. From an initial examination of most of the Belfast Map task corpus, we selected 126 utterances for further analysis. Any utterances without nuclear rises were omitted as were utterances with major perturbations or hesitations in the target region. It proved particularly difficult to find utterances without such perturbations in the Map task corpus, which accounts for the smaller number of utterances that were further analysed there. Both data sets were analysed separately. There were two reasons for this. Firstly, we would be able to see if the same trends emerged across two different data sets. Secondly, it enabled us to examine the two speech styles against each other, to see if differences would emerge in the alignment of L based on speech style.

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2 Preceding unstressed syllables will henceforth be referred to by the term Anacrusis.
3 The nuclear accent is the last pitch accent in the IP (intonational phrase), usually on the IP-final lexical word unless special emphasis (e.g. contrastive focus) is elicited.
Our hypotheses were as follows: simply, that the alignment of L would be affected by a number of factors, beginning with the factor of anacrusis, which had been raised in relation to Glasgow English.

(1) Anacrusis
(2) Segmental structure
(3) Sentence type
(4) Position of accent in the IP
(5) Gender
(6) Speech style

These factors fall roughly into two groups: structural ((1) to (4)) and sociolinguistic ((5) and (6)). We believe that they are not incongruent and as we will show, it is important not to restrict one’s vision of the type of factors that may be involved in alignment.

If at least some of these hypotheses are borne out, it will have shown variability in alignment the valley region in this Belfast data, variability that can be accounted for. If none of the hypotheses are confirmed, it may reflect stability of alignment of the type reported elsewhere or that different variables are needed to account for any variability in the data.

2.1 General Alignment of L

Before examining the effects of the various factors mentioned above, it is useful first to note the general pattern of the alignment of L. Overall, there seems to be a difference with the Glasgow data examined by Ladd (1996), because in this Belfast data there was no strong tendency for L to align before the beginning of the accented syllable. If anything, the tendency was for L to align rather at the end of the accented syllable and possibly beyond it in cases. This is similar to what Lowry (1997) observed in her short treatment of alignment in Belfast English. This strong trend for alignment towards the right edge of the accented syllable has also been noted in rises in Donegal Irish by Dalton and Ni Chasaide (forthcoming). Simultaneous work on Belfast English and Donegal Irish might confirm these similarities in the future.

3 Results

As an initial very brief overview of our results, all hypotheses except one were supported statistically at least in some cases. The one exception was in relation to factor (4) ‘The position of accent in the IP’. As it turned out, there was too little appropriate data for a real examination of the effect of this factor on the alignment of L. The vast majority of nuclear rises in this data were produced utterance-finally so different data would be needed to examine this factor properly. We now proceed to a more thorough examination of the other factors.

3.1 Anacrusis

In relation to L in this Belfast data, we hypothesised that if there were to be such an effect of anacrusis, it would be most evident between cases in which there was only one preceding unaccented syllable and in which there were four or more unaccented syllables. We also

4 Also located in the Ulster region (though Republic of Ireland).
5 Following Ladd (1996: 144), we assumed initially that we would examine the number of ‘unstressed syllables [our italics]’ preceding the accented syllable. From looking at the two examples he provides from Glasgow English however, it appears that he in fact means ‘unaccented’ and not merely ‘unstressed’. Therefore, we re-considered this hypothesis in respect of ‘unaccented’ syllables and not just ‘unstressed’ syllables.
hypothesised that if there were to be such an effect, it would reflect the same tendency as Ladd (1996) had observed for Glasgow i.e. also a leftward pulling effect. Wilcoxon-Mann-Whitney tests (one-tailed) were carried out, comparing the groupings ‘1 unaccented syllable’ and ‘4 or more unaccented syllables’. The distances referred to are those between the beginning of the accented syllable (c1) and L for the Read sentences and between the beginning of the accented vowel (v1) and L for the Map task.6 The results were significant both for the Read Sentences and for the Map Task data (Read sentences: $z = 2.352, p<0.01$; Map Task: $z = 2.322, p<0.025$). So L was indeed aligned earlier in the accented syllable with the increase in the number of preceding unaccented syllables.

3.2 Segmental Structure

The effect on alignment of segmental structure has received a good deal of attention. Previous studies have shown the composition of the syllable rhyme in particular to influence alignment (e.g. Silverman and Pierrehumbert, 1990) though some studies have also shown an effect of the onset (e.g. Rietveld and Gussenhoven, 1995). We must preface this section though, by saying that segmental structure could only be examined in a limited way in the present study. This is because we chose to focus on accented syllables comprising mainly of sonorant segments. These cause the least degree of perturbations on the $F0$ contour and thus make analysis more straightforward. Other studies have examined the effects of segmental structure on the alignment of peaks (in particular) in a less restricted way (e.g. Arvaniti et al, 1998; Rietveld and Gussenhoven, 1995; Welby and Loevenbruck (in press)). The three factors we did examine were Onset/Lack of Onset, Vowel length and Word medial /l/ or /m/. For all of these factors, we simply hypothesised that there would be an effect on the alignment of L. We did not specify the direction of that effect, in contrast with section 3.1 above. Taking the Onset/Lack of Onset factor first of all, we compared the distance between c1 and L in both groupings. Wilcoxon-Mann-Whitney tests (two-tailed) were carried out and the results were strongly significant for both Read sentences and Map task data (Read sentences: $z = 4.579, p<0.001$; Map task: $z = 4.862, p<0.001$). The tendency was for L to be aligned earlier when the accented syllable was onsetless than when it contained an onset.

Next, we turn to the issue of vowel length. The two groupings examined here were Long vowel/diphthong and Short vowels. Previous work showing alignment effects based on vowel length has been carried out by Ladd et al (2000) on Dutch.7 The measurement here was from v1 to L. The results were significant from the Wilcoxon8 test for the Read sentences but not for the Map task (Read sentences: $z = 2.851, p<0.01$; Map task: $z = 0.179, n.s.$). The trend in the Read sentences was for L to be aligned earlier in the Short vowel group. However, a further test on the Map task data, examining if there would be a correlation between the phonetic length of each vowel with later alignment of L yielded a strongly significant result (Spearman-Rank Correlation Coefficient $r_s = 5.785, p<0.0005$). So in both cases, L appears to be aligned earlier if the vowel is at least phonetically short. The tests comparing the groupings of word-medial /l/ or word-medial /m/ in the accented word did not yield significant results in either the Read sentences or the Map task data.

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6 The distance ‘c1 to L’ was also examined in the Map task data but did not yield a significant result.
7 There is also some unpublished work by Ladd and Schepman (mentioned in Atterer and Ladd (2004: 179)) to suggest that vowel length may be involved in alignment differences of the L in British English rises. It is important to remember though, that the vowel length distinction in Belfast English is not the same as in Southern British English (Harris 1985).
8 The Wilcoxon-Mann-Whitney test is hereafter referred to as the ‘Wilcoxon’ test.
3.3 Sentence Type

The reason we chose to examine this variable in the context of the alignment of L was due to Grabe (2002). In her examination of the IViE Belfast data (Read sentences), Grabe found that rises were produced almost exclusively throughout the five different sentence types examined (coordination, declarative, wh-question, y/n question, declarative question). However, higher rises were produced in y/n questions and declarative questions. If speakers use a subtle phonetic mechanism like peak raising to distinguish different sentence types, we hypothesised that they might also use alignment. However, this hypothesis was not confirmed on any great scale. The Kruskal-Wallis ANOVA by ranks carried out for the five different Read sentence types yielded a weakly significant result ($\chi^2 = 9.49, p=0.05$ (df 4)). However, on further examination using Wilcoxon tests, only declarative questions were significantly different from a general grouping of coordination and y/n questions in relation to the alignment of L ($z = 2.479, p<0.02$). The point measured here was from v1 to L. Sentence type could only be examined in a very reduced way in the Map task data, given its more spontaneous nature. The only categories examined here were very general grouping of ‘question’ and ‘non-question’ (includes declaratives, imperatives etc). However, a significant effect on the alignment of L was not found here (Wilcoxon test: $z = 1.438$).

3.4 Gender

The potential that sociolinguistic factors such as gender might have an effect on alignment has been deeply neglected to date. However, there is an exception to this in Fletcher et al (2005), where the possibility of alignment differences between males and females in New Zealand English high rises is raised. The IViE project data offered an ideal opportunity in which to examine potential effects of gender on alignment as an equal number of male and female speakers (6 each) were recorded in each dialect. Our hypothesis here was simply that there would be a difference in the alignment of L between male and female speakers in the Belfast data we examined. Significant results emerged from Wilcoxon tests (two-tailed) conducted on both Read sentences and Map task data. The measurement referred to is the distance between v1 and L in both data sets (Read sentences $z = 5.638, p<0.001$; Map task $z = 2.47, p<0.02$). The trend in both data sets was for the male speakers to have L aligned earlier in the syllable than the females. These significant results motivated an interest to explore alignment and gender a little more so we examined some of the IViE data recorded in Dublin (Malahide). Here we also looked at L in nuclear rises (though such rises are much less frequent in Malahide than in Belfast). Due to this, we carried out a Wilcoxon test on a combined grouping of Read sentences and Map task speech. The result was significant ($z = 2.89, p<0.01$) and again the trend for earlier alignment in the male speakers was the same as we had noted in the Belfast data.

3.5 Speech style

The examination of this variable involved direct comparison between equivalent or quasi-equivalent sets of data from the Read sentences and Map task. We did not find comprehensive evidence of alignment differences between the two styles, though some significant results were achieved and a trend was evident within them. The significant results were achieved in relation to segmental structure, sentence type and gender. When we compared the alignment of L (with respect to c1) in acccentual words With Onsets in the Read sentences and in accentual syllables With Onsets in the Map task, the Wilcoxon test (two-tailed) yielded a result of $z = 2.442, p<0.02$. For the comparison between Onsetless accentual syllables in the Read sentences and Onsetless accentual syllables in the Map task, the result was $z = 2.754, p<0.01$. For accented words with word-medial nasal in the Read sentences and Map task
respectively, the result was 3.637, \( p<0.001 \). In all cases, the trend was for earlier alignment of L in the Map task data. In relation to Sentence type, when we compared the alignment of L (with respect to v1) in a general grouping of Read Sentences ‘questions’ and in the quasi-equivalent Map task grouping of ‘questions’, the result was 3.291, \( p=0.001 \). Again, the trend was for L to be aligned earlier in the accented syllable in the Map task data. The only other significant result we achieved was in the alignment of L (with respect to v1) between the female data from the Read sentences and female Map task data (\( z=3.784, p<0.001 \)). The trend of earlier alignment in the Map task data continued. We must advocate a note of caution on these results. Read sentences and Map task data are of course very different from each other, and it is possible that the significant results that we found are a reflection of the difficulty of finding adequately comparable material rather than displaying any major intrinsic difference in alignment between the two speech styles.

4 SUMMARY AND CONCLUSIONS

This study of the alignment of L in Belfast nuclear rises has revealed a number of issues. First of all, the degree of variability in L was high. The fact that we found a number of different factors involved in affecting the alignment of L (sections 3.1-3.5 above) is testament to this. We found that the alignment of L was affected by Anacrusis (the expected leftward pulling effect), Segmental structure (Presence/absence of Onset; Vowel length; with earlier alignment in onsetless syllable and shorter vowel respectively; Sentence type (very limited effect); Gender (earlier alignment in males) and Speech style (earlier alignment in Map task for elements of segmental structure, female gender etc). These findings stand in contrast to previous studies on other languages which reported the valley region as displaying a much more fixed alignment. It also casts some doubt on the notion of stable valleys as a language universal. What we think to be worthy of some further discussion is the fact that some of the factors which had previously been reported on in relation to the variability of peaks (e.g. anacrusis, segmental structure) have here been shown to affect the valley region too. This suggests to us some erosion of the major contrast between peaks and valleys in alignment that has been made by others, at least in relation to this dialect. In the case of anacrusis, the effect of the valley (a leftward pulling effect) was similar first of all, to what Ladd (1996) had observed in the valley region in Glasgow English. More interestingly perhaps, this leftward effect is similar to that reported on for peaks (including peaks in Belfast data (Nolan and Farrar, 1999)). So we may tentatively suggest some kind of parallel with Nolan and Farrar’s (1999) findings, as there are now some indications that both the peak and the valley region in Belfast English data are affected in a similar way by anacrusis. It is also important to make a similar link between peaks and valleys in relation to some aspects of segmental structure. The factor of vowel length in particular, and also the issue of the presence/absence of an onset (related to the composition of the onset as studied by Rietveld and Gussenhoven, 1995) are factors that have been shown to affect the alignment of peaks. Here we showed that they could also affect the valley region. This Belfast data gives us some evidence therefore, to purport that valley regions may behave quite similar to peaks in some respects in their variability of alignment and in the factors involved in this variability.

The other aspects of the findings that we feel are worthy of note are the results we received in relation to gender and speech style. For gender first of all, we draw attention to the striking trend that emerged across both Belfast and Dublin (Malahide) data and is also evident in Fletcher et al’s (2005) treatment of New Zealand English (accepting that the latter rises are somewhat different). This trend is of course, for the male speakers to display earlier alignment of the low turning point of the rise in all three data sets. Especially as the study of alignment and gender is still in its infancy, we would be very reluctant to claim that the significant results we achieved in Belfast and Dublin must be caused by the gender difference alone, or that there must be either a cross-linguistic or even biological tendency for males to begin rises
earlier. Such claims would be far too forward at this stage. What we do assess though is that the similar trends evident in the Belfast, Dublin and New Zealand English data point to an evident need for much greater examination of the role of gender in alignment generally. Turning to speech style, though we stress that we did not find comprehensive evidence of differences in alignment of L between the two styles, we did find some differences and a trend uniting them. Again, we must be cautious about drawing absolute conclusions from these results, as explained at the end of section 3.5 above. Nevertheless, taking the results at face value, they would not entirely support Lickley et al’s (2005) view that Read speech data is wholly representative of the phonetic realisation of intonational events. Alignment differences such as those we found are indeed differences in phonetic realisation. We would advocate rather that more spontaneous speech data should be included in alignment studies until such time as Lickley et al’s findings are replicated on a much greater scale.

We would not wish to claim that this is the only study which has uncovered variability in the valley region. Of course, it was the observations of Ladd (1996) on Glasgow English, which provided the impetus for conducting the present study. In addition, Welby and Loevenbruck (in press), for example, also report variability in the valley region of the French late rise. Future work would involve looking at some important variables which we omitted to examine in the present study. Most prominent among these is perhaps Speech Rate, which has been examined in other studies of alignment (including Welby and Loevenbruck (in press)). Another direction would be examining the alignment of the Belfast peaks to see if they would be affected by segmental structure in the same way as the valleys have shown to be here. We would also need to tackle a crucial issue, astutely highlighted by Atterer and Ladd (2004). They observed that it is as yet unclear what reference point should be used by which to measure alignment e.g. should it be a segment, a syllable or a unit larger or smaller than these? There is an absence of an appropriate framework on which to base one’s decision but yet there will be statistical consequences of one’s choice. This issue was impressed on us in this study by the fact that we attained a significant result when measuring the alignment of L with respect to v1 but no significant result when measuring from c1 in the Read sentences for example, and then finding exactly the reverse in the Map task data for the same variable (e.g. anacrusis) (see section 3.1 above). As an overall theoretical concern, therefore, it would seem that unless soon resolved, it could prove a major stumbling block to progressing the field generally. These and other issues remaining, however, we conclude this treatment of alignment of L in Belfast nuclear rises for the moment, at its current state of development.

REFERENCES


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