Monolingual and trilingual production of Northern Standard German vowels

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Abstract

Studies on vowel productions of speakers from bilingual communities report L1-L2 interactions but also monolingual-like realizations ([1], [2], [3]). Where the languages differed in communicative range and size of the speech community, monolingual-like productions of early bilinguals were found in the languages with the wider communicative range and larger speech community. We compare the acoustic realizations of Northern Standard German (NSG) vowels in monolingual speakers from Hanover, representing the larger speech community of Northern Germany, and in trilingual speakers from the Saterland, speaking the local variant of High German, Low German, and Saterland Frisian. To examine whether the NSG vowels of the Saterland speakers approached the vowels of the monolingual speakers in terms of spectral and durational features, we elicited all stressed NSG monophthongs in /hVt/ context. Our data show an orientation towards the larger speech community of Northern Germany in the productions of the trilinguals. Vowel productions which neither differed across the trilinguals' three languages nor from the monolinguals suggest contact-induced phonetic convergence towards NSG. The observed bidirectional interaction of the trilinguals' three vowel systems further supports the claim that all vowel categories are organized in a common phonological vowel space.

Index Terms: Northern Standard German, vowel production, trilingualism, phonetic interference, Low German

1. Introduction

Research on second-language acquisition and bilingualism shows that the sounds of the languages acquired influence each other mutually in the production of L1 and L2 categories (cf. [4], [5]). The observed cross-linguistic interactions suggest that the vowels of the L1 and L2 are organized in a common phonological space (cf. [6], [7], [8], [1]). Despite language-specific categories and near-monolingual-like performance in one or both of the acquired languages, early and simultaneous bilinguals from bilingual communities showed some effect of cross-linguistic interference in the production of vowel categories ([1]; [2]). In a recent study on the vowel productions of speakers from a Welsh-English community, [3] studied the substrate effect of Welsh and present a case in which interference is observable in terms of large-scale phonetic convergence in the context of regional bilingualism (cf. [9]). In [1] and [3] monolingual-like productions were observed in the languages of the early bilinguals that have the wider communicative range and larger speech community, i.e. Spanish and English.

Similar to the findings in [3], the trilingual speakers of Saterland Frisian (SF), Low German (LG), and Northern Standard German (NSG) studied by [10] showed mergers of vowel categories used in two or all three of their languages. The trilingual speakers were recruited from Scharrel, a village in the municipality of Saterland, located in the northwestern part of Lower Saxony in Northern Germany. Whereas no systematic differences were reported in the trilinguals' phonetic realizations of corresponding categories between the two languages confined to the close-knit community of Saterland, SF and the local variety of LG, deviant realizations were found for several vowel categories in NSG, which is spoken by several millions of speakers in Northern Germany.

The question that arises from the previous acoustic investigation of vowel productions in Saterland trilinguals is whether the deviant realizations of NSG vowels found in the Saterland point into the direction of NSG vowels produced by monolingual speakers of NSG. The present study expands the acoustic investigation in [10] by studying the substrate effect of SF and LG on the standard language through a comparison with monolingual speakers of the standard variety, which are more representative of the wider speech community of Northern Germany. To this end, the NSG vowel productions of the trilingual Saterland speakers reported in [10] are compared with those of monolingual speakers of NSG from Hanover. Hanover is the state capital of Lower Saxony, about 170 kilometers from Scharrel. The High German variety of Hanover is commonly considered most typical of NSG and the language used in the Northern German media.

We hypothesize that the NSG vowel productions of the Saterland speakers approach the productions of the monolingual speakers in terms of spectral and durational features. In particular, we expect that those vowel categories which showed deviant realizations in NSG in the study of [10] can be identified as instances of contact-induced phonetic convergence towards NSG.

2. Method

2.1. Participants

Twenty-three male native speakers participated in the study, 11 trilinguals from Scharrel and 12 monolinguals from Hanover. The trilingual speakers had lived in Scharrel all their lives and thus had extensive exposure to all three languages from birth. All subjects considered SF as their mother tongue and primary home language. Even though they differ somewhat in their reports on the order and the age of acquisition of LG and High German, the Scharrel subjects may all be categorized as early sequential trilinguals in the sense of [11] because all speakers were exposed to the three languages from

early childhood on within the Saterland (SF, LG, NSG), through contact with people outside of the Saterland (LG and NSG), and through the media (NSG). The monolingual Hanover subjects lived and grew up within the Hanover region with a maximum distance from the city center of about 50 kilometers. Only one subject deviates from this profile, growing up in Lüneburger Heide about 90 kilometers north of Hanover but having lived in Hanover for the larger part of his life. The 23 subjects were all aged between 50 and 75.

2.2. Material and recording procedure

The vowel systems of the three languages spoken in the Saterland share the majority of vowel categories. All 15 monophthongs of High German (/i: y: u: e: ø: o: ɛ: a: ɪ ʏ ʊ ɛ œ ɔ a/) have an equivalent in SF and LG. In addition, SF and LG have two long lax open-mid vowels, /œ:/ and /ɔ:/.

In spoken NSG the vowel phoneme /ɛ:/, which is believed to be mostly due to spelling pronunciation, tends to be merged with /e:/ and thus realized as a close-mid vowel (cf. [12], [13, p.50], [14], [15, p. 172f.]). In careful speech, however, the opposition between /e:/ and /ɛ:/ in hVt context may be upheld even by North German speakers (cf. [16, p. 79]). In the trilingual inventory of the Saterland speakers, the distinction between /ɛ:/ and /e:/ may get further support by the fact that SF and LG have two more open-mid long lax vowels, /œ:/ and /ɔ:/, which contrast with both the long tense vowels /ø:/ and /o:/ and the short lax vowel /œ/ and /ɔ/.

The 15 High German vowel categories were recorded in monosyllabic /hVt/ context. For all sessions, a native monolingual speaker of NSG guided the participants through the experiment. The /hVt/ words were elicited via rhymes in sequences of High German triggers followed by the /hVt/ target word. For this matter, the informants were first instructed to read aloud the High German trigger word displayed on the computer screen and to produce the rhyming /hVt/ target word (e.g. Boot 'boat' – Hoot) subsequently, with only the frame H_t presented on the computer screen (cf. [17], [18]). Target words were elicited as rhyming words and not displayed directly to account for a possible influence of the written form on the production data. All informants were instructed to not overarticulate but to pronounce the target word in a more habitual style.

The sequences of trigger and target words were presented in a controlled randomized order to secure that a vowel was never directly succeeded by the same vowel in the following sequence. Each sequence of a trigger and the rhyming target word was presented three times per speaker, thus eliciting a sample size of 45 tokens per subject (15 monophthongs × 3).[1] The recordings were monitored for the target pronunciation and intonation to ensure that all /hVt/ words were elicited with a falling contour. Where mistakes occurred, individual sequences were repeated at the end of each recording session. The first three valid productions of each target vowel and speaker were analyzed. Six practice sequences preceded all blocks. The recordings were made with a Tascam HD P2 digital recorder and a head-mounted microphone (DPA 4065 FR) in a quiet room and digitized at a sampling rate of 48 kHz.

2.3. Acoustic analysis

All acoustic analyses were done with the Praat software package ([19]). Measured acoustic variables included F1 and F2 at vowel midpoint, as well as vowel duration. In addition, we calculated the duration ratios for the vowel pairs of short/lax and long/tense monophthongs. Only the vowel mid-point frequencies were included in the analysis since neither High German nor SF monophthongs are diphthongized (cf. [16, p. 86], [20], [21]). Onset and offset of the vocalic segment were labeled manually for each /hVt/ word. Vowel onset was measured at the zero-crossing before the first positive peak in the periodic waveform. Vowel offset was set at the last negative-to-positive zero-crossing before the (abrupt) reduction in amplitude and/or cessation of periodicity in the waveform before the stop closure.

A Praat script was used to automatically estimate the frequencies of the first and second formant. The window length was set to 0.025 seconds. Formant settings for the LPC analysis were adapted upon visual inspection for each realization individually in the script by de- or increasing the LPC order in steps of 1 (default order of 10) and the maximum frequency in steps of 500 Hz (default 5000 Hz). Outliers due to measurement errors were corrected by hand.

A normalization of the data is necessary to mitigate variation caused by physiological differences among the different speakers while preserving sociolinguistic variation. We followed the normalization method applied in Guion (2003). In a first step we converted the Hertz data to the Bark scale using Traunmüller's (1990) formula (1).

$$z = [26.81/(1+1960/F_i)] - 0.53 \quad (1)$$

where F_i is the value for a given formant *i*.

Subsequently, we normalized the Bark formant values through the multiplication with a speaker-specific k factor, which is derived by dividing one fixed subject's average F3 ($F_3\ S_{median}$) of the open vowel (/a/) by speaker *j*'s mean F3 ($F_3\ S_j$), using the formula in (2).

$$\text{mean } F_3\ S_{median}/\text{mean } F_3\ S_j = k_j \quad (2)$$

All calculations in this study are based on normalized formant values.

2.4. Statistical processing

Function lmer from the *lme4* package [22] was used to perform linear mixed effects analyses in R [23]. As dependent variables we used *duration*, *duration ratio*, *F1*, and *F2*. As fixed effect, we entered the variables *speaker group*, which distinguishes between monolingual speakers and trilingual speakers, and *repetition* into the full model. As random effects, we had intercepts for *speaker* and *vowel* (or *vowel pair* in the comparison of the duration ratios) as well as by-vowel (pair) random slopes for the effect of *speaker group*. In addition, by-speaker random slopes for the effect of *repetition* were included in the full model. When comparing speaker groups per individual vowel/vowel pair, only random intercepts for *speaker* and by-speaker random slopes for *repetition* were included in the full model as the random effects. A backward elimination of non-significant effects of each full model was performed with the step function of the *lmerTest* package [24]. All *p*-values were calculated using the Satterthwaite approximation in the *lmerTest* package.

3. Results

3.1. Vowel duration

Figure 1 shows the mean vowel duration for the long and short monophthongs of NSG averaged over each speaker group.

Within both speaker groups, a clear separation between long and short vowels is confirmed by a linear mixed effects model with vowel duration as the dependent variable and random intercepts for speaker (MON_NSG long vs. short: β=121.88, SE=3.29, t(522)=37.08, p<.001, TRI_NSG long vs. short: β=83.85, SE=2.75, t(474)=30.48, p<.001). No general effects of *speaker group* were found regarding the subgroups of long and short vowels, i.e. the two speaker groups do not differ in the realization of all long or short categories regarding vowel duration. The comparison of single long vowel categories, however, shows significant durational differences between the two speaker groups for /a:/ (β=43.62, SE=19.37, t(23)=2.25, p<.05) and /e:/ (β=40.56, SE=18.05, t(23)=2.25, p<.05). In both cases the vowel durations are longer for the monolingual speakers. For the short vowels, no effect of *speaker group* on vowel duration was found.

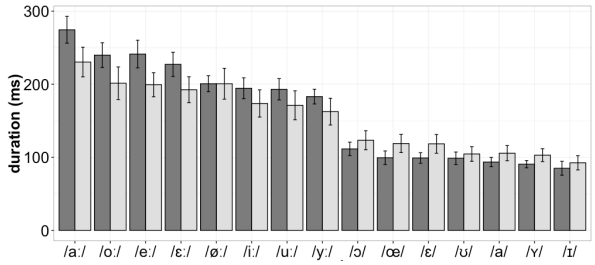

Figure 1: *Mean duration of monophthongs averaged over all speakers per group (monolinguals = dark grey, trilinguals = light grey). Error bars represent 95% confidence intervals of the means.*

[10] found the longest mean durations for the trilinguals' productions in NSG compared to SF and LG but no differences between the SF and LG productions of monophthongs. This effect is most pronounced in the subgroup of long vowels. The mean long vowel duration of the monolinguals exceeds all of the trilingual values, among which the NSG values are the highest.

	ratio monoling.	ratio triling.	β	SE	t(df)	p
a:-a	3.0	2.3	0.75	0.20	3.84(23)	<.001
ɛ:-ɛ	2.3	1.7	0.71	0.16	4.43(21)	<.001
e:-ɛ	2.5	1.8	0.75	0.20	3.73(23)	<.01
ø:-œ	2.2	1.7	0.47	0.16	2.88(23)	<.01
o:-ɔ	2.3	1.7	0.57	0.17	3.32(23)	<.01
i:-ɪ	2.5	1.9	0.56	0.21	2.70(23)	<.05
y:-ʏ	2.1	1.6	0.31	0.10	2.99(23)	<.01
u:-ʊ	2.0	1.7	-	-	-	n.s.
mean	2.4	1.8				

Table 1: *Mean duration ratios measured per vowel pair for each speaker group and the overall mean ratio of each speaker group averaged over all pairs.*

Table 1 illustrates the mean duration ratios for the vowel pairs of short/lax and long/tense monophthongs per group. Averaged over all vowel pair ratios, long vowels are 140% longer than short vowels in the productions of the monolinguals. In the trilinguals, long vowels are only 80% longer. On average, vowel duration differences in phonological short/lax and long/tense oppositions are smaller for the trilingual speaker group. Per vowel pair we compared the duration ratios of the monolinguals with the High German duration ratios of the trilinguals. We found a significant difference for all pairs but /u:-ʊ/. Regarding the pairs /a:-a/ and /e:-ɛ/, the difference between the speaker groups is directly attributable to the longer durations of the long tense vowels in the productions of the monolinguals.

Considering the data from [10], the differences in the duration ratios are similar to the differences observed above for the absolute durations. The trilinguals' average short/lax - long/tense ratios in NSG are higher than the non-distinct SF and LG ratios but smaller than the average ratios of the NSG monolinguals.

3.2. Formant frequencies

Figure 2 shows mean formant values for the 15 measured NSG monophthongs averaged over all subjects per group. No overall effect was found for the relative location of the vowel phonemes within the F1-F2 plane, suggesting that there is no general shift in F1 or F2 between the two speaker groups.

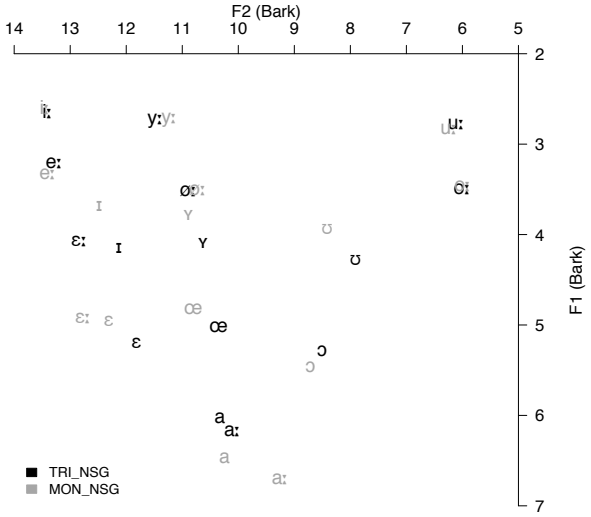

Figure 2: *Mean normalized F1-F2 values of 15 monophthongs measured at vowel midpoint.*

We applied mixed effects models in order to explore the relationships among /ɛ:-ɛ/, /e:-ɛ:/, and /a:-a/ within the speaker groups. The linear mixed effects models were carried out with either *F1* or *F2* as dependent variable, *vowel category* as fixed factor, and random intercepts for *speaker*. The results of the pairwise comparisons for *vowel category* suggest that contrary to prior reports for NSG (e.g. [16, p. 81]) the two speaker groups distinguish between long /ɛ:/ and short /ɛ/ both by duration and by vowel quality (F2 MON_NSG: β=-0.33, SE=0.07, t(54)=-4.46, p<.001; F2 TRI_NSG: β=-1.02, SE=0.06, t(54)=-17.36, p<.001). Long /ɛ:/ and short /ɛ/ are not distinguished by F1 within the monolingual vowel space but within the trilingual vowel space (F1 TRI_NSG: β=1.14, SE=0.04, t(54)=26.01, p<.001). While the /ɛ:/-/ɛ/ opposition is secured by a clearer qualitative distinction in the trilingual vowel space, it is supported by the greater difference in duration in the monolingual vowel space (see 3.1, table 1). Moreover, the results of the pairwise vowel comparisons showed that the monolingual speakers did not neutralize the distinction between /e:/ and /ɛ:/ (F1: β=-1.59, SE=0.08, t(58)=-19.22, p<.001; F2: β=0.78, SE=0.07, t(54)=11.11, p<.001; see footnote 1).

NSG is often reported to distinguish /a/ and /a:/ primarily by duration (cf. [25, p. 59]). As in the study by [16, p. 81], we

found that the /a-aː/ opposition was not only upheld in terms of vowel duration (MON_NSG: β=-180.92, SE=7.72, t(60)=-23.44, p<.001; TRI_NSG: β=-124.64, SE=8.12, t(55)=-15.35, p<.001)) but also in terms of acoustic quality (F1 MON_NSG: β=-0.24, SE=0.07, t(60)=-3.45, p<.01; F2 MON_NSG: β=0.97, SE=0.09, t(60)=11.00, p<.001; F1 TRI_NSG: β=-0.15, SE=0.07, t(55)=-2.14, p<.05; F2 TRI_NSG: β=0.20, SE=0.07, t(55)=2.99, p<.01).

Significant differences were found for the comparison of subgroups of short lax vowels: the trilingual speakers produced /ɪ ʏ ʊ/ with higher F1 values (β=-0.38, SE=0.09, t(23)=-4.16, p<.001) and lower F2 values (β=0.37, SE=0.17, t(22)=2.15, p<.05). Within the trilingual vowel space, the qualitative difference between the phonemically close short/lax and long/tense pairs /iː-ɪ/, /yː-ʏ/, and /uː-ʊ/ is enlarged by lowering of the short lax vowels. Secondly, in comparison to the monolingual productions, short lax /ɛ/ and /œ/ are also lowered and retracted in the trilingual vowel space (/œ/ F1: β=-0.27, SE=0.11, t(23)=-2.56, p<.05; /œ/ F2: β=0.44, SE=0.16, t(23)=2.82, p<.01; /ɛ/ F1: β=-0.24, SE=0.09, t(23)=-2.66, p<.05; /ɛ/ F2: β=0.49, SE=0.19, t(23)=2.59, p<.05). The larger separation of /ɛː/ and /ɛ/ in the trilingual vowel space as compared to in the monolingual vowel space is thus due to both a more close position of /ɛː/ (β=0.85, SE=0.12, t(21)=7.10, p<.001) as well as the lowering of /ɛ/.

Moreover, as with the oppositional pairs described above, the respective lowering of /ɛ/ and /œ/ in the trilingual vowel space results in an enhanced qualitative difference for the oppositions of long tense /eː øː/ with short lax /ɛ œ/. Thirdly, the trilinguals show a more close production of both open vowels and a less retracted realization of the long open category in comparison to the trilinguals (/a/ F1: β=0.44, SE=0.16, t(23)=2.81, p<.05; /aː/ F1: β=0.53, SE=0.17, t(23)=3.06, p<.01; /aː/ F2: β=-0.85, SE=0.13, t(23)=-6.31, p<.001).

All in all, the results for mid-vowel formant frequencies suggest a different internal organization of the two vowel spaces but they also show similarities in the production of shared categories. /iː yː uː/, /eː øː oː/, and /ɔ/ do not differ in phonetic quality between the monolinguals and trilinguals. Moreover, while no phonological opposition was found to be purely quantitative or qualitative in nature for either speaker group. The qualitative difference in the vowel space of the trilinguals is enlarged relative to the qualitative difference in the monolingual vowel space for the close oppositional pairs (/iː-ɪ/, /yː-ʏ/, /uː-ʊ/), the phonemically close-mid long/tense and short/lax oppositions /eː-ɛ/ and /øː-œ/, and the opposition /ɛː-ɛ/.

[10] found significant differences in F1 between the trilinguals' SF and NSG productions of /iː yː uː/, /ɪ ʊ ʏ/, and /ɛː/. The trilinguals produce the long vowels /iː yː uː/ monolingual-like and the short /ɪ ʊ ʏ/ with intermediate F1-values. The position of /ɛː/, however, is neither monolingual-like nor intermediate but instead more close than the monolinguals' realizations of NSG as well as the trilinguals' realizations of SF.

4. Discussion

The majority of the trilinguals' NSG category realizations (10 of 15 categories) approach, or are similar to, the acoustic properties of the monolingual productions. Among these vowels, /oː/, /øː/, and /ɔ/ do not differ in F1 or F2 among the trilinguals' three languages [10]. Similar to [3], we argue that these category realizations present a case of contact-induced phonetic convergence between the two local languages and the standard language in a situation of regional trilingualism and extensive language contact. /ɪ ʏ ʊ/ follow the pattern observed by [1] and the respective hypothesis of the Speech Learning Model (hypothesis #6 in [7]) that language-specific categories are shifted and realized with intermediate values. The observed bidirectional interaction of the trilinguals' three vowel systems further supports the claim that all vowel categories are organized in a common phonological vowel space.

Among the remaining five[2] categories, three (/ɛ œ a/) were produced with values equal to the SF and LG merged categories [10]. The last vowel (/ɛː/) was produced more close than the LG/SF merged category and the productions of the monolinguals. A possible explanation for the high position of NSG /ɛː/ in the phonetic space of the trilinguals is a pull effect: /ɛː/ is produced with the same tongue height as /ɪ ʏ ʊ/ in the trilingual vowel space in SF and LG. Because /ɪ ʏ ʊ/ are produced more close as they approach the F1-F2 values of the monolingual speakers, the maintenance of the internal structure, i.e. the same degree of openness for /ɛː ɪ ʏ ʊ/ in all of the trilinguals' subsystems, would explain the more close position of NSG /ɛː/ as compared to LG and SF.

Our findings differ from [1] and [3] who both report all or the majority of the early bilingual vowel productions in the language with the supraregional communicative range and larger speech community to resemble those of monolingual speakers. In contrast to [1] our data need to be explained with recourse to the crowded trilingual vowel space and the preservation of phonemic contrasts. [2] even report (nearly) monolingual-like vowel productions in both of the bilinguals' languages. However, [2] studied only four of the 15 vowel phonemes distinguished within the bilinguals' language inventories. It is unclear whether further monolingual-like productions would be found in a comparison of all shared categories.

Acoustic distances between non-open short and open long positions are enlarged in the vowel system of the trilingual speakers with the exception of /ɔ-oː/. Primarily due to the relatively lowered short/lax vowels, the perceived vowel length distinction between oppositional pairs is likely to be enlarged by listener compensation (cf. [26]). The comparison of duration ratios revealed larger ratios for the monolingual speaker group. This finding suggests that duration is a more important cue for distinguishing long tense and short lax vowels in the monolingual speaker group, whereas the larger qualitative differences between long tense and short lax vowels in the trilingual speakers – and the entailed larger difference in perceived vowel length – is more important for the preservation of vowel contrasts in the trilingual system.

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[1] Two monolinguals did not produce a clear distinction between /eː/ and /ɛː/ but a merger of the two with /eː/-like formant values. Their productions of /ɛː/ were therefore excluded from the analysis.

[2] Due to the lack of Saterland Frisian elicitations of /aː/ from the Scharrel trilinguals no conclusion can be drawn for the long open category in this variety.