The influence of vowel quality and syllable structure on the temporal organization of pitch accents in Berlin German

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ABSTRACT

The main goal of this study is to test the temporal organization of pitch accent realization in the context of two different vowels, hypothesizing that intrinsic duration does not have an effect. Secondly, temporal organization is tested on different syllable structures with decreasing voicing time, showing that the same pattern of temporal organization can be found on different syllable structures. Assuming cross-dialectal differences in the realization of pitch accents, this study examines the above questions in Berlin German. The rate of F0-change which is measured by dividing F0-excursion on a test item by its F0-duration is chosen to measure the temporal organization. While a significant difference in duration between phonologically long and short vowels is found, no significant durational differences are found between /i/ and /a/. Results show that falling and rising accents get truncated. Similar results can be found on different syllable structures.

1. INTRODUCTION

The issue of temporal organization of accent realization goes back to the early studies of [1], [2], and [3]. These studies analysed the course of fundamental frequency as a function of vowel duration in accented position. A shared interest of these studies was to provide insights in the tonal distinction between Accent I and Accent II in Swedish. Realizational differences in F0 and duration were, thus, identified as acoustic correlates of accent type. Two hypotheses were tested by systematically shortening the vocalic and voiced part of the accented syllable: if the voiced part of the syllable is considerably shorter, the fundamental frequency may (1) “be identical initially but be cut off at the end of the voiced period” [1], i.e. truncated, or (2) be affected by means of a temporal reorganization in which the fundamental frequency change enlarges. The latter was called “rate adjustment” by [1] and “compression” by [2].

The study by [1] was based on nonsense words and concentrated on phonological vowel length distinction in Accent II words. The studies [2] and [3], on the other hand, were based on naturally occurring words and focussed on phonological vowel length distinctions in both Accent I and Accent II words. For the Standard variety of Swedish spoken in the Stockholm area, both [1] and [2] found a truncation pattern in Accent II words when less sonorant material is available in the accented syllable. Moreover, the studies by [2] and [3] compared subjects from different regions of Sweden, all of whom spoke a local variety. The results showed variation which depended on dialect variation: a compression pattern in the south eastern area and a truncation pattern in the other areas. However, it is a problem that the results are based on only one speaker per region and have thus not been proved statistically.

Recently, [4] and [5] re-invented the analysis method of truncation and compression and assumed the acoustic measure of *rate of F0 change* to be a correlate of realizational properties of pitch accents. In these studies, realizational properties of Southern British English were compared with Northern Standard German in order to systematically account for different realizations in the languages. Both rising and falling nuclear pitch accents were considered. In contrast to [1], [2], and [3], the goal of [4] and [5] is to explain surface phonetic variation that refers to the same phonological tonal categories. Furthermore, in a cross-dialectal study on English varieties, [6] provided a systematic account for cross-dialectal differences in pitch accent realization. The results showed, on the one hand, that the same tonal category is realized in different ways in different dialects, and, on the other hand, that different realizations may reflect one and the same tonal category. These findings support the evidence for cross-dialectal differences in the accent realization of one language which was found for Swedish by [2] and [3]. The results emphasize the importance of dialectal data in order to account for intonational variation.

The present paper examines whether the intrinsic duration of two vowels differing in vowel height has an effect on the temporal organization. It is hypothesized that the temporal pattern found for an accent type will not differ between different vowels. Additionally, this study compares the temporal organization of pitch accent realization on syllable structures with decreasing voicing time. The question is whether we may observe the same temporal organization in test items with less voicing time in syllables as in those with maximal voicing, i.e. voiced onset and coda. Based on the above discussion about dialectal variation, this study will examine Berlin German in order to keep the variation in speech materials as minimal as possible. On the basis of a study on Berlin German [7], we expect a truncation pattern for falling accents; for rising accents, however, no predictions will be made since [7] only considers falling accents.

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2. METHOD

Speech materials. As [4] and [5], I assume that F0 will be modified throughout the accented syllable, and therefore I chose test items that varied in F0 duration. To test the influence of vowel quality, the high unrounded front vowel /i/ and the low unrounded vowel /a/ were embedded in syllables with unvoiced onset and unvoiced coda. To test different syllable structures, additional syllables with unvoiced onset and voiced coda, and voiced onset and voiced coda were chosen (see Table 1 for the speech materials used in this study). Additionally, the names chosen varied in number of syllables (one and two). Following [4], test items were embedded in carrier sentences like *Das ist doch Herr Schief!* ‘It’s Mr. Schief!’ to elicit falling intonation, and like *Ist das nicht Herr Schief?* ‘Isn’t that Mr. Schief?’ to elicit rising intonation.

vowel type	2 syllables		1 syllable	
/i/	ʃi:fəɐ	ʃɪfəɐ	ʃi:f	ʃɪf
/a/	ʃa:fəɐ	ʃafəɐ	ʃa:f	ʃaf
/i/	ʃi:ləɐ	ʃɪləɐ	ʃi:l	ʃɪl
/a/	ʃa:ləɐ	ʃaləɐ	ʃa:l	ʃal
/i/	li:nəɐ	lɪnəɐ	li:n	lɪn
/a/	la:nəɐ	lanəɐ	la:n	lan

Table 1: Speech materials used in this study.

Recordings. 10 male speakers were recorded on a portable DAT-recorder. However, one of the speakers had to be ignored for analysis since he consistently failed to produce the desired intonation patterns. All subjects were born and raised in the urban area of Berlin. Subjects were provided with lists of sentences on a paper and were asked to read every sentence in the same way. Instructions were, as in [4], that the recordings will serve as a “pronunciation drill for non-native speakers”. An introductory paragraph was given in order to build up the scene for the subsequent sentences. Additional fillers at the end of each list prevented us from downstepped test items.

Analyses. Speech data were digitized at a sampling rate of 16 kHz, 16 bit, and transcriptions and acoustic analyses were performed using Praat (© 1992-2003 Boersma & Weenik). Following [4], the rate of F0 change was assumed to be the acoustic correlate of truncation and compression. The work by [4], [5], [6], and [7] proved that this measurement resulted in reliable and systematic data for each language or dialect under consideration. Rate of F0 change is defined as follows: “The measure was calculated by dividing the maximum F0 excursion on a test word by F0 duration for that word, as measured from the F0 trace” [5]. This algorithm measures the highest and lowest points of the F0 curve from left to right in the accented syllable.

The accent patterns, used in this study, are shown schematically in Fig. 1. Rate of F0 change (E_{rel}) was calculated on the basis of the formulas given in Equation (1). The frequencies f_1, f_2, f_3, and f_4 are the F0 measurements taken at the corresponding time points, which can be seen in Fig. 1. The value of F0 excursion (E) of the accented syllable was calculated as the sum of the difference between two adjacent F0 measurement points, as in Equation (1a). The time measurement t_4 - t_1 is equivalent to the F0 duration of the accented syllable.

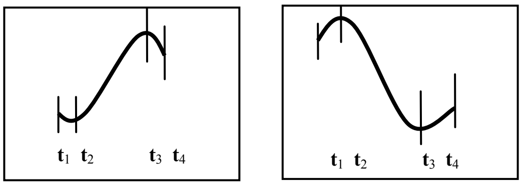

Figure 1: Measuring points on the F0 curve of the nuclear rising (left) and the nuclear falling pitch accent (right).

$$E = \sum_{i=1}^{3} | f_i - f_{i+1} | \quad \text{(a)} \quad E_{rel} = \frac{E}{t_4 - t_1} \quad \text{(b)} \quad (1)$$

If the accent shape differs from the prototypical one, either f_1 and f_2 or f_3 and f_4 get the same F0 value. In other words, a rising accent need not be realized with a slight fall at the beginning of the syllable down to the F0 minimum, nor need it be realized with a slight fall after the accent peak up to the end of the syllable. The same holds for falling accents.

3. RESULTS: VOWEL QUALITY

Since the effect of pitch accent realization is highly time dependent, we first have to support the assumed differences in F0-duration on the test items. Therefore, an ANOVA was carried out with vowel type as a variable. The results for the falling accent showed that the duration of F0 decreases significantly from the longest to the shortest test item ($F[3,32] = 8.48$, $p < 0.001$ for /i/ and $F[3,32] = 15.68$, $p < 0.001$ for /a/). Post hoc t-tests showed that, in all cases, the test item with the phonologically longer vowel has significantly longer duration of F0 than its counterpart, e.g. /ʃi:f/ vs. /ʃɪf/ ($p < 0.05$). Similar results for rising accents were found ($F[3,32] = 25.30$, $p < 0.001$ for /i/ and $F[3,32] = 25.56$, $p < 0.001$ for /a/).

Comparing these two vowels with each other, a significant effect of vowel type was observed ($F[7,62] = 10.63$, $p < 0.001$ for falling accents and $F[7,64] = 21.81$, $p < 0.001$ for rising accents). However, post hoc t-Tests revealed that each variable group, e.g. long /a/ compared to long /i/, showed no significant difference in F0-duration ($p > 0.05$). Fig. 2 presents the mean duration of F0 for falling accents and Fig. 3 shows the same for rising accents.

Having established that F0 duration on the test items systematically decreases from the bisyllabic word with a long vowel to the monosyllabic word with a short vowel, statistical analyses on the results of rate of F0 change were carried out. Analysis of Variance for the factor word length for each of the two vowels for both falling and rising accents revealed no significant effect ($F[3,30] = 0.37$, $p > 0.05$ for /i/ in falling accents, $F[3,32] = 1.52$, $p > 0.05$ for /i/

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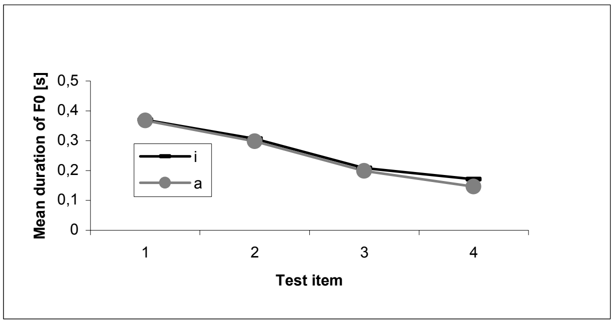

Figure 2: Mean duration of F0 on test item with falling accents; 1 is [ʃVːfəɐ], 2 is [ʃVfəɐ], 3 is [ʃVːf], and 4 is [ʃVf].

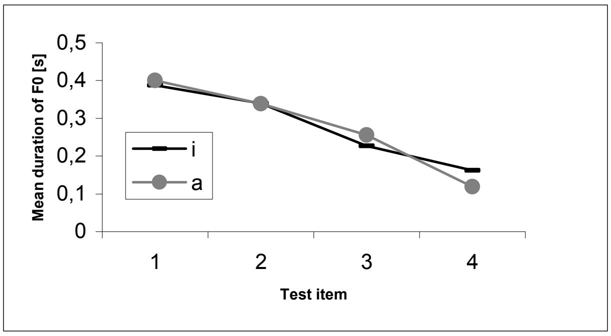

Figure 3: Mean duration of F0 on test item with rising accents; 1 is [ʃVːfəɐ], 2 is [ʃVfəɐ], 3 is [ʃVːf], and 4 is [ʃVf].

in rising accents, $F[3,32] = 0.56$, $p > 0.05$ for /a/ in falling accents, and $F[3,32] = 0.80$, $p > 0.05$ for /a/ in rising accents). Subsequent post hoc t-tests supported the view that within each group, e.g. falling accents on test items with the vowel /i/ (Schiefer-Schiffer-Schief-Schiff), no significant effect was observed between the long and short vowels for both bisyllabic and monosyllabic words (all above the 0.05 level). The means of rate of F0 change are given in Fig. 4 for falling accents and in Fig. 5 for rising accents.

The graph given in Fig. 5 seems to point to a compression pattern for rising accents. However, we did not find any significant differences in the rate of F0-change. If we had a compression pattern, we would expect such differences in the rate of F0-change. Thus, we have to conclude that both rising and falling accents are truncated in Berlin German.

Comparing the two vowels with each other, again, no significant effect was found ($F[7,62] = 0.96$, $p > 0.05$ for falling accents, and $F[7,64] = 1.19$, $p > 0.05$ for rising accents). Thus, we found no significant differences between the two vowels according to pitch accent realization. We can conclude that vowel quality has no effect on the temporal organization of pitch accent realization.

4. RESULTS: SYLLABLE STRUCTURE

In this section, we will concentrate the analysis on test

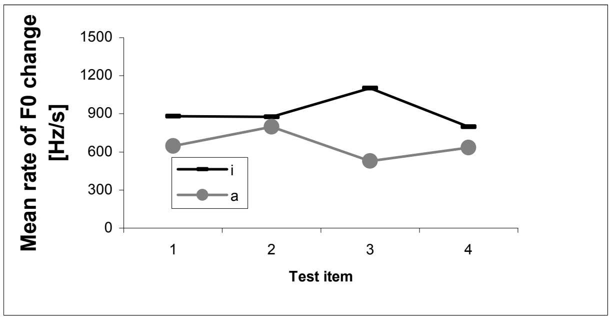

Figure 4: Mean rate of F0 change on test items with falling accents; 1 is [ʃVːfəɐ], 2 is [ʃVfəɐ], 3 is [ʃVːf], and 4 is [ʃVf].

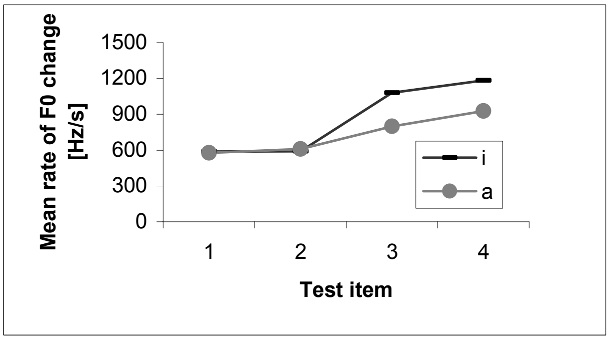

Figure 5: Mean rate of F0 change on test items with rising accents; 1 is [ʃVːfəɐ], 2 is [ʃVfəɐ], 3 is [ʃVːf], and 4 is [ʃVf].

items with the high unrounded front vowel /i/ since we did not find any influence of vowel quality. Moreover, we will limit the analysis to monosyllabic test items since we want to demonstrate that we will find the same temporal pattern as before on syllables that differ in duration of voicing. As before, the analysis of duration of test items has to establish a difference in F0-duration between the conditions. The results for the falling accent showed that duration of F0 decreases significantly from the fully voiced to the minimally voiced test item ($F[2,23] = 4.53$, $p < 0.05$ and $F[2,24] = 7.51$, $p < 0.005$ for syllables with long and short vowel, respectively, with falling accent, $F[2,24] = 5.53$, $p < 0.05$ and $F[2,23] = 11.55$, $p < 0.001$ for syllables with long and short vowel, respectively, with rising accent), as illustrated in Fig. 6.

Moving on to the analysis of rate of F0-change for different syllable structures, Fig. 7 presents the results for the falling intonation pattern, and Fig. 8 presents the results for the rising one. Although we found that F0-duration decreased significantly, we found no significant effect for rate of F0-change on syllable structures with falling accents ($F[1,16] = 0.50$, $p > 0.05$ for fully voiced syllables, $F[1,15] = 0.001$, $p > 0.05$ for syllables with unvoiced onset but voiced coda, $F[1,16] = 0.70$, $p > 0.05$ for minimally voiced syllables). The same holds for rising accents ($F[1,16] = 0.01$, $p > 0.05$ for fully voiced syllables, $F[1,15] = 0.32$, $p > 0.05$ for syllables with unvoiced onset but voiced coda, $F[1,16] = 0.05$, $p > 0.05$ for minimally voiced syllables). Since we found no significant differences for each syllable

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type, we can conclude that a truncation pattern is also observed for falling and for rising accents in syllables with longer duration of F0.

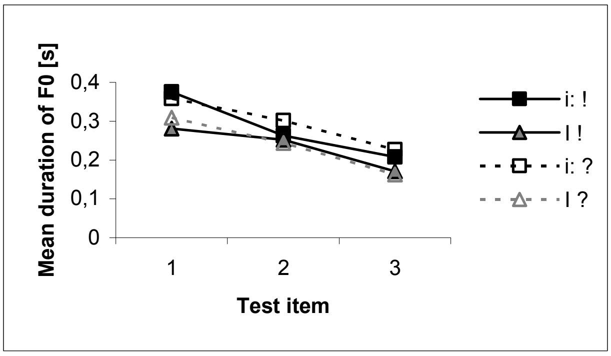

Figure 6: Mean duration of F0 on test items, where the long vowel is compared to the short one; dotted lines correspond to rising, full lines to falling intonation; 1 is [lVn], 2 is [ʃVl], 3 is [ʃVf].

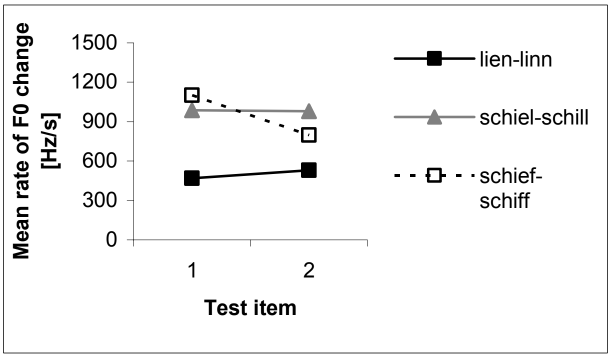

Figure 7: Mean rate of F0 change on test items with falling intonation; 1 contains the long vowel and 2 the short one.

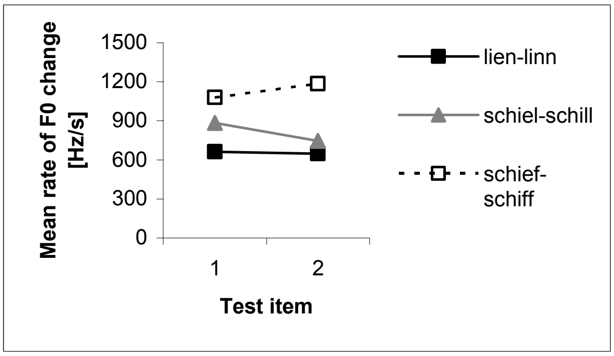

Figure 8: Mean rate of F0 change on test items with rising intonation; 1 contains the long vowel and 2 the short one.

5. CONCLUSIONS

This study is about the temporal organization of pitch accent realization. We have shown, that vowel quality has no effect on pitch accent realization. For the two vowels tested, i.e. /i/ and /a/, we found truncation for falling and rising accents when less sonorant material for accent realization was available. The results for falling accents support the findings by [7]. For rising accents, Berlin German seems to truncate as well. This result supports the reported differences between varieties of a language; see [6]. While for Braunschweig German (a variety of Northern German) compression for rising accents was found [5], in Berlin we found truncation.

It remains unclear why test items with voiced onset and voiced coda have the lowest rate of F0-change in comparison to syllables with less voicing (cf. Figs. 7 and 8). However, comparing long and short vowels for each syllable type (cf. Figs. 7 and 8) the same pattern as shown above arises: since no significant differences for each syllable type were found, we have to conclude that a truncation pattern is observable even on syllables with an increase in voicing time. Concerning fully voiced syllables, it might be the case that onsets do not have an effect on pitch accent realization and that duration of F0 should be restricted to the syllable rhyme. Further research has to be done on this issue.

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