Vowel shortening in German as a function of syllable structure

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Abstract

This study reports on a production experiment investigating acoustic vowel shortening as a function of syllable structure in German. Ten speakers were recorded producing mono- and disyllabic target words differing in vowel quality (low, mid and high vowels) and in the number of coda consonants, that is, the number of consonants following the stressed vowel. The results show that the acoustic vowel duration is significantly shorter when (1) the number of coda consonants increases and (2) another syllable is added to the monosyllabic target words. The degree of vowel shortening is similar between (1) and (2), that is, adding a coda consonant to a monosyllabic target word with an open syllable shortens the vowel duration to the same degree as adding an entire syllable to this target word. In addition, our results show that all vowels, regardless of quality, undergo shortening, thus preserving their intrinsic durations.

Introduction

Compensatory vowel shortening describes the process whereby vowels are shortened when preceded or followed by one or more consonants. In general, there are two types of compensatory vowel shortening. First, it can be driven by the addition of syllables (syllable induced or polysyllabic shortening), that is, a stressed vowel in a trochaic target word is shortened in comparison to the same vowel in a monosyllabic word (Fowler, 1981; Vayra et al., 1999).

Second, vowel shortening can be driven by the addition of onset or coda consonants (onset or coda induced compensatory shortening). Evidence for onset and coda induced shortening comes from a number of studies on English (Clements & Hertz, 1996; Munhall et al., 1992; Shaiman, 2001; van Santen, 1992). However, Marin & Pouplier (2010), Katz (2012) and Marin & Bucar Shigemori (2014) could show that this type of vowel shortening is not straight forward, but depends on the number and segmental identity of the added consonants.

Specifically, Marin & Pouplier (2010) provided clear evidence for onset compensatory vowel shortening comparing CV and CCV target words in American English. They did not, however, find coda induced compensatory shortening (comparing the vowel duration in (C)VC and (C)VCC target words). Rather, the vowel duration remained unchanged unless the the first consonant in the coda cluster was the liquid /l/. This effect was corroborated by studies from Katz (2012) on American English and from Marin & Bucar Shigemori (2014) on Romanian.

For German, Peters & Kleber (2014) found evidence for both onset and coda induced vowel shortening in monosyllabic German pseudowords of the structure (C)CV:C(C). They found that the acoustic duration of the phonologically long vowel /a:/ is shorter in target words containing onset or coda clusters compared to target words with a single onset or coda consonant. Similar results for German were obtained by Siddins et al. (2014) who report on an interaction between coda consonants and vowel tensity. More specifically, their data suggest that phonologically tense vowels may undergo shortening when followed by a consonant cluster compared to lax vowels that are not shortened in this position.

The present study builds on these findings and aims to broaden our understanding of shortening effects on vowel duration. We conducted an experiment comparing coda induced vowel shortening versus syllable induced vowel shortening. Specifically, we tested whether vowel quality (height) has an effect on the degree of vowel shortening, and we examined the interaction between compensatory vowel shortening and intrinsic vowel duration, the latter presumed to be a phonetic universal (Maddieson, 1997).

Method

We recorded 10 native speakers of Standard German (five female, five male). All speakers were in their mid-20s (mean = 24.5, SD = 1.84) and grew up in the area surrounding Cologne. Recordings took place at the I*f*L-Phonetics laboratory in Cologne (Institut für Linguistik). The acoustic signal was recorded with a DAT-recorder using a condenser microphone and digitised at 44.1 kHz/16 bit.

The speech material consisted of target words (pseudo words) differing in vowel quality (low: /a:/, mid: /e:,o:/, and high /i:,u:/ vowels), syllable structure and number of coda consonants (open and closed syllables) as well as the number of syllables (mono- and trochaic disyllabic target words) resulting in the following five structures: /mV:/, /mV:m/, /mV:ms/, /mV:.la/ and /mV:m.la/ (see Table 1 for all combinations). All target words were placed in phrase medial position in the carrier sentence /nax [target word] vɪl kɪm di: ra͡ɪzə maxən/ ‘Kim wants to travel to [target word]’.

Table 1. Possible structures for target words; twenty-five targets in total

C1	V1	C2	C3	/l/	/ɐ/
m	i: u: e: o: a:	m	s	l	ɐ

All carrier sentences were produced as an answer to the question /vɪl kɪm di: ra͡ɪzə nax [filler] maxən/ ‘Does Kim want to travel to [filler]?’, thus putting each target word in contrastive focus resulting in a rising nuclear pitch accent on the target word.

Speakers were shown a map displaying the target words as city names of a foreign planet in order to elicit a more natural handling of the production task. Both the question and the carrier sentence containing the target word then were displayed on a computer screen in a pseudo-randomised order with three repetitions each. Speakers were prompted to read the carrier sentence in a comfortable and natural way.

In sum, we recorded 750 tokens (10 speakers x 5 vowels x 5 structures x 3 repetitions + fillers). Six tokens had to be discarded from the analysis due to mispronunciations and/or the production of a pause or phrase boundary immediately after the target words.

All target words were displayed and labelled manually in Praat (Boersma, 2001; see Figure 1), splitting target words into their segments (first consonant C1, first vowel V1, second consonant C2, third consonant C3, and onset and vowel of the second syllable). In this paper, we focus on the duration of the accented vowel V1.

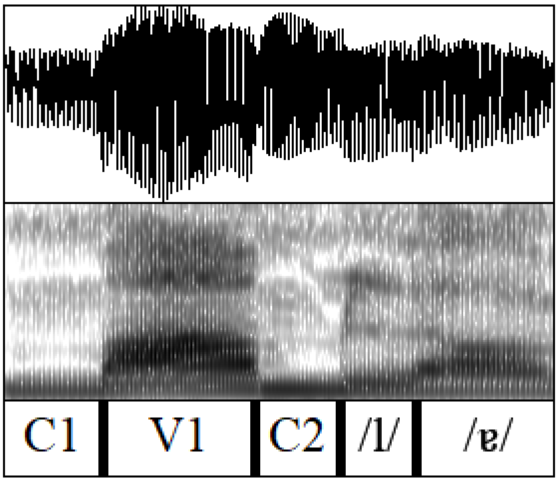

Figure 1. Segmentation of the target word /maːmlɐ/

All data were analyzed with linear mixed effects models, using R (R Development Core Team, 2008) and the package *lme4* (Bates et al., 2015). The fixed effect under investigation was STRUCTURE (with the levels /mV:/, /mV:m/, /mV:ms/, /mV:.la/ and /mV:m.la/). Following the random effect specification principles outlined by Barr et al. (2013), we included random intercepts and slopes for subjects for both STRUCTURE and VOWEL HEIGHT (with the levels low, mid and high). For post hoc comparisons, p-values were determined using the Tukey adjusted contrast in the *multcomp* package for R (Hothorn et al., 2008).

Results

Coda induced compensatory shortening

Figure 2 displays the vowel duration for all monosyllabic target words as a function of both structure and vowel height.

Vowel duration is longest in target words with open syllables, followed by target words with one coda consonant, which in turn are longer than target words with two coda consonants. Averaged across vowel height, the vowel duration in CV: is 220 ms and is reduced by 61 ms in CV:C (= 159 ms) and by

79 ms in CV:CC (= 141 ms) indicating a robust coda induced vowel shortening. In addition, low vowels display a longer duration than mid and high vowels. Table 2 provides means and standard errors for all conditions.

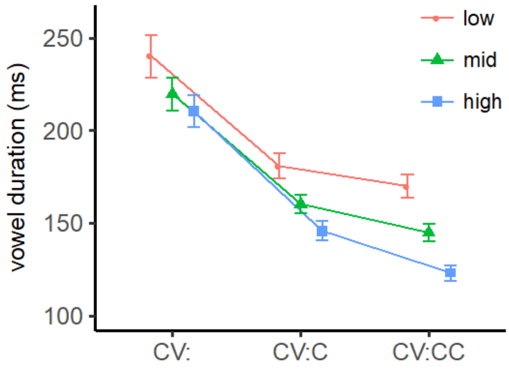

Figure 2. Vowel duration as a function of monosyllabic structure and vowel height

A likelihood ratio test comparing our linear fixed effects model with STRUCTURE as fixed effect to a null model with only the random effects shows a significant difference (χ^2 (4) = 22.89, p<0.001). Thus, we compared this model with a second one containing VOWEL HEIGHT as a new fixed effect. Again, this comparison was significant, thus improving the model (χ^2 (2) = 34.78, p<0.001) with no interaction between the two factors (χ^2 (2) = 9.24, p=0.322). The effect of vowel height holds across all syllable structures, that is, the coda induced shortening found here did not influence the intrinsic differences in duration for vowels depending on their height. Low vowels were always longer than mid and high vowels, and mid vowels were always longer than high vowels for all target structures.

Degree of vowel shortening

Comparing monosyllabic and disyllabic target structures showed that the addition of a coda consonant and the addition of a second syllable influence the vowel duration to almost the same extent. Figure 3 depicts the vowel duration in the target words CV:C and CV:.CV (left-hand side) and CV:CC and CVC:.CV (right-hand side). Importantly, there was no significant difference (p>0.05) in vowel duration between CV:C and CV:.CV target words, that is, adding a coda consonant or another CV syllable to CV: target word has the same effect of shortening on the vowel duration. On average, the vowel duration in CV:C is 159 ms and 153 ms in CV:.CV. We found the same pattern between CV:CC and CV:C.CV target words. Again, there was no significant difference (p>0.05) between their vowel durations. On average, the vowel duration is 141 ms in CV:CC target words, while it is 131 ms in CVC.CV target words.

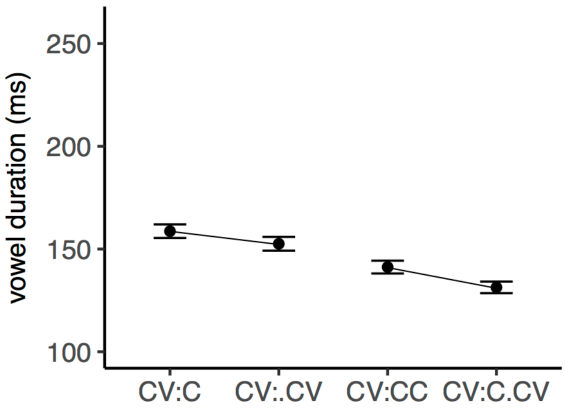

Figure 3. Vowel duration as a function of target structure

Table 2. Means and standard errors for the duration of low, mid, and high vowels for all structures

	coda induced shortening				
	CV:	CV:C	CV:CC	CV:.CV	CV:C.CV
low	240 (11)	181 (7)	170 (6)	180 (7)	154 (7)
mid	220 (9)	161 (5)	145 (5)	152 (5)	133 (4)
high	211 (9)	146 (5)	123 (4)	139 (5)	119 (4)
mean (se)	220 (6)	159 (3)	141 (3)	153 (3)	131 (3)
		degree of vowel shortening			

Conclusion

In this study, we examined coda and syllable induced compensatory vowel shortening and its interaction with vowel quality. We confirmed coda induced shortening in that all vowels are generally shorter in CV:C target words compared to CV: target words. This finding is in line with those by previous studies on compensatory vowel shortening in English (e.g. Clements & Hertz, 1996; Munhall et al., 1992, Shaiman, 2001; van Santen, 1992). The comparison between CV:C and CV:CC target words revealed that all vowels undergo further shortening when a coda cluster follows the vowel (see Figure 4). These findings are in line with Peters & Kleber (2014) but partially contradict the results obtained by Marin & Pouplier (2010) and Katz (2012). We think that the usage of only phonologically long vowels in our study has led to the consistent vowel shortening as the findings from Siddins et al.

(2014) suggest that short vowels (lax vowels) are not prone to compensatory shortening.

In addition, our findings on syllable induced shortening are in line with Fowler (1981) and Vayra et al. (1999) in that vowels are longer in monosyllabic target words as compared to their counterparts in disyllables. Figure 5 illustrates the effects of coda induced and syllable induced shortening. We found that the presence of a coda and the presence of another syllable resulted in a similar degree of vowel shortening.

Importantly, vowel shortening did not interact with vowel quality, that is, all else being equal, low vowels were longer than mid and high vowels, and mid vowels were longer than high vowels. Hence, intrinsic vowel duration was maintained across all tested structures. In conclusion, we showed that compensatory vowel shortening does not affect the dependency between vowel height and duration, supporting the claim of universality by Maddieson (1997).

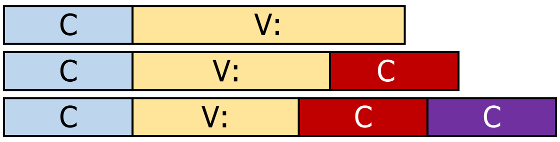

Figure 4. Schematized coda induced vowel shortening

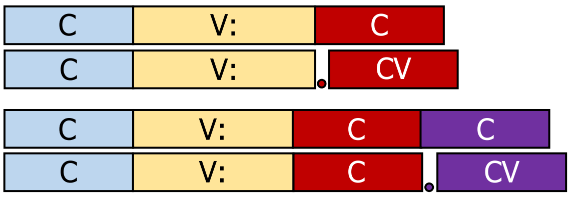

Figure 5. Comparison of coda vs. syllable induced vowel shortening

References

Barr, D. J., Levy, R., Scheepers, C., Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68*, 255–278.

Bates, D., Maechler, M., Bolker, B., Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software, 67*, 1-48.

Boersma, Paul (2001). Praat, a system for doing phonetics by computer. *Glot International, 5*, 341-345.

Clements, G. N., & Hertz, S. R. (1996). An Integrated Model of Phonetic Representation in Grammar. *Working Papers of the Cornell Phonetics Laboratory, 11*, 43-116.

Hothorn, T., Bretz, F., Westfall, P. (2008). Simultaneous Inference in General Parametric Models. *Biometrical Journal, 50*, 346-363.

Katz, J. (2012). Compression effects in English. *Journal of Phonetics, 40*, 390-402.

Maddieson, I. (1997). Phonetic Universals. In W. J. Hardcastle & J. Laver (Eds.), *The Handbook of Phonetic Sciences* (pp. 619-639). Oxford and Cambridge: Blackwell.

Marin, S. & Bucar Shigemori, L. S. (2014). Vowel compensatory shortening in Romanian. *International Seminar on Speech Production, Cologne*, 265-268.

Marin, S. & Pouplier, M. (2010). Temporal organization of complex onsets and codas in American English: Testing the predictions of a gestural coupling model. *Motor Control, 14*, 380-407

Munhall, K., Fowler, C., Hawkins, S., Saltzman, E. (1992). "Compensatory Shortening" in monosyllables of spoken English. *Journal of Phonetics, 20*, 225-239.

Peters, S., & Kleber, F. (2014). Articulatory mechanisms underlying incremental compensatory shortening in German. *International Seminar on Speech Production*, Cologne, 316-319.

R Development Core Team (2008). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Shaiman, S. (2001). Kinematics of compensatory vowel shortening: the effect of speaking rate and coda composition on intra- and inter-articulatory timing. *Journal of Phonetics, 29*, 89-107.

Siddins, J., Harrington, J., Reubold, U. & Kleber, F. (2014). Investigating the relationship between accentuation, vowel tensity and compensatory shortening. Proceedings of the *7th Speech Prosody Conference*, Dublin, Ireland.

van Santen, J. P. H. (1992). Contextual effects on vowel duration. *Speech Communication, 11*, 513-546.

Vayra, M., Cinzia A. & Fowler, C. (1999). On the phonetic bases of vowel consonant coordination in Italian: A study of stress and „compensatory shortening“. Proceedings of the *International Conference on Phonetic Sciences*, San Francisco, 495-498.