An acoustical analysis of pronunciation of German suffixes by learners with different language rhythms*

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1 Introduction

This paper focuses on non-native speech rhythms in German. The goal is to confirm whether a measurement developed by [1] can be useful to classify non-native speech.

Languages have various differences, one of which is the structure of their speech rhythm. In traditional descriptions of speech rhythm, languages have been classified as “stress-timed” languages (e.g., German and English), in which stressed syllables occur at equal intervals, “syllable-timed” languages (e.g., French), in which syllables occur at equal intervals and “mora-timed” languages (e.g., Japanese), in which moras occur at equal intervals.

Vowel reduction is one of the major phenomena observed in native speakers of German, a language that features lexical stress accent. Further, speech rhythm in a second language (L2) is often influenced by the learners’ first language (L1). Combining these observations, it has been suggested that some common errors by L2 German learners relate to reduction in "stress-timed" language rhythms. Some previous studies indicate that the phonetic and phonological correlates of “stress-timed” languages include durational differences between prominent and non-prominent syllables, phonemic vowel length contrasts, and other matters related to vowel reduction. The difference between prominent and non-prominent syllables in German is primarily one of duration [2], and recent research [1] has thus investigated non-native vowel reduction in terms of “syllable durational ratio”; however current data provide insufficient evidence to explain difficulties in L2 learning achievement by non-native German speakers with various L1s or to provide evidence whether a measurement can be useful to classify non-native speech as each speech rhythm above.

2 Speech rhythm in German

2.1 Vowel reduction in German

Previous studies suggest that vowels in “stress-timed” languages such as German, especially in the unstressed position, are gradually reduced depending on speaking rate and other variables. This reduction is, phonetically, a gradual process that results in a shrunken vowel space; Kohler [3] presents the example of the German inflected definite article *dem*, which undergoes the following progressively stronger reductions:

de:m → dem → dəm → dm → bm → m

In addition, Kohler [4] has suggested that vowel reduction is affected by the place where it occurs within a spoken word. In particular, all German post-stress unstressed syllables are reduced to a schwa and shortened. The phenomenon of inflected words called “syllabification” overrides morphological boundaries in German, and inflections such as the <-en> in *hab+en* ‘to have’ and the <-e> in “*wollt+e*” ‘wanted’ syllabify with the preceding consonant. The accents lie on the stems, and the subsequent unaccented syllables exhibit vowel reduction in their citation form. As a rule, German C+<-en> syllables, where C stands for any consonant, are produced as C+[ən], with the reduced vowel schwa. In connected speech, these reduced vowels may be deleted: one corpus analysis of German speech [5] found that 59% of the schwas in post-accent syllables were deleted. The vowel in C+<-en> syllables, which occur frequently in verb endings and inflected nominal word categories, was deleted in 93% of the cases. Altogether, this means that, in German, durational differences between prominent and non-prominent syllables are pronounced.

2.2 Acquisition of German speech rhythm by non-native speakers

A number of studies on speech rhythm have investigated how L2 learners master the speech rhythm patterns of the language they are learning [6]. However, there is not yet sufficient research on connected speech processes in non-native German. With regard to what research does exist, Kaltenbacher [6] analyzed vowel reduction processes. On the basis of the assumption that native language structures will become evident in L2 productions, she [6] asked native speakers of English, Russian, and Japanese to imitate and then to read a list of sentences read by a native speaker of German. As expected, English speakers exhibited vowel reduction in unacceptable places for German speakers—mainly in word-initial unstressed syllables—and produced reduced vowels in function words in ways that were not compatible with German phonology. The Russian native speakers, conversely, showed a tendency to reduce vowels in word-final syllables in inappropriate contexts. However, only the Japanese native speakers failed to produce the required vowel reductions. On this basis, she [6] concluded that these production strategies result in a foreign speech rhythm in German. Further, Gut [1] investigated speech rhythms in German produced by non-native speakers, and showed that differences in speech rhythm manifest themselves in the syllable durational ratio. To do so, she analyzed the duration of non-reduced and reduced vowels produced by non-native speakers of German with three different native language backgrounds. The author of [1] determined a new measurement method for speech rhythm, in which she calculated syllable durational ratio by dividing the length of each non-reduced-vowel syllable by the length of a following syllable with a reduced or deleted vowel, and then averaging the sum of all the ratios by their total number. This measurement indicates the durational difference between syllable pairs consisting of syllables with non-reduced vowels and those consisting of syllables with reduced or deleted vowels, thus reflecting the effect of vowel reduction. For native German speakers, non-reduced vowel syllables were on average 1.87 times longer than syllables with reduced or deleted vowels. All non-native speakers of German, in contrast, showed a significantly lower ratio between the duration of non-reduced and adjacent reduced syllables. This suggests that reduced vowels produced by non-native speakers are longer than those produced by German native speakers. Comparing the duration of reduced vowels among non-native speakers with different L1s, Gut [1] suggests that the lack of durational difference between syllables with non-reduced, reduced, and deleted vowels in non-native speakers of German can be traced back to structural differences between the speakers' various L1s and the L2. However, although that study succeeded in describing relevant differences in non-native speech [1], its treatment might be insufficient to explain this data and determine categories for speech rhythms. Thus, the new measurement method is needed not only to investigate vowel reduction in L2 speech rhythms.

These previous investigations into some properties of the speech of non-native speakers of German thus leave room for extension and the implementation of the new method. Although [1] tried to investigate non-native speech rhythms across different L1s with the new measurement, the speakers in that case did not belong to the same language family as German.

2.3 Aims and hypothesis

Our hypothesis is as follows: syllables containing non-reduced vowels in L2 German should show a significantly larger durational ratio than syllables with reduced or deleted vowels. In keeping with this hypothesis, the aims of this study are: 1) to help elaborate a phonetic description of non-native speech in German, and 2) to investigate the optimality of the measurement of syllable durational ratio across different L1s adopted in [1], and specifically, whether the new measurement is effective for the phonetic description of language rhythms.

3 Method

3.1 Participants

Ten native speakers of Standard German were selected, as were 20 non-native speakers in two different L1 speech rhythm groups with ten native speakers each: Japanese and American English, respectively. Most of the Japanese speakers were students in the Department of German Studies at Sophia University, and the American English speakers were students of the Faculty of Liberal Arts; each of the students had stayed for at least one year in Germany.

3.2 Data and procedures

Our recordings consisted of two parts. First, all participants were asked to read out a fable-like story in German ("The North Wind and the Sun"). Second, all participants re-told the story in their own (German) words, without reference to the written text. All recordings were carried out in a soundproof room at Sophia University.

3.3 Analysis

Acoustic analysis was carried out using Praat. All syllables (non-reduced syllables; reduced syllables, which contained only /ə/ as a vowel; or syllables where the vowel was deleted) were measured for syllable durational ratio. The mean of all such ratios was then determined between adjacent non-reduced and reduced syllables. The syllable durational ratio (*SR*) between non-reduced syllables and following reduced syllables was calculated using the following formula, (the same one presented as a new measurement of speech rhythm by [1]).

$$SR = \frac{1}{n}\sum_{k=1}^{n}\frac{durNR_k}{durR_k}$$

Here, *dur* stands for syllable duration; *NRk* is a non-reduced syllable; *Rk* is the immediately adjacent, reduced, non-final syllable; and *n* stands for the number of syllable pairs. That is, to determine the syllable ratio between non-reduced and reduced syllables, the length of each non-reduced syllable was divided by the length of the following reduced syllable, and the sum of all the ratios was averaged by their total number. The syllable ratio between adjacent non-reduced syllables was calculated by dividing the sum of all the ratios between non-reduced syllable pairs by their number. Then, reduced and deleted vowels (that is, the vowels of all the words ending in C+<-en> syllables [*n*=1050]) were analyzed. Finally, the syllables were categorized, based on the following criteria.

Table 1 Criteria for measurement of degree of vowel reduction.

	Vowel quality	Vowel quantity
Non-reduced vowel	Non-/ə/ vowel	Periodic waveform
Reduced Vowel	/ə/	Periodic or pseudo-periodic waveform
Deleted Vowel	No vowel formants	No waveform

4 Results

4.1 Categorization by level of vowel reduction

Table 2 lists the respective percentages of C+<-en> suffixes produced with non-reduced, reduced, and deleted vowels by each participant group (German natives, Japanese learners of German, and American-English-speaking learners of German, hereafter GNs, J-GLs, and A-GLs in all tables and figures).

Whereas 72% of these syllables were produced without a vowel by the GNs, vowel deletion occurred less frequently among J-GLs, who also tended to clearly produce German suffixes and assign them a non-reduced vowel. A-GL tokens were divided roughly equally between those without a vowel (55%) and those with a reduced vowel (45%). Compared with GNs, many of AG-Ls tended to produce C+<-en> syllables with reduced vowels.

Table 2 Number of C +<-en> syllables in each vowel category across L1 groups.

	GNs	J-GLs	A-GLs
Non-reduced vowel	0 (0%)	473 (45%)	0 (0%)
Reduced vowel	294 (37%)	189 (18%)	472 (45%)
Deleted vowel	756 (72%)	388 (37%)	578 (55%)

4.2 Syllable durational ratio

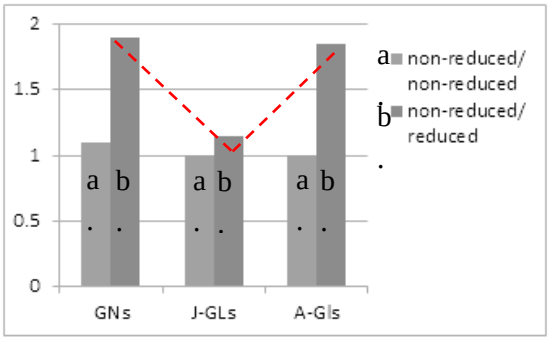

Fig. 1 Respective average syllable durational ratios for non-reduced/reduced and non-reduced/non-reduced syllable pairs in read speech.

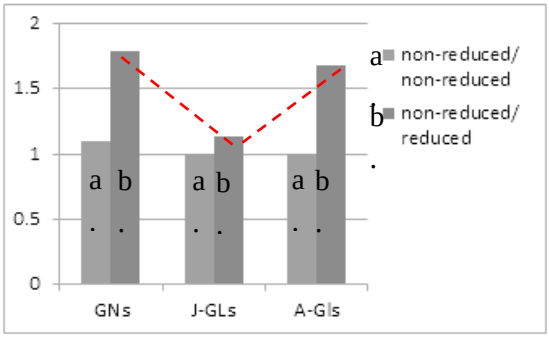

Fig. 2 Respective average syllable durational ratios for non-reduced/reduced and non-reduced /non-reduced syllable pairs in retellings.

Fig. 1, showing data for read speech, and Fig. 2, for retellings, show speech rhythms produced by all participant groups, measured by syllable ratio. In particular, in Fig. 1, we see that for GNs, the length of non-reduced syllables preceding syllables with reduced or deleted vowels are on average about 1.92 times longer than otherwise. For A-GLs, similarly, this ratio is on average about 1.82 times longer. In contrast, J-GLs show a significantly lower ratio between the duration of non-reduced and that of reduced syllables (t (6), p<0.01). As seen in Fig. 2, there was also a tendency for GNs to show a significantly lower ratio between syllables (t (6), p<0.01).

5 Discussion

The present study provides an answer to the questions presented in the introduction (Sec. 1), that is, whether the new measurement is effective for the phonetic description of "stress-timed" language rhythms. As shown in the production analysis of syllable durational ratio (Sec. 4.2), systematic differences in speech rhythm were found for J-GL as compared to GN, in vowel reduction and deletion with one particular inflectional ending and in overall speech rhythm; however, these differences were not found for A-GLs. Similarly to [1], these differences were more pronounced in read speech than in extemporaneous retellings of the same story. The results for J-GLs thus partially confirm the hypothesis of [6] that low-level phonetic and/or phonological processes of speakers using their native language are likely to extend to L2 speech. Further, the similarity of English and German in this regard was confirmed. The analysis of syllable durational ratio might be insufficient to explain the measurement to determine German by non-native speeches. On the other hand, these results seem to show that the formula presented by [1] has potential for the identification of stress-timed language rhythms. This result should be tested using data from other stress-timed languages.

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