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Durational consonant categories in Alemannic and Swiss Standard German across tempo and age

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Abstract

German-speaking Switzerland classifies as diglossia, meaning that the Swiss German public speak both an Alemannic dialect and a respective variety of Swiss Standard German (SSG). Both varieties have a quantitative contrast in obstruent consonants, resulting in different durational categories. One aim of this study is to investigate these categories, focusing on plosives, in both Alemannic and SSG. Furthermore, articulation rate (AR) and its influence on these categories are examined. 20 speakers of two age groups, i.e. younger and older adults, from the canton of Lucerne (LU) were recorded. They read words containing different vowel consonant combinations (VC combinations) within carrier sentences in two conditions, i.e. normal and fast speech tempo. Results show that older speakers have a slower AR in SSG while they behave similar to younger speakers in Alemannic. Most importantly, this investigation confirms a three-way distinction in consonant durations, namely lenis, fortis, and extrafortis in both Alemannic and SSG. In addition, older speakers produce longer consonant durations in the extrafortis category than younger speakers. Despite these age-related differences, durational consonant categories are stable across both tempo and age.

Index Terms: Alemannic, Swiss Standard German, articulation rate, consonant duration

1. Introduction

German-speaking Switzerland belongs to the rare set of speech communities that classifies as diglossia [1], meaning that the Swiss German public speak both a variety of Alemannic and a respective variety of Swiss Standard German (SSG). In every-day life as well as in private settings, Swiss German speakers talk Alemannic. SSG is learned in school and is typically spoken only in formal situations, such as parliament sessions or formal news reports. From a sociolinguistic perspective, Alemannic and SSG belong to different functional domains rather than forming a dialect-standard continuum [2].

A phonological property of Alemannic dialects as well as SSG is the quantity contrast not only in vowels but also in obstruent consonants [3–7]. In this study, short consonants are referred to as 'lenis' and long consonants as 'fortis'. Phonotactically, all combinations of short and long vowels and consonants are legal in both Alemannic and SSG, resulting in four possible vowel-consonant sequences (VC combinations): VC, VC:, V:C, and V:C:.

The diglossic nature and the quantitative distinction in obstruents make the Swiss German varieties an interesting case of prosody in contact. Nevertheless, the number of studies focusing on the durational features of Swiss German is limited, even more so when it comes to the comparison between Alemannic and SSG. This study therefore examines the durational properties of different types of plosive consonants in two conditions, i.e. normal and fast speech tempo, in both Alemannic and SSG. In addition, articulation rate (AR) and its influence on these consonant types are investigated. The focus is on the varieties of the canton of Lucerne (LU), which has never been examined in terms of these temporal properties before. Furthermore, the speakers recorded belong to two age groups, i.e. younger and older adults. Whereas in other southern German varieties, such as Eastern and Western Central Bavarian, a sound change in progress seems to be taking place, resulting in younger speakers' productions of the previously phonotactically illegal sequence V:C:, Swiss German varieties of Alemannic are considered to have stable quantity contrasts [8, 9]. Nevertheless, age is an additional sociolinguistic factor that needs attention when examining the stability of durational properties. Taking all of these aspects into account, the aim of this study is to investigate temporal properties of the lesser-studied region of LU in terms of durational consonant categories and AR.

1.1. Alemannic

The dialects of German-speaking Switzerland comprise Low Alemannic, spoken in the city of Basel, High Alemannic, spoken in the north, and Highest Alemannic, spoken in the south [10, 11]. The region of interest in this study belongs to High Alemannic and will simply be referred to as 'Alemannic' for the sake of brevity. It is also important to note that not only Alemannic but also SSG varies among regions of German-speaking Switzerland. In addition to the aforementioned three main dialect groups, there is a broad four-way division between areas that differ in particular linguistic features, i.e. east, west, north, and south [12]. While LU clearly belongs to the northern area, it lies in between the western and eastern area. In contrast to LU, other dialects, such as Zurich German, have been studied quite extensively, also regarding their temporal properties [6, 8, 9, 13–19].

Highly relevant for this investigation is previous work from Zihlmann [16, 17], who investigated four regions of German-speaking Switzerland (Zurich, Berne, Chur, and Brig), also with respect to AR and consonant quantities in both Alemannic and SSG. The areas covered belong to each of the four dialectal areas mentioned above. Although LU was not a part of that investigation, comparisons between the regions of Zurich (east) and Berne (west) are valuable, as the canton of LU is located between the two.

1.2. Articulation rate

AR is known to differ across age, region, and gender [19–21]. This study focuses on the first of these aspects, also examining

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two different varieties (dialect, standard) spoken by the same individuals. There is broad consensus across different languages that older speakers have a slower AR than younger speakers [19–22]. Although this is true in general, age-related differences in AR might be small, depending on the region speakers come from [19, 20]. It is also important to note that differences in AR are only perceivable if they reach a threshold of the 'just noticeable difference' (JND) of 5% [21].

Regarding Alemannic in particular, a crowdsourcing study by Leemann [22] revealed that age-related differences in a number of dialects are quite small. Instead, previous research reported that speakers from western regions of German-speaking Switzerland have a slower AR than those from eastern regions in both Alemannic and SSG [17, 22]. Note that for the crowdsourcing, only single words were recorded [22]. Furthermore, the AR has been found to be generally faster in SSG than in Alemannic [17]. One aim of this study is to examine whether there are age-related differences in AR among the speakers from LU. Additionally, it can be expected that the speakers also have a slower AR in Alemannic than in SSG.

1.3. Lenis and fortis plosives

It is quite common for lenis and fortis stops to differ in overall duration in several languages, yet they often occur in combination with other distinctive features, such as voice or aspiration [23]. In Swiss German dialects, there is no distinction in voice, as all obstruents are voiceless, and there is no significant difference in voice onset time (VOT) between lenis and fortis [5, 6, 14, 24–28]. While there are slight F0 effects on the vowel following the obstruent, closure duration remains the primary distinction between lenis and fortis plosives [5, 27].

Furthermore, there might be an additional consonant category in Swiss German obstruents, resulting in a three-way distinction, namely lenis, fortis, and extrafortis [14, 24, 25]. While the contrast between lenis and fortis remains, extrafortis consonants are even longer than fortis ones and occur after short vowels [16, 26]. Zihlmann [16] found a three-way distinction in consonant categories for two varieties in Alemannic (Zurich and Berne), while speakers from all of the investigated varieties (Zurich, Berne, Chur, and Brig) produced extrafortis obstruents in SSG. This study aims to examine the behaviors of speakers from LU in that respect as well, also investigating potential age- or tempo-related differences. Regarding the comparison between Alemannic and SSG, it has been shown that speakers generally produce longer consonants in Alemannic than they do in SSG, though the differences are quite small [16].

1.4. Hypotheses

Based on previous research, age-related differences in AR are expected, with older speakers having a slower AR than younger speakers. Furthermore, the AR should be faster in SSG than it is in Alemannic.

Regarding consonant durations, there is no previous research on Alemannic indicating as to how age or a fast speech condition might influence consonant categories. Still, it can be expected that they are generally stable across both age and tempo [31]. Regarding the relationship between Alemannic and SSG in terms of consonant quantity, durations might be slightly longer in Alemannic than they are in SSG.

2. Methods

2.1. Participants

20 speakers (10 female) from LU were recorded. 10 of them were younger, aged between 25 and 32 years (mean=28.7, SD=1.94), and 10 of them were older, aged between 47 and 64 (mean=58.0, SD=6.30). All speakers grew up in LU and at least one but in most cases both of their parents come from the same canton. One of the originally selected speakers had to be excluded because her speech was strongly influenced by another dialect. This participant was replaced by another one, so that the number of speakers remained the same.

2.2. Stimuli

2.2.1. Alemannic

The dialect stimuli consisted of 52 disyllabic target words with the stress always being on the first syllable. Each target word was part of a series of three or four words. 46 words contained plosives in medial position, which were the stimuli chosen for this study.

The nucleus of the first syllable of the target words contained one of the three vowels /a i u/ (short or long) followed by one of the six consonants /b̥ d̥ g̊ p t k/. 12 target words were logatomes. The target words were embedded in carrier sentences with a total of six to eight syllables each, the nuclear accent being on the first syllable of the target word.

2.2.2. Swiss Standard German

For the SSG stimuli, there were 43 disyllabic target words with the stress always being on the first syllable. Again, each target word was part of a series of three or four words. 35 words contained plosives in word-medial position, which were the stimuli chosen for this study.

The target words contained the same vowels and consonants as those in Alemannic. 12 target words were logatomes. The target words were embedded in carrier sentences with a total of seven syllables each, the nuclear accent being on the first syllable of the target word.

2.3. Procedure

Whenever possible, the participants were recorded in a soundproof booth at the Phonetics Laboratory of the University of Zurich, using a personal computer with the interface USBPre® 2 (*Sound Devices)* and the microphone NT2-A (*RØDE*). Otherwise, they were recorded in a quiet room, using a laptop computer with the same interface and the microphone Opus 54.16/3 (*BeyerDynamic*). As for the recording software, *SpeechRecorder 3.8.0* [32] was used, with the exception of the interviews (cf. below), which were recorded using *Audacity* [33]. All recordings had a sample rate of 16-bit/44.1 kHz and were saved as *.wav*-files. Prior to the recording, participants signed a declaration of consent. They attended two appointments, the first one lasting about 75 minutes, the second one about 105 minutes. The participants received a reimbursement of 15 CHF per 30 minutes, resulting in a payment of 60 CHF for most participants.

At the first appointment, an interview of five to ten minutes was conducted to gather information about the sociolinguistic background of the participants and for them to get used to the recording situation. After the interview, there was a training phase, in which the average utterance duration

for each speaker was calculated based on three test sentences for normal and for fast speech tempo. This duration plus 400ms served as the basis for a time bar that appeared in the actual experiment. Speakers read four more test sentences in each speech tempo including the time bar. First, they saw the sentence, which they should read silently. Next, the text disappeared and they only saw the time bar which served as a limit during which they had to say the sentence out loud. An additional purpose of the training phase was for the participants to get used to the Swiss German spelling system by Dieth [34], which was used for the Alemannic production task. After the training, the actual experiment began. Each of the Alemannic sentences was repeated five times in normal and in fast speech tempo, resulting in 520 recordings (460 with plosives in medial position of the target word) for each participant. All stimuli were recorded in one session and presented in semi-random order, with two of the same stimuli never appearing twice in a row. Participants were instructed to repeat the sentence from the beginning in case they made a mistake.

At the second appointment, the participants' productions of SSG were recorded. The procedure was the same as for the Alemannic recordings, except there was no interview and for the SSG stimuli, the sentences were written in the official standard German orthography. Each sentence was repeated five times in normal and in fast speech tempo, resulting in 430 recordings (350 with plosives in medial position of the target word) for each participant. All stimuli were recorded in one session and presented in semi-random order, with two of the same stimuli never appearing twice in a row. After the production experiment, the same speakers participated in a perception experiment, which is not part of this study.

2.4. Data preparation

After the recordings were saved, they were automatically segmented with WebMAUS [35], selecting *German Dieth (CH)* for the Alemannic recordings and *German (DE)* for the SSG recordings in the language annotation settings. The phonetic segments were adjusted in the EMU-webApp [36], using the following procedure: the beginning and the end of each sentence were corrected if necessary. For the sentences beginning with a plosive, the release was used as the beginning of the first segment. If speakers paused within a sentence, the pause segment was removed and its duration was cut off at the beginning or end of the recording. If there was more than one longer pause, the recordings were not included in the analysis.

Each of the phonetic segments of the target words was precisely adjusted. The plosives were segmented into two phases: closure, indicated by /b̥ d̥ g̊/ for lenis and /p t k/ for fortis, and release, indicated by *_h*. When participants produced by accident the target word in a different way than expected, i.e. produced another word or pronounced the word incorrectly, the recording was excluded from the analysis. Further recordings were excluded not only if participants made mistakes that resulted in an alteration of the number of syllables or produced obvious hesitations, but also if the recording was cut in the beginning or end or if the quality of the recordings that were not conducted at the University of Zurich was not sufficient. From the total of 9200 of the Alemannic recordings (plosives only), 7586 were used for the analysis. From the total of 7000 of the SSG recordings (plosives only), 6529 could be used for the analysis.

2.5. Measurements

The duration of each sentence as well as the durations of the consonants within the target words were measured in milliseconds using the emuR package [37] in RStudio [38]. For the purpose of this study, only the measurements of the closure duration were included for the plosives. AR was calculated in terms of mean syllable duration (MSD) by dividing the utterance duration by the number of syllables of the sentence. The consonant (i.e. closure) durations were normalized by dividing their absolute durations by the utterance durations.

2.6. Statistical Analysis

The statistical analysis was done in RStudio [38]. Linear mixed-effects models were fitted for all the analyses, using the lme4 and the lmerTest package [39, 40]. For the model regarding the AR, *MSD* was defined as the dependent variable. Fixed effects were *tempo* (normal vs. fast speech), *age* (younger vs. older adults), and *variety* (Alemannic vs. SSG), including interactions. Random intercepts were added for *speaker* and *word*. For the model regarding consonant durations, *normalized consonant duration* (i.e. closure duration) was defined as the dependent variable. Fixed effects were *VC combination*, *tempo*, *age*, and *variety*, including interactions. Random intercepts were added for *speaker* as well as for *word* nested within *VC combination*.

A Type II ANOVA for each model was calculated, using the R package car [41], which yielded the Chi-square and the p values that are reported in the results section of this paper. Furthermore, pairwise comparisons using Tukey's test were calculated for the interactions that turned out to be significant, using the R package emmeans [42]. Additional Tukey's tests were calculated in case there was a significant effect of *VC combination* in order to compare the closure durations of each combination to each other.

3. Results

3.1. Articulation rate

The model for the AR revealed a significant effect of *tempo* (χ^2=6737.21, p<.001). The factors *age* and *variety* did not reach significance. Yet, there were significant interactions between *age* and *variety* (χ^2=251.59, p<.001), *tempo* and *variety* (χ^2=18.61, p<.001) and *tempo* and *age* (χ^2=14.71, p<.001).

Pairwise comparisons for each *variety* revealed a significant effect of *age* only for SSG (z=2.41, p=.016), with older speakers having a longer MSD, i.e. a slower AR, than younger speakers. As for *tempo*, there was a significant effect of *variety* for both normal (z=2.55, p=.011) and fast (z=-2.42, p=.016) speech tempo, with the dialect having a shorter MSD in fast speech and a longer MSD in normal speech compared to the standard. As for *age*, unsurprisingly there was an effect of *tempo* for both the younger (z=-55.59, p<.001) and the older speakers (z=-60.81, p<.001), with the fast speech tempo condition having a shorter MSD than the normal one. Additionally, there was a significant effect of *variety* for both younger (z=9.18, p<.001) and older speakers (z=-9.14, p<.001), with older speakers having a longer MSD in SSG and younger speakers having a shorter MSD in SSG compared to Alemannic, as can be seen in Table 1.

Table 1: *MSD in milliseconds and percentage increase/ decrease (%I/D) for both age groups in Alemannic and SSG in each speech tempo condition.*

Normal Tempo				Fast Tempo		
Age	**Variety**		**%I/D**	**Variety**		**%I/D**
	Alemannic	**SSG**		**Alemannic**	**SSG**	
Young	201	196	-2.49	173	165	-4.62
Old	210	218	3.81	180	184	2.22

The percentage of the increase and decrease of the MSD was calculated post-hoc with Alemannic as the basis. It turned out that the difference was below the JND of 5% in all measurements shown in Table 1, meaning that it is most likely not perceivable.

3.2. Consonant durations

The model for the normalized consonant durations revealed significant effects of *VC combination* (χ^2=313.51, p<.001) and *variety* (χ^2=763.01, p<.001). The factors *tempo* and *age* did not reach significance. There were significant interactions between *VC combination* and *age* (χ^2=94.50, p<.001), *VC combination* and *variety* (χ^2=241.51, p<.001), and *VC combination* and *tempo* (χ^2= 21.13, p<.001).

Pairwise comparisons for each *VC combination* revealed a significant effect of *age* for the combination VC: (z=2.48, p=.013), with older speakers producing longer consonants. Furthermore, there was a significant effect of *variety* for the combinations VC (z=6.15, p<.001), VC: (z=25.67, p<.001), V:C (z=5.04, p<.001), and V:C: (z=16.85, p<.001), with consonant durations being longer in Alemannic than in SSG. A significant effect of *tempo* was found for the combinations VC (z=2.59, p=.001), with the consonants having a higher temporal share in fast speech tempo, and VC: (z=-3.24, p=.001), where the consonant had a higher temporal share in normal speech tempo.

As for *age*, *tempo, and variety*, similar results were found. There was a significant effect of *VC combination* for all the comparisons (each p<.001) except for the comparison between VC and V:C for both younger and older speakers, normal and fast speech tempo, and Alemannic and SSG, as can be seen in Table 2. This confirms a significant difference between V:C: and VC:, i.e. between fortis and extrafortis, which is stable across *age*, *tempo*, and *variety*.

Table 2: *Z ratios and* p *values for the comparisons between VC combinations in both Alemannic and SSG (averaged over age and tempo).*

VC combinations	Alemannic		SSG	
	Z ratio	**P value**	**Z ratio**	**P value**
VC -VC:	-10.89	<.001	-8.95	<.001
V:**C - VC**	-1.40	.498	-1.27	.583
V:**C - VC**:	-17.08	<.001	-13.49	<.001
V:**C - V**:**C**:	8.76	<.001	7.08	<.001
V:**C**: - VC	-5.32	<.001	-3.84	<.001
V:**C**: - **VC**:	-14.33	<.001	-11.13	<.001

4. Discussion and conclusions

4.1. Methodological remarks

To begin the discussion, some methodological remarks that might have influenced the results must be made. First of all, it would have been optimal if the target words for Alemannic and SSG were the same. Due to different pronunciations, this was not possible, resulting in a comparison not of words but of groups of VC combinations. Second, participants might have been influenced by the fact that two different spelling systems were used for Alemannic and SSG. Lastly, despite the manual adjustment of segment boundaries in annotation files being a time-consuming process, it is worth considering a higher number of participants for future research, especially when it comes to generational comparisons.

4.2. Discussion of the results and conclusions

This study investigated AR and durational consonant categories of speakers from LU comparing two age groups in both Alemannic and SSG.

Regarding AR, results show that, as expected, older speakers have a slower AR than younger ones in normal speech tempo. This effect was only significant in SSG. Surprisingly, older speakers decrease the AR in SSG, while younger speakers increase it compared to Alemannic, in which both age groups behave similarly. The behavior of the younger speakers is in accordance with the results found by Zihlmann [17], whose investigation was focused on speakers who belong to the same age group. It is unclear as to why older speakers behave in the opposite way. At least, the fact that the differences in AR are below the JND of 5% is in accordance with the crowdsourcing study by Leemann [22]. Finally, even though the differences are small, it is worth to further investigate age-related differences in AR between Alemannic and SSG.

The results regarding the consonant durations reveal that older speakers produce longer extrafortis consonants than younger speakers. Moreover, the results show that consonant durations are significantly longer in Alemannic than they are in SSG, which is in accordance with previous research [16]. Regarding tempo, although some significant differences were found, the differences in measured values are small.

Ultimately, the results of the current study confirm that there are three durational consonant categories in LU German, i.e. lenis, fortis, and extrafortis. The three categories are stable across age, tempo, and variety. This finding is in accordance with Zihlmann [16] who detected a significant difference between fortis and extrafortis in some Alemannic varieties (Zurich and Berne) and in the four investigated standard varieties (Zurich, Berne, Chur, and Brig). The fact that not in all Alemannic varieties a third consonant category appeared might be due to the investigation of both obstruents and sonorants, while the current study is focused solely on plosives. It therefore is worth investigating different kinds of consonants separately. Another explanation might be that the regions with a three-way consonant distinction in Alemannic all belong to the northern dialectal area of German-speaking Switzerland. More research is needed in both the northern and the southern area in order to confirm this assumption. Lastly, it would be of great importance to examine if the category of extrafortis is perceptually distinguishable from fortis.

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6. References

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