

Unstressed vowels in non-native German

Ulrike Gut

English Department
University of Freiburg, Germany
ulrike.gut@anglistik.uni-freiburg.de

Abstract

Vowel reduction and deletion are prominent correlates of stress in German and some preliminary investigations have suggested that this constitutes an area of difficulty for non-native speakers. This paper explores the production of vowels in unstressed syllables by learners of German, focusing especially on the acoustic properties duration and formant structure. It is shown that the realization of unstressed vowels in non-native German is influenced by the speakers' native language (L1), but not by speaking style.

1. Introduction

Vowel reduction and deletion are two of the most prominent speech processes correlated with stress in German. On the physiological side, vowel reduction involves that, compared to their stressed counterparts, unstressed vowels are produced with a more central position of the tongue, a much narrower jaw-opening and a loss of lip-rounding, especially in the back-rounded vowels [2]. The acoustic correlates of this can be observed in the duration and quality of vowels in unstressed syllables and the weak forms of function words. The degree of vowel reduction depends on speaking style and speaking rate. In most speaking styles in German, all post-stress unstressed syllables are reduced to a schwa [9]. In connected speech, these vowels may even be deleted. In a corpus analysis of German speech, Helgason & Kohler [7] found that 59% of all vowels in post-stress syllables were deleted. The vowel in C+<en> syllables (i.e. syllables consisting of any consonant plus the <en> morpheme), which occur frequently in verb endings (e.g. *laufen* [to run]), was deleted in 93% of the cases. Investigating only plosive+<en> syllables, Kohler [9] found that vowel deletion is slightly higher in function words than content words and more common in spontaneous speech than in reading passage style. Vowel reduction processes have been variously suggested to constitute areas of difficulty for second language learners. Yet, only a small number of studies have so far been concerned with the phonetic quality of unstressed vowels in non-native German. In the following section, previous findings on vowel reduction in non-native German will be discussed. Section 3 describes the methodology of the present investigation and section 4 presents the results. These are summarized in section 5.

2. Vowel reduction in non-native German

Only two studies so far have investigated vowel reduction in non-native German. Kaltenbacher [8] analysed vowel reduction processes in words spoken in isolation and embedded in short phrases. Based on the assumption that native language structures would become evident in L2 productions, she asked native speakers of English, Russian and Japanese to imitate and read a list of sentences and then

analysed a number of target words. As expected, English speakers showed vowel reductions in unacceptable places for German speakers, mainly in word-initial unstressed syllables, and produced reduced vowels in function words not compatible with German phonology. The Russian native speakers, conversely, showed a tendency to reduce vowels in word-final syllables in inappropriate places. The Japanese native speakers, finally, failed to produce the required vowel reductions in unstressed syllables.

Gut [6] reports that non-native speakers of German produce, in the same passage, an overall lower amount of reduced vowels than native speakers. She also analysed the duration of full and reduced vowels produced by non-native speakers of German with three different native languages. She calculated the syllable ratio by dividing the length of each full-vowelled syllable by the length of a following syllable with a reduced or deleted vowel and averaging the sum of all ratios by their total number. This measurement indicates the durational difference between syllable pairs consisting of syllables with full vowels and syllables with reduced or deleted vowels, thus reflecting the effect of vowel reduction. For German native speakers, full-vowelled syllables are on average 1.87 times longer than syllables with reduced or deleted vowels. All non-native speakers of German, in contrast, show a significantly lower ratio between the duration of non-reduced syllables and adjacent reduced ones. Syllables with full vowels are on average only 1.5 times longer than syllables with reduced vowels. This suggests that reduced vowels produced by non-native speakers are longer than those produced by native speakers. Comparing the durational extent of vowel reduction among non-native speakers with different L1s, Gut [6] suggests that the lack of durational difference between full-vowelled and reduced syllables in non-native German can be traced back to structural differences between the speakers' first and second language. She further found that the vowel reduction of learners of German, measured with the syllable ratio, was more similar to native speech rhythm in the retellings of a story than in the readings of the story.

On the whole, these previous studies suggest that vowel reduction in non-native German differs significantly from that in native German. Yet, a more systematic approach is necessary in order to capture the nature of the deviation from native speech. The previous studies analysed non-native speech auditorily [8] or measured the duration of syllables containing unstressed vowels [6]. An acoustic analysis of unstressed vowels in terms of their duration and formant structure has not been carried out yet. Further, it cannot be decided yet whether vowel reduction is influenced by the L1 as claimed in [6] and [8], or whether it constitutes a universal difficulty for language learners. A series of studies analysed vowel reduction in non-native English, for example, and reported similar findings to those for non-native German. Some non-native speakers of English do not produce reduced vowels in unstressed syllables and the weak forms of function

words ([5], [11]) and some learners do not reduce vowels in unstressed syllables to an appropriate extent both in post-stress and in pre-stress syllables ([3], [13]). Native language influence can only be established in the investigation of speakers with L1s with systematically different phonological systems from German in terms of stress and vowel reduction.

3. Aims and Method

The present study has three aims:

- the analysis of the acoustic properties of unstressed vowels in non-native German both in terms of duration and vowel formant structure
- the investigation of the influence of native language structures on non-native speech
- the investigation of the influence of speaking style

3.1. Participants

16 non-native speakers of German with three different language backgrounds – five English native speakers, six Italian native speakers and five Mandarin Chinese native speakers – and three native speakers of Standard German participated in the study. Non-native speakers of German with L1 English were chosen because even more frequently than in German, vowels in unstressed syllables are reduced or deleted in English [1]. Whereas in German reduced vowels only occur in post-stress syllables such as inflectional morphemes, in English they can occur in a wide variety of positions, including pre-stress ones. Both vowel reduction and vowel deletion in pre-stress syllables, for example in the word *police*, which can be pronounced [pə.lis] or [p.lis], exists only in English but not in German. There is a pronounced difference in the phonetic quality of reduced vowels in German and English. English reduced vowels tend to be shorter and more central than German reduced vowels. The extent of vowel reduction in terms of tongue centering and lip unrounding is much smaller in German than in English [2]. It is expected that L1 influence will become apparent in the speech of English speakers of German in both the quality of reduced vowels in terms of their formant structure as well as the occurrence of reduced and deleted vowels in pre-stress syllables.

Unstressed syllables in Italian do not have reduced central vowels and, consequently, the durational difference between stressed and unstressed vowels is less pronounced than in German [12]. It is expected that non-native speakers of German with L1 Italian will fail to produce vowel reduction and especially vowel deletion to an appropriate extent and that these vowels will differ in quality from native German vowels.

The Mandarin Chinese vowel system, finally, contains the phoneme schwa and there is a phonological rule that a mid vowel before a consonant turns into a schwa. Fox [4] considers Chinese a non-accentual language. Kratochvil [10] claims that accentuation exists but that accented syllables are correlated with greater loudness and more pronounced pitch height or movement rather than increased duration. It is therefore expected that this group of non-native speakers will produce more reduced vowels (schwas) than the native Italian speakers but will show the greatest deviation from native reduced vowels in terms of duration. Vowel deletion is predicted to be low.

3.2. Material and analysis

The speech material consisted of two speaking styles: reading passage style (a story of 268 words) and semi-spontaneous speech obtained in story retellings of about two minutes length. They were transcribed phonemically and the vowel reduction patterns of the three learner groups were investigated in unstressed syllables such as post-stress C+<-en> and C+<-em> syllables, as for example in *treffen* (to meet) and *diesem* (inflected form of the determiner *dieser*), where C stands for any consonant and the vowels are realized as schwa in native German. The vowels produced by the learners were categorized as either

- a full vowel
- a reduced vowel /ə/
- a reduced vowel /ɐ/ or
- a deleted vowel

For the analysis of the acoustic properties of unstressed vowels, the duration of all vowels in post-stress C+<-en> syllables and the pre-stress syllable *ver-* was measured using standard phonetic criteria (at the beginning of a stable formant structure, especially at the onset of the first formant, and end at the end of a stable formant structure, especially at the end of the second formant). The frequency of the first and second formant (F1 and F2) was measured at each vowel midpoint.

4. Results

Table 1 illustrates the overall percentage of the three types of post-stress syllables produced by each speaker group: non-reduced (with full vowel), reduced (with schwa /ə/ or a-schwa /ɐ/) and with deleted vowel. Significant differences between native and non-native speakers are found for the L1 Italian and the L1 Chinese groups. On average, the Italian native speakers produce fewer reduced-vowelled syllables and fewer syllables without vowels than the German native speakers. The Chinese native speakers produce, on average, fewer syllables with deleted vowels than the German native speaker group. Several ANOVAS revealed significant differences between the three non-native speaker groups. The percentage of syllables with reduced vowels is higher in the Chinese non-native German speech than in the other two non-native speaker groups ($p < 0.001$). Syllables with deleted vowels occur more often in the speech of English learners of German than that of Italian or Chinese learners ($p < 0.01$).

	German	English	Italian	Chinese
non-reduced	69.05	73.1	82.35	73.08
reduced	25.75	21.7	15.4 *	25.28
deleted vowel	5.2	5.2	2.25 ***	1.64*
<i>n</i>	671	866	1333	1675

Table 1: Overall percentage of non-reduced, reduced and deleted vowel syllables produced by each speaker group (mean values). (Significant differences from the native speaker group are indicated by ***= $p < 0.001$, *= $p < 0.05$)

Table 2 illustrates the phonetic realisation of the vowel in the unstressed syllables C+<-en> and C+<-em> by all speakers.

The percentages of productions without vowel (= deleted), productions with a schwa, the a-schwa /ə/ or a full vowel are given for each group. The German native speakers produce roughly half of the word-final syllables C+<en> and C+ without a vowel and half with the reduced vowel [ə]. A-schwa and full vowels never occur in these syllables. The L1 English speakers show a different pattern by producing the majority of these syllables without a vowel. The L1 Italian speakers produce a similar quantity of syllables without vowel and with [ə]. In 9% of these syllables, however, a full vowel is produced, which is significantly different from the German native speakers. The Chinese learners of German show a clear preference for the [ə] vowel in these positions, followed by some deleted vowels (17%) and some full vowels. A-schwa occurs in 6% of the cases, which is significantly different from the German native speakers.

	German (n=3)	English (n=5)	Italian (n=6)	Chinese (n=6)
deleted	54	87	44	17
ə	46	13	45	76
ɐ	-	-	2	6*
full vowel	-	-	9*	1
n	44	66	59	118

Table 2: Mean percentage of production of word-final syllables ending in C+<en> and C+ with deleted vowel, /ə/, /ɐ/ or a full vowel by each speaker group. (Significant differences from the native speaker group are indicated by *=p<0.05)

There are significant differences in the vowel realisation between the different non-native speaker groups. An ANOVA revealed a significant (p<0.05) difference in the percentage of schwa produced in the syllables of the type C+<en> and C+ between the three non-native speaker groups. The L1 Chinese speakers produce significantly more schwas in this phonetic environment than the other two speaker groups. Deleted vowels in these syllables are produced significantly more often (p<0.01) by the English non-native speakers of German than the other two non-native speaker groups. A-schwa and full vowels in this environment are produced only by the Italian and the Chinese non-native speakers of German, but not the native English speakers.

Table 3 illustrates the mean duration and the percentage of deletion for all post-stress syllables of the type C+<en> in the reading passages and retellings of German native speakers and the English, Italian and Chinese non-native speakers of German. The English native speakers delete more syllables of this type when speaking German than the German native speakers do. In those few cases where the vowel is not deleted, however, it is on average significantly longer than that produced by the German native speakers. The Italian and the Chinese non-native speakers of German delete fewer vowels in post-stress syllables than the German native speakers. In addition, the Chinese learner group produces on average significantly longer vowels. An ANOVA carried out for the three non-native speaker groups revealed significant differences in vowel duration between them (p<0.001).

	German (n=3)	English (n=5)	Italian (n=6)	Chinese (n=6)
duration	0.046	0.06*	0.054	0.068***
percentage deleted	76.5	88.9	48.3	32.2
n	98	118	178	236

Table 3: Mean duration of all vowels and percentage of deleted vowels in the post-stress syllables of the type C+<en> produced by the German native speakers and the three non-native speaker groups. (Significant differences from the native speaker group are indicated by ***=p<0.001, *=p<0.05)

Table 4 presents the duration of unstressed C+<en> vowels and the percentage to which they were deleted in the reading passages and the retellings produced by the native speakers of German and the three groups of non-native speakers. In terms of duration, only the Chinese speakers of German produced different vowels in the two speaking styles. For them, in the retellings, the vowels were significantly longer than in reading passage style. The percentage of deleted vowels does not differ between the speaking styles for any of the speaker groups.

	German (n=3)	English (n=5)	Italian (n=6)	Chinese (n=6)
dur. read	45	56	54	62
dur. retelling	48	64	55	75**
% del. read	36,5	89,8	49,6	33,3
% del. retelling	44	88	56,9	31,3

Table 4: Mean duration (in ms) and percentage of deleted vowels of all vowels in the post-stress syllables of the type C+<en> produced by the German native speakers and the three non-native speaker groups in the reading passages and retellings. (Significant differences between speaking styles are indicated by **=p<0.01)

In order to analyse whether non-native speakers produce a phonetically different vowel in C+<en> syllables than native speakers, vowel quality was compared in the female speech of all speaker groups by measuring the mean values of the first two formants F1 and F2 of the vowels (see Table 5). Unfortunately, the number of vowels produced by the two English non-native speakers of German is very small so that a statistical evaluation is difficult. These two speakers produce the unstressed vowel with a higher F1, which reflects a lower tongue position, than the German native speakers. Both the Italian and the Chinese non-native speakers of German also have higher values for F1 and in addition also for F2. This means that the vowel they produce is tenser than the one produced by the German native speakers. An ANOVA carried out for the F1 of the vowels produced by the English, Italian and Chinese non-native speakers of German revealed no significant group differences.

	German (n=2)	English (n=2)	Italian (n=4)	Chinese (n=4)
F1	376	629***	517.5**	521.9**
F2	1440	1427	1968***	1600*
n	9	4	40	122

Table 5: Mean F1 and F2 of all vowels in the post-stress syllables of the type C+<en> produced by the female German native and non-native speakers in the reading passages and retellings. (Significant differences from the native speaker group are indicated by ***= $p<0.001$, **= $p<0.01$, *= $p<0.05$)

Table 6 illustrates that the English and the Chinese native speakers also produce a different vowel quality in the German pre-stress syllable *ver-* compared to the German native speakers. The vowel is significantly shorter when pronounced by the English non-native speakers of German than in German native speech. In terms of tongue height, English speakers produce the schwa with a higher tongue position, which is reflected in the lower F1 values (430Hz compared to 522Hz for the German native speakers). F2 is on average higher in both the non-native German of English and of Chinese native speakers.

	German (n=2)	English (n=2)	Italian (n=4)	Chinese (n=4)
F1	522	430*	532	463
F2	1457	1638**	1574	1928**
duration	0.062	0.041**	0.054	0.087
n	13	8	6	5

Table 6: Mean F1 and F2 values and mean duration of all vowels in the pre-stress syllables *ver-* produced by the German native speakers and the three non-native speaker groups. (Significant differences from the native speaker group are indicated by **= $p<0.01$, *= $p<0.05$)

5. Summary and discussion

The aim of the present study was to investigate the acoustic properties of unstressed syllables in non-native German and to determine the influence of L1 and speaking style on their realization. Several analyses showed that there is a difference in the overall amount and quality of reduced syllables in native and in non-native German. An acoustic analysis of the duration and quality of the vowel produced in various post-stress and pre-stress unstressed syllables showed significant differences in duration and the first two formants, which reflect the speakers' tongue position. This means that non-native speakers produce phonetically different vowels in these positions.

Some evidence was found for native language influence on the realisation of unstressed syllables in non-native German. As predicted, Italian and Chinese L1 speakers delete fewer unstressed syllables than the English L1 and the native German speakers. Conversely, the reduced vowel /ə/ is more frequent in Chinese L1 speech than in the other two learner groups. They are also significantly longer than those produced by the Italian or English L1 speakers. Only Italian and

Chinese L1 speakers produce full vowels or a-schwas in post-stress unstressed syllables, but not English native speakers. No significant differences between the learner groups were found in the vowel quality produced in post-stress unstressed vowels. The duration and type of vowel produced in pre-stress unstressed syllables, however, differs between native English speakers and the other two non-native speakers.

No influence of speaking style was found on the duration of unstressed vowels or percentage of vowel deletion. The percentage of deleted vowels found for the German native speakers here is much lower than that reported in [7].

6. References

- [1] Delattre, P. 1969. An acoustic and articulatory study of vowel reduction in four languages. *International Review of Applied Linguistics* 7, 295-325.
- [2] Delattre, P. 1981. An acoustic and articulatory study of vowel reduction in four languages. In *Studies in Comparative Phonetics*, P. Delattre (ed.). Heidelberg: Groos, 63-93.
- [3] Flege, J.; Bohn, O.-S. 1989. An Instrumental Study of Vowel Reduction and Stress Placement in Spanish-Accented English. *Studies in Second Language Acquisition* 11, 35-62.
- [4] Fox, A. 2001. *Prosodic features and prosodic structure*. Oxford: Blackwell.
- [5] Ghazali, S.; Bouchhioua, N. 2003. The learning of English prosodic structures by speakers of Tunisian Arabic: word stress and weak forms. *Proceedings of the 15th International Congress of Phonetic Sciences, Barcelona*, 961-964.
- [6] Gut, U. 2003. Non-native speech rhythm in German. *Proceedings of the ICPHs conference, Barcelona*, 2437-2440.
- [7] Helgason; Kohler, K. 1996: Vowel deletion in the Kiel Corpus of Spontaneous Speech. In *Sound Patterns in Spontaneous Speech*, K. Kohler; C. Rehor; A. Simpson (eds.). Arbeitsberichte des Instituts für Phonetik und digitale Sprachverarbeitung Universität Kiel 30, 115-157.
- [8] Kaltenbacher, E. 1998. Zum Sprachrhythmus des Deutschen und seinem Erwerb. In *Eine zweite Sprache lernen*, H. Wegener (ed.). Tübingen: Narr, 21-38.
- [9] Kohler, K. 2001. Variability of opening and closing gestures in speech communication. In *Sound Patterns in German Read and Spontaneous Speech; Symbolic Structures and Gestural Dynamics*. K. Kohler (ed.). Arbeitsberichte des Instituts für Phonetik und digitale Sprachverarbeitung Universität Kiel 35, 33-96.
- [10] Kratochvil, P. 1998. Intonation in Beijing Chinese. In *Intonation Systems*, D. Hirst; A. Di Cristo (eds.). Cambridge: Cambridge University Press, 417-431.
- [11] Mairs, J. 1989. Stress assignment in interlanguage phonology: an analysis of the stress system of Spanish speakers learning English. In *Linguistic perspectives on second language acquisition*, S. Gass; E. Schachter (eds.). Cambridge: Cambridge University Press, 260-283.
- [12] Rossi, M. 1998. Intonation in Italian. In *Intonation Systems*, D. Hirst; A. Di Cristo (eds.). Cambridge: Cambridge University Press, 219-238.
- [13] Wenk, B. 1985. Speech Rhythms in Second Language Acquisition. *Language and Speech* 28(2), 157-174.