Speech Prosody 2002
Aix-en-Provence, France
April 11-13, 2002

Realisations of Nuclear Pitch Accents in Swabian Dialect and Parkinson's Dysarthria: a Preliminary Report

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Abstract

The phonetic realisation of pitch accents associated with little sonorant material varies between languages and dialects. For speakers of Northern Standard German it has been shown that nuclear falling accents are truncated while rising accents are compressed. In order to further investigate effects of the German Swabian dialect native Swabian speakers were investigated with regard to truncation and compression. In addition, two Swabian speakers suffering from Parkinson's disease were examined, because basal ganglia dysfunction – a typical morphological trait of parkinsonian subjects - is frequently accompanied by dysarthophonia. Results of the present study indicate that there is no dialect-specific effect between Northern Standard German and Swabian. In contrast, Swabian parkinsonian subjects show compression both in rising and falling nuclear pitch accents. Further investigations of the timing concept (alignment) of the H* peak in monosyllabic test items with nuclear falling accents (H*L) reveal different timing concepts of parkinsonian subjects as compared to healthy control subjects.

1. Introduction

1.1. Truncation and compression

The phonetic realisation of accents associated with little sonorant segmental material can differ between languages and dialects. Erikson and Alstermark [5] were the first to suggest that there are two different strategies to realise the Swedish *grave accent (accent II)* depending on phonological vowel length: *truncation* and *compression*. The falling pitch contour of phonological short vowels ending early, that is most of the fall tending to obligerate, was referred to by the authors as *truncation* (fig. 1a). However, for the fundamental frequency (F0) contour of short vowels falling faster than those of long vowels, a temporal reorganisation of the tonal contour takes place, which was referred to as *rate adjustment* (later: *compression*, fig. 1b).

In Swedish, Bannert and Bredvard [2] showed dialect specific effects regarding the occurrence of truncation or compression *(rate adjustment)*. Furthermore, Grønnum [7] described truncation of F0 contours in short stress groups for some Danish varieties as well as compression and truncation for speakers of a variety of Northern German. In cross-linguistic experimental studies of English and Standard German, Grabe [6] investigated the realisation of phrase-final falling and rising pitch accents. She provided evidence for different realisations of falling pitch accents when associated with little sonorant material (e.g. the German word *Schift* where a short vowel is surrounded by voiceless consonants): Speakers of English showed compression as opposed to those of Northern German who showed truncation. Phrase-final rising pitch accents were compressed in both languages.

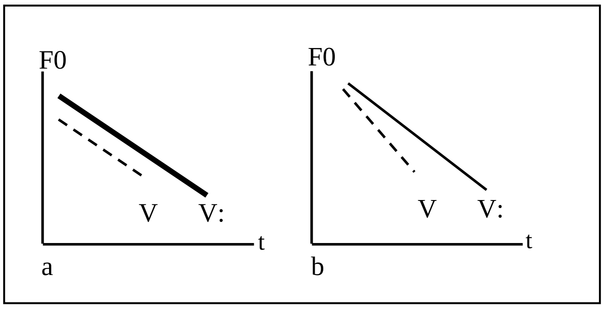

Figure 1: Schematic representation of truncation (a) and compression (b) adapted from [5]. V= short vowel; V:= long vowel. F0= fundamental frequency; t= time.

1.2. Dysprosodia in Parkinson's disease

In patients with basal ganglia dysfunctions such as Parkinson's disease (PD), speech motor control is compromised. In their comprehensive work Darley, Aronson and Brown [4] reported that prosodic alterations like monotony of pitch, reduced stress, and monotony of loudness represent the most salient auditory-perceptive symptoms of parkinsonian dysarthria. Parkinsonian patients were chosen for evaluation of truncation and compression because dysprosodic symptoms in these subjects may possibly be expressed by deviant phonetic realisations as compared to non-dysprosodic subjects.

1.3. Aim of the study

The aim of the present study was to investigate the following questions:

- Do dialect specific effects arise for speakers of Northern Standard German and Swabian (a south German Dialect) with respect to truncation and compression?
- Do parkinsonian subjects adopt the same strategy in realising phrase-final falling and rising accents as do normal controls?
- Do normal controls and parkinsonian subjects realise the same timing concept (alignment) of the H* peak in vowels with nuclear falling accents (H*L)?

2. Material and methods

The experimental design was in most of the parts adapted from Grabe [6] in order to gain comparability with her experimental data.

2.1. Subjects

Two male subjects suffering from idiopathic Parkinson's disease (PD) were recruited:

- PD_B: A 68-year-old native Swabian speaker with mild dysarthrophonia,
- PD_R: A 63-year-old native Swabian speaker with mild dysarthrophonia.

A group of ten age-matched native Swabian speakers (NC) was investigated, comprising

- 5 female and 5 male subjects aged in the range of 48 to 75 years, born in Baden-Württemberg with no history of previous neurological disease.

2.2. Speech material

Test words were constructed of nine surnames containing /a/, /i/ and /u/ vowels. By variation of the number of syllables *(two vs. one)* and phonological vowel length *(short vs. long)* a systematic manipulation of voiced material of the test words was realised, resulting in the following combinations:

/ Sch**ie**fer - Sch**ie**f - Sch**i**ft / [i:-i:-I]
/ Sch**aa**fer - Sch**a**f - Sch**a**ft / [a:-a:-a]
/ Sch**uh**fer - Sch**u**f - Sch**u**ft / [u:-u:-U]

The resulting three sentences per vowel group were presented within a semi-randomised sentence list in the following order:

bisyllabic word with long vowel *(lvw2)*
monosyllabic word with short vowel *(svw)*
monosyllabic word with long vowel *(lvw1)*

Test items were embedded in carrier phrases in phrase-final position and set in a context which elicits falling *(declaratives)* and rising pitch accents *(yes/no-questions*). Each item occurred six times per accent type. Subjects were instructed to read aloud the introductory paragraph and the sentence list in a non exaggerated manner.

Introductory paragraph:
"Anna und Peter sehen fern. Ein Lottogewinner wird vorgestellt. Anna sagt: Na sowas!"

(Anna and Peter are watching TV. A photograph of this week's National Lottery winner appears. Anna says: 'Look!')

Carrier phrases for falling accents:
Das ist doch Herr /**Schiefer/Schief/Schift/**! Unser neuer Nachbar!"

(It's Mr. [...]! Our new neighbour!')

Carrier phrases for rising accents:
Ist das nicht Herr **/Schiefer/Schief/Schift/**? Unser neuer Nachbar?

(Isn't that Mr. [...]? Our new neighbour?)

2.3. Recording procedure

Recordings were taken in a sound-proof room at the Phonetics Department of the Institute of Natural Language Processing (IMS), University of Stuttgart, digitised at a sampling rate of 16 kHz/16 bit. Data analysis was carried out on a SGI work station using the signal processing package ESPS/xwaves (Entropic Inc.).

2.4. Acoustic measurements

The "rate of F0 change" *(Sigma)* was chosen as acoustic correlate for truncation and compression (fig. 2). However, unlike the procedure in [6], a speaker normalisation of mean frequency *(mean_f0)* and speaking rate *(vowel_dur)* was performed for calculation of *Sigma*:

$$f0\_exc = f0max - f0min \quad (1)$$

$$Epsilon = f0\_exc / mean\_f0 \quad (2)$$

$$Delta = f0\_dur / (vowel\_dur - f0\_dur) \quad (3a)$$

$$Delta = f0\_dur / (mw\_vowel\_dur - f0\_dur) \quad (3b)$$

$$Sigma = Epsilon / Delta \quad (4)$$

$$Alignment = (vowel\text{-}dur - f0\text{-}dur) / vowel\_dur \quad (5)$$

F0 excursion *(f0_exc)* of a test word was calculated by subtracting the lowest from the highest frequency point of the F0 movement of the sonorant section (eq. 1) normalised to the mean fundamental frequency of each speaker (*Epsilon;* eq. 2). The duration of F0 excursion *(f0_dur)* was normalised to the speaking rate of each subject *(Delta)* by dividing by the duration of the constant F0 course *(vowel_dur – f0_dur)* (eq. 3a) in falling accents, and by dividing by mean vowel length of monosyllabic items *(mw_vowel_dur – f0_dur)* in rising accents (eq. 3b). *Sigma* was calculated by division of Epsilon by Delta.

Alignment of H* peak was computed by dividing the duration of the beginning of the sonorant section to F0 peak *(vowel-dur - f0-dur)* by the vowel duration (eq. 5).

The duration measurements on bisyllabic words included the section where the F0 contour is interrupted (fricative /f/), and F0 excursion was measured over the whole word [6].

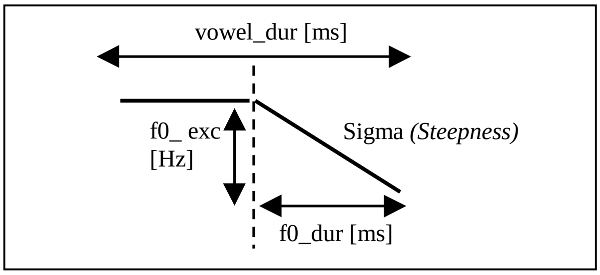

Figure 2: Acoustic analysis of rate of F0 change (Sigma).

2.5. Statistical analysis

Mean values for vowel duration, rate of F0 change, and alignment of H* peak as well as standard deviations were calculated for normal controls and parkinsonian speakers. The Mann-Whitney-U-Test was used to analyse differences of vowel duration, *Sigma* and alignment of H* peak between normal controls and parkinsonian subjects.

3. Results

The analysis of rising pitch accents was performed for all except one subject of the normal control group *(NC_FDi)* and the parkinsonian patient PD_B. Both speakers did not realise rising pitch contours (L*H) but falling pitch contours (H*L).

3.1. Vowel duration

Results indicate that all subjects (NCs, PD_B, PD_R) realise a significantly different vowel duration in long vowel (lvw2, lvw1) and short vowel test items (svw). Furthermore, NC and PD_B show significant differences of vowel duration from the longest to the shortest test item, whereas PD_R did not show significant differences in vowel duration between longest (lvw2) and mid-length test items (lvw1) (fig. 3).

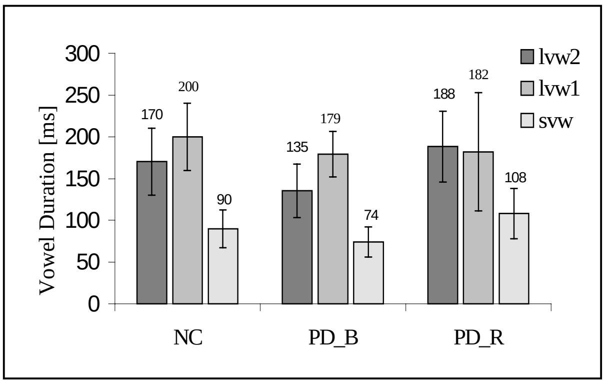

Figure 3: Vowel duration. NC= normal controls, PD_B/PD_R: parkinsonian subjects. lvw2= bisyllabic test items with long vowel; lvw1= monosyllabic test items with long vowel; svw= monosyllabic test item with short vowel

3.2. Truncation vs. compression

Phrase-final falling pitch accents
Healthy Swabian subjects (NC) truncate nuclear falling pitch accents (H*L) in test items containing short vowels (svw). Parkinsonian subjects PD_R and PD_B show compression on phrase-final falling pitch accents.

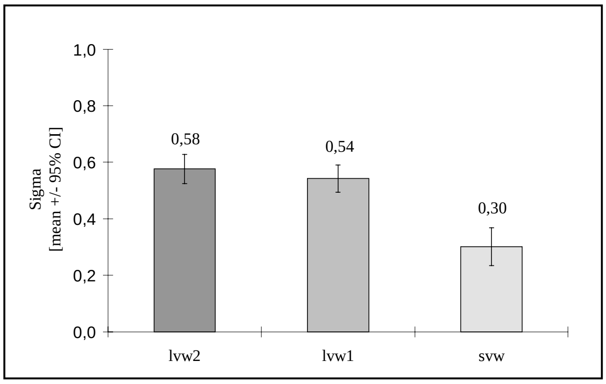

Figure 4: Rate of F0 change (Sigma) for falling accents in normal controls (NC).

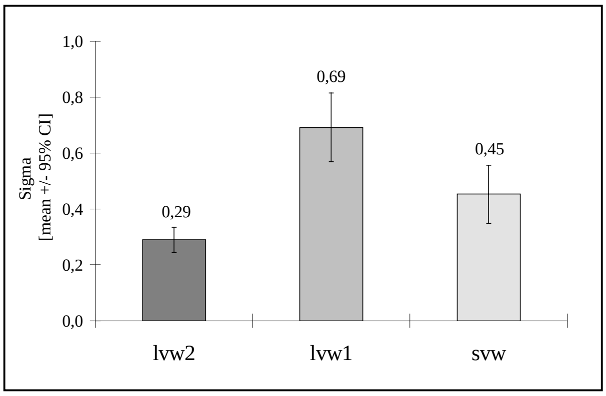

Figure 5: Rate of F0 change (Sigma) for falling accents in parkinsonian patient PD_R.

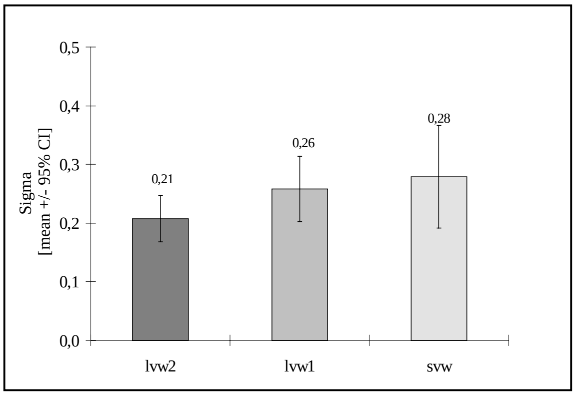

Figure 6: Rate of F0 change (Sigma) for falling accents in parkinsonian patient PD_B.

Phrase-final rising pitch accents

Swabian subjects (NC) and parkinsonian patient PD_R compress nuclear rising pitch accents (L*H).

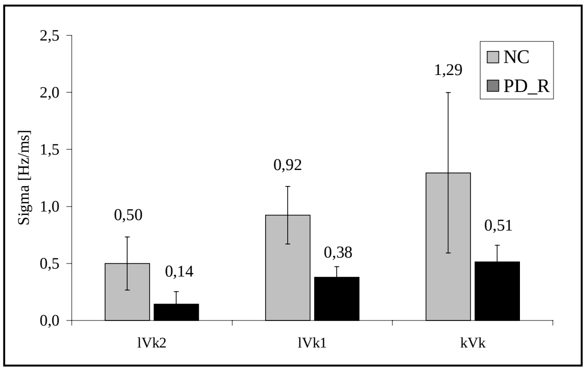

Figure 7: Rate of F0 change (Sigma) for rising accents in normal controls (NC) and PD_R.

3.3. Alignment

All subjects (NC, PD_B, PD_R) show significantly different realisations in timing of the H* peak between /a/- vowels on the one hand and /i/ and /u/ vowels on the other hand, meaning that f0 peaks in /a/ vowels appear later than in /i/- and /u/ vowels. In all vowel groups PD_B shows significantly earlier H* peak alignment than all other subjects (PD_R, NCs). There is no difference in peak alignment regarding phonological long and short vowels.

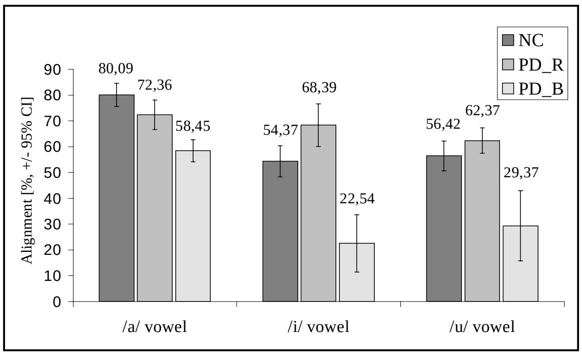

Figure 8: Alignment. NC= normal controls, PD_B/PD_R= parkinsonian subjects.

4. Discussion

Comparison of results in the present study for native Swabian speakers with previous experiments by Grabe [6] disclose no differences in phonetic realisations of phrase final falling and rising pitch accents. For Northern Standard German as well as for the Swabian dialect truncation is observed in falling and compression in rising pitch accents associated with little sonorant material. As far as parkinsonian patients are concerned there is a controversial debate whether dysprosodic speech symptoms are restricted to motor speech disorders due to akinesia and rigidity of the laryngeal and respiratory musculature [1], or whether dysprosody is accompanied by higher planning deficits [3]. Only two subjects suffering from Parkinson's disease were investigated in the present study. Hence, results have to be interpreted cautiously. Both patients exhibit compression for rising as well as for falling pitch accents. In general, PD_B shows a preference for a falling intonational pitch pattern which could be interpreted as a hint for a reduced inventory of intonational patterns. This phenomenon has also been observed in ongoing analyses of spontaneous speech in this subject. However, in general both parkinsonian subjects show preserved categorical aspects of pitch accents with only moderate deviations in quantitative measurements as compared to normal controls. This has become evident in the present study when analysing the timing concept (alignment) of the H* peak in monosyllabic test items with nuclear falling accents. All subjects (NC and PD) revealed different timing realisations between vowel groups without differences in peak alignment regarding phonological vowel length. Among two parkinsonian subjetcs investigated in the study, one patient exhibited significantly earlier F0 peaks than all other subjects, while the second patient did not significantly differ from normal controls. It would appear, then, that the results of the experiments in parkinsonian patients are due to disturbed motor control as proposed by Hertrich and Ackermann [8], rather than to impaired processing at the cognitive planning level.

5. References

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