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The influence of consonantal context on the tense-lax contrast in two standard varieties of German

Abstract

This study investigates differences in the implementation of the tense-lax vowel contrast in three consonantal contexts in Standard Austrian German (SAG) and Standard German (SG). Previous research suggested a partial neutralization of tense and lax high vowels due to the approximation on vowel quality and / or quantity. However, it remains unclear which of these two influences exerts the greatest influence on this neutralization. Physiological articulatory data with synchronized audio were analyzed containing all common tense and lax vowel pairs in symmetrical /p, t, k/ contexts from seven SG and eight SAG speakers. For the analysis of duration, an additional audio corpus was recorded from 12 SAG speakers from Vienna. We compressed the multichannel tongue data using principal component analysis at the temporal midpoint of the vowel to a two-dimensional space whose axes could be related to phonetic height and backness. For the duration measures, we analyzed the interval between vowel on- and offset. The results showed a greater vertical approximation of tense and lax vowels, but no greater neutralization of quantity for Standard Austrian German than for Standard German.

Keywords

Tensity contrast, vowel quality, quantity, neutralization, Standard Austrian German, Standard German

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1.0 Introduction

Some Germanic languages, including English and German, distinguish tense and lax vowels phonologically (e.g. German tense *Miete* ‘rent’ vs. lax *Mitte* ‘middle’). In English and German, tense vowels tend to be longer and more peripheral than their lax counterparts (Lehiste & Peterson, 1961). In Standard German (SG), the tense-lax contrast has also been described by differences in the dynamic formant transitions into the following consonant in terms of syllable cut (*Silbenschnitt*). The idea behind this concept is that the following consonant cuts or truncates tense and lax vowels in a different way: the cut is smooth for tense vowels (*sanfter Schnitt*) but abrupt for lax vowels (*scharfer Schnitt*; Restle, 2003; Vennemann, 1991, based on original idea from Sievers, 1901).

There is some physiological evidence that lax vowels are resistant to shortening and that the duration of German lax vowels is much less variable than the duration of their tense counterparts (Mooshammer et al., 1999; Geng & Mooshammer, 2000). Nevertheless, German lax vowels can be reduced spatially (Mooshammer & Geng, 2008) and have been shown to be more variable, possibly because lax vowels are more affected by coarticulation of the flanking consonants than their tense counterparts (Hoole & Mooshammer, 2002).

Just how the tensity contrast is implemented may differ in the two varieties, given the evidence of a greater tendency for the tensity contrast to be neutralized in Standard Austrian German (SAG) than in Standard German (SG) (Wiesinger 2009; Moosmüller, 2007, 2008; Brandstätter & Moosmüller, in press). A physiological analysis of Austrian and German vowels related differences in quality primarily to the vertical dimension of the tongue movement, such that lax /ɪ, ʏ, ʊ, a/ were found to be more peripheral and closer to the tense counterparts, resulting in a vertical expansion of the lax vowel space in SAG compared with SG (Cunha et al., 2013).

One of the aims of this study was to investigate whether the degree of neutralization was influenced by place of articulation. This is based on the results of a recent physiological study showing that spatial neutralization of the tensity contrast in a velar context occurs for both varieties (Harrington et al., 2012). Thus, the SAG and SG might differ in tensity primarily in labial and alveolar contexts in which SG exhibits substantial spatial reduction of the lax vs. the tense vowels, but not in the velar context in which the tense vs. lax contrast is spatially neutralized in both varieties.

The second aim was to investigate whether vowel quantity is also neutralized in SAG. Given the correlation between vowel duration and fortis / lenis stops of the Middle Bavarian varieties, in which lax vowels tend to be lengthened before lenis and tense vowels shortened before fortis stops (Bannert, 1976; Ronneberger-Sibold, 1999), we expected vowel quantity differences between tense and lax vowels to be smaller in SAG than in SG.

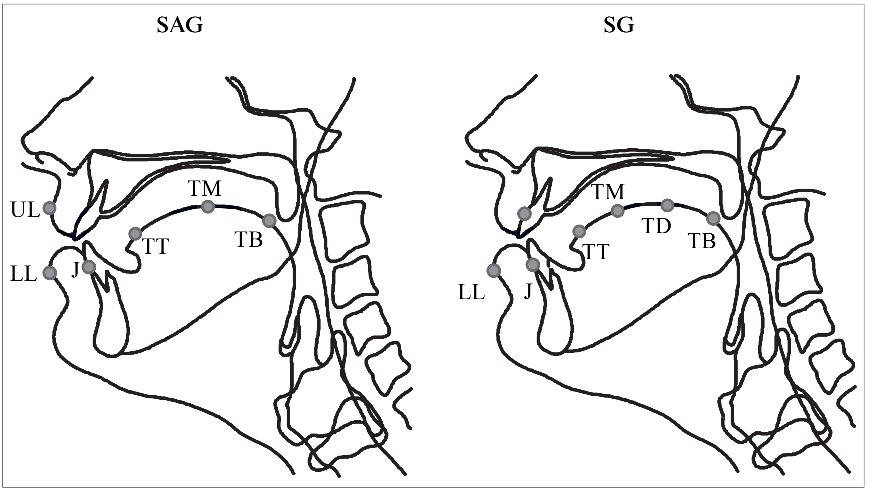
2.0 Materials and methods

2.1 Data collection and participants

Physiological movement data were collected from seven SG using EMMA (Carstens AG 100) and eight SAG speakers using EMA (Carstens AG 500). The SG speakers were all staff or students of the Institute of Phonetics and Speech Processing Munich at the time of recording and included six male speakers and one female speaker aged between 26 and 58 years. Four of the SG speakers were born in Bavaria, two in the Rhineland and one in Schleswig-Holstein. All seven SG speakers were judged by a standard speaker of SG to speak in a Standard German variety. The SAG speakers (four male and four female) aged between 19 and 54 years, were highly educated, born in Vienna and lived there at the time of the recordings.

The recordings were carried out with the sensors fixed mid-sagittally on the jaw and on lower lip (UL) and with four sensors attached to the surface of the tongue for the SG speakers (tip, mid, dorsum and back) and three for the SAG speakers (tip, mid, back) in the approximated positions presented in Figure 1. Additional reference sensors were also attached on the maxilla, on the nose bridge, on the left and right mastoid bones. Sensors were attached to also to the upper lip for the SAG speakers, which was not the case for the SG speakers. However, this is of no consequence for the current paper, which deals exclusively with tongue movement). The tongue tip sensor was attached 1 cm behind the tongue tip and tongue back sensor as far back on the surface of the tongue as the subject could tolerate. Since the relative positions remained stable over groups, they are comparable. Apart from these differences, the data from the two articulography systems can be regarded as comparable since both acquire flesh-point data of the articulators using exactly the same kind of sensor (see Hoole & Zierdt, 2010, for an extensive comparison of the systems).

Figure 1: A cross-sagittal view of the vocal tract showing the approximate positions of the sensors in the recordings from the Standard Austrian (left) and Standard German (right) speakers for the upper lip (UL), lower lip (LL), jaw (J), tongue tip (TT), tongue mid (TM), tongue dorsum (TD), and tongue back (TB)



The synchronized acoustic data was digitized at 16 kHz in both corpora and automatically segmented using the Munich Automatic Segmentation tool (Schiel, 2004). The acoustic boundaries of the vowels were corrected manually at the beginning and end of the acoustically periodic signal. An additional acoustic corpus of twelve SAG speakers (6 male, 6 female, aged between 18–55 years) was analyzed.

2.2 Speech material

For the articulatory experiment, both the Austrian and the German participants produced symmetrical CVC sequences with C = /p, t, k/ combined with all the German monophthongs embedded in the target non-word and carrier phrase *ich habe* /ɡəCVCə/ *gesagt* (literally: 'I have /ɡəCVCə/ said'). The carrier phrases were randomized, presented individually on a computer screen in the corresponding orthography and repeated five times at a self-selected rate, separately by each participant. For the duration measurements we analyzed the synchronized audio from the seven SG and eight SAG speakers as well as the same target non-words embedded in the same carrier phrase were performed with two repetitions by twelve additional SAG speakers.

2.3 Parameterization of the tongue data

We compressed the multi-channel articulatory data using principal component analysis (PCA) at the temporal midpoint of the vowel to a two-dimensional space whose axes could be related to phonetic height and backness. For each of the 15 speakers who participated in the physiology study, we applied PCA to parameters extracted at the acoustic vowel midpoint in each of the three consonantal contexts (bilabial, alveolar and velar). This PCA procedure was applied separately to the horizontal and the vertical tongue position data. In order to facilitate the comparison of the relative vowel positions between speakers, the PCA-transformed data were further rotated separately per speaker such that the mean position of each speaker's /aː/ was set to a value of 0 on PCA-X. (For a detailed description of this method, see Cunha et al., 2013; Harrington et al., 2011). For the analysis of vowel duration, we presented the interval between vowel on- and offset.

2.4 Statistics

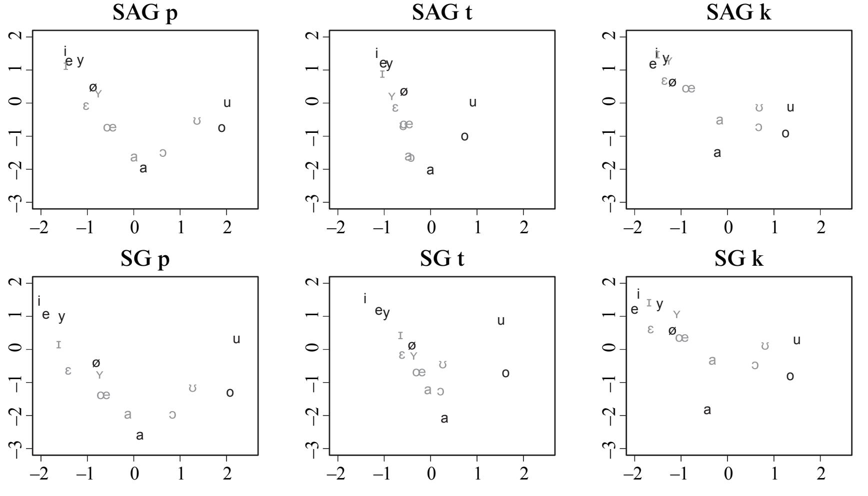
For the quantification of the data, we ran mixed models in R (R Core Team, 2013) with the (non-aggregated) PCA distances for the vertical Y and horizontal X tongue position as dependent variable. Vowel, variety and the place of articulation of the consonant were fixed factors and speaker was the random factor in all mixed models. In the case of a significant interaction between at least two factors, subsequent Tukey post-hoc tests were run with the help of the *multcomp* library (Hothorn et al., 2008) in the R package.

3.0 Results

Figure 2 shows a quadrilateral-like vowel space arising from the spatial distribution of all analyzed tense (in black) and lax vowels (in gray) in the first two dimensions of the PCA-transformed space. The figure shows a plausible degree of separation between the vowel types, such that tense are seen to be more peripheral than lax vowels, high front vowels /i, y/ above middle /e/ and low /a/ vowels and to the left of the back vowels /u, o/.

Regarding the tensity contrast, the overview in Figure 2 shows more compression of the vowel space vertically and smaller differences between tense and lax vowel pairs for SAG than for SG in all three consonantal contexts. Across places of articulation, the vowel distribution was less compressed

Figure 2: PCA-transformed articulatory vowel space extracted at the (acoustic) temporal midpoint of tense (black) and lax (gray) vowels in the bilabial (left), alveolar (in the middle) and velar (right) consonantal context, for seven speakers of Standard Austrian German (top) and eight speakers of Standard German (bottom)



vertically in the bilabial than in the remaining consonantal contexts. More specifically, back vowels /u, ʊ/ were more fronted in the alveolar context and the low vowels /aː, a/ were raised in the velar context in both varieties, so that in both varieties the relative distance between /i – u/ was smallest in the alveolar context; and the distance between /i – a/ was smallest in the velar context.

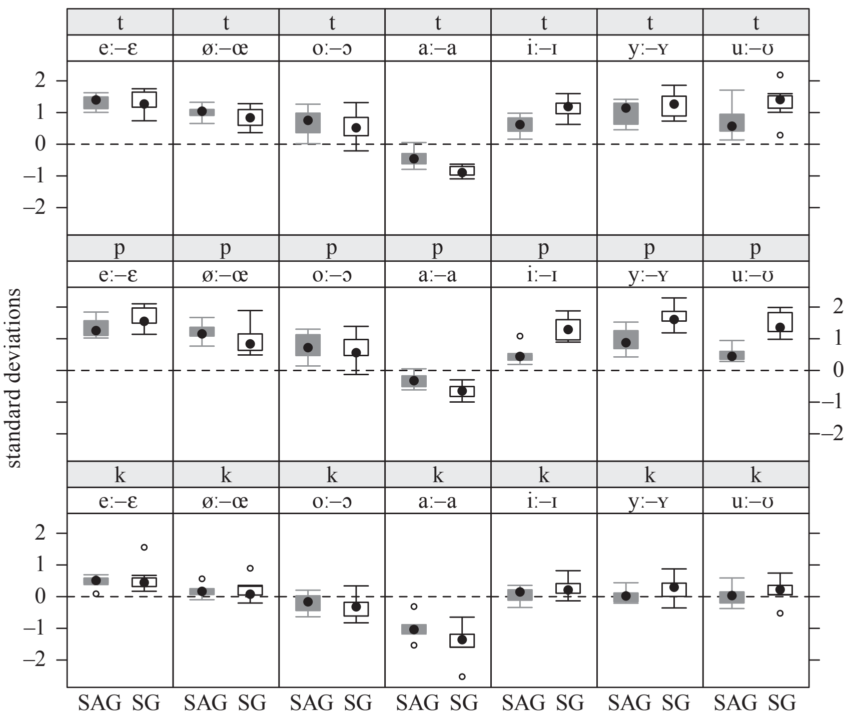
The quantification of the relative distances is displayed in Figures 2, 3 separately for the vertical and the horizontal PCA. Each distribution consisted of one value per speaker on the speaker means calculated from

$$V_T - V_L, \quad (1)$$

where V_T and V_L denote a speaker-specific aggregate for a tense vowel and lax vowel, respectively, on either the vertical or horizontal dimensions in Figure 2. Thus, values closer to zero on (1) denote that tense and lax vowel pairs for a given speaker are closer together.

Figure 3 shows the difference in the mean vertical difference between tense and lax pairs. Consonant ($\chi^2[3] = 233.0$, $p < 0.001$) had a main effect which comes about because the distance between tense and lax pairs was smaller in the velar than in the other two contexts. As far as variety was concerned, Figure 3 suggests a tendency for smaller vertical differences between tense and lax vowels in SAG, but not for all vowels. There were significant effects of vowel ($\chi^2[6]=259.9$, $p<0.001$) and variety ($\chi^2[1]=3.6$, $p<0.05$) on the mean vertical difference between tense and lax vowels; but since the results also showed a significant interaction between variety and consonant ($\chi^2[2]=12.6$, $p<0.01$) and between variety and vowel ($\chi^2[6]=79.7$, $p<0.001$), we carried out post-hoc Tukey tests on all pairwise combinations.

Figure 3: Mean distance differences (one value per speaker) of the vertical Y-PCA space between tense and lax vowel pairs in three consonant contexts produced by eight Standard Austrian German (gray) and seven Standard German (white) speakers



The results of the Tukey t-tests on the vertical distance differences are displayed in Table 1. They showed significant variety differences between tense and lax vowel pairs exclusively for the vowel pairs /uː – ʊ/ ($p < 0.001$), /iː – ɪ/ ($p < 0.01$) and /yː – ʏ/ ($p < 0.05$) in the bilabial context and /aː, a/ in the alveolar context. Regarding consonantal context, there was, with the exception of /iː – ɪ/ and /uː – ʊ/, a smaller vertical difference between tense and lax vowel pairs in the velar compared with the other two consonantal contexts.

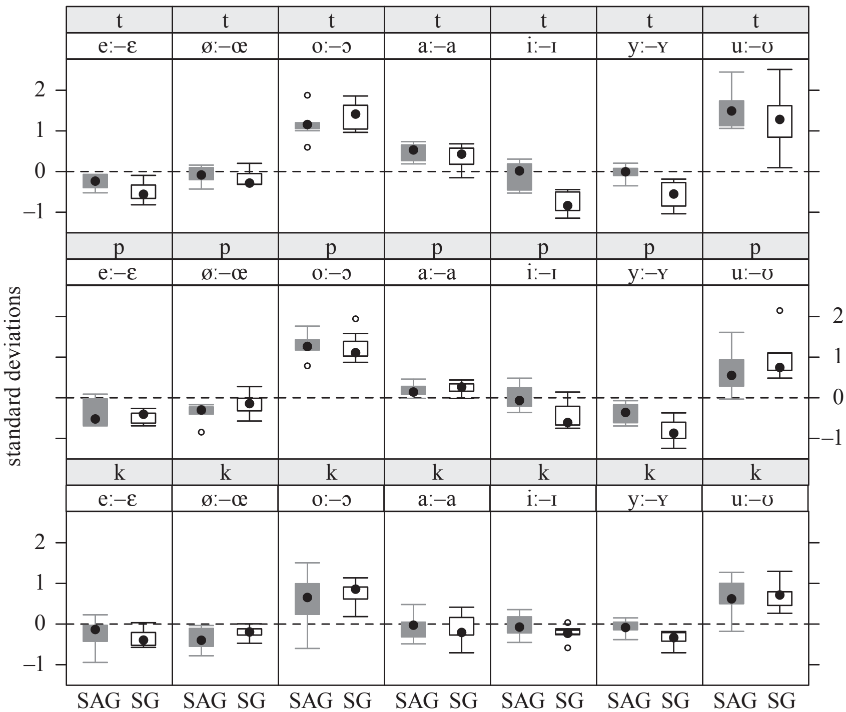
Figure 4 shows the mean difference between tense and lax vowel pairs on the horizontal dimension, PCA-X. Variety differences were not significant for the horizontal tongue position. Vowel ($\chi^2[6] = 665.5$, $p < 0.001$) and consonant ($\chi^2[2] = 12.9$, $p < 0.01$) showed main effects on this parameter. However, there was also a three-way interaction between vowel, consonant and variety. Post-hoc tests showed influence neither of variety nor of consonantal context on the relative horizontal distances. The only exception was /oː, ɔ/ in SG, in which the relative distances were greater in bilabial than in velar context ($p < 0.01$). None of the remaining paired t-tests (total of 42, seven vowel x three consonantal contexts x two varieties) had a significant influence.

Figure 5 displays the vowel duration (in ms) of the acoustic data from the EMA recordings and the twelve additional SAG speakers. The results showed that vowels were significantly longer in SAG than in SG ($\chi^2[1] = 21.2$, $p < 0.001$), and in both varieties tense vowels were longer than their lax counterparts ($\chi^2[1] = 2946.6$, $p < 0.001$). Consonantal place of articulation had a significant influence on the vowel duration ($\chi^2[2] = 302.0$, $p < 0.001$), but post-hoc tests showed longer tense and lax vowels in SAG comparing to SG for all three places of articulation ($p < 0.001$).

Table 1: Summary of the results of the Tukey post-hoc tests for the comparison of places of articulation in the vertical PCA-Y

Variety	Comparison	/eː – ɛ/	/øː – œ/	/oː – ɔ/	/aː – a/	/iː – ɪ/	/yː – ʏ/	/uː – ʊ/
SAG	velar – bilabial	***	***	***	*		**	
	velar – alveolar	***	***	**			**	*
	alveolar - bilabial							
SG	velar – bilabial	***	*	***	**	***	***	***
	velar – alveolar	***		**		**	***	***
	alveolar – bilabial							

Figure 4: Mean distance differences (one value per speaker) of the horizontal X-PCA space between tense and lax vowel pairs in three consonant contexts produced by eight Standard Austrian German (gray) and seven Standard German (white) speakers



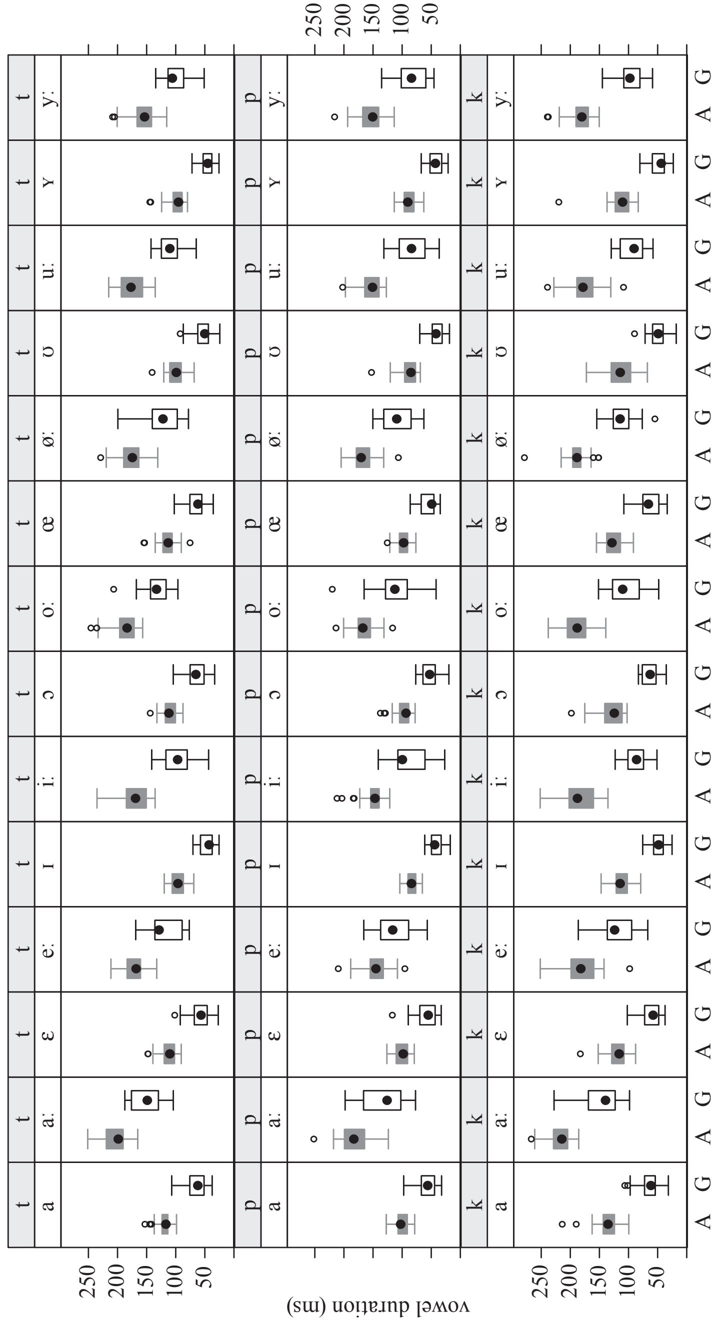


Figure 5: Absolute vowel durations in three consonant contexts produced by twenty SAG (gray) and seven SG (white) speakers

4.0 Discussion and Conclusions

In this paper we investigated the influence of consonantal context and vowel quantity on the implementation of the tense-lax vowel contrast in SAG compared to SG, focusing on articulatory tongue movement and vowel duration. The first main finding was that the implementation of the tense-lax contrast on the vertical dimension of the tongue was clearly influenced by consonantal context: generally, the difference between tense and lax vowel pairs was smaller in the velar context. The reason for this is that in velar contexts the vowel is higher because of the influence of the raised tongue position for the production of the velar consonant (Harrington et al., 2012). The major differences over varieties were primarily in bilabial contexts, such that lax /ɪ, ʊ, a/ are tenser and closer to their tense counterparts vertically in SAG compared to SG.

Vowel duration was distinctive in both varieties and it was not neutralized in SAG: the study showed that both tense and lax vowels are longer in SAG than in SG, but the tensity contrast remained stable for each vowel pair and in all three analyzed consonantal contexts with no exceptions. Our interpretation of these results is that, for the high and lower vowels that have been neutralized in terms of their quality, the phonological contrast is rather based on quantity than on vertical tongue position.

Given the greater proximity in the vertical tongue position between tense/lax high and low vowel pairs in SAG than in SG and no neutralization of vowel quantity, the latter may also be perceptually more important in the differentiation of these vowel pairs in SAG than in SG. This is an issue we are currently investigating with the high vowel pair /iː – ɪ/ in a perception study.

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