Age-dependent differences in the neutralization of the intervocalic voicing contrast: Evidence from an apparent-time study on East Franconian

Viola Müller, Jonathan Harrington, Felicitas Kleber, Ulrich Reubold

Institute of Phonetics and Speech Processing (IPS),
University of Munich (LMU), Munich, Germany
viola|jmh|kleber|reubold@phonetik.uni-muenchen.de

Abstract

The main aim of the present study was to investigate the extent to which East Franconian speakers neutralize the voicing opposition in intervocalic stops when they produce a variety of Standard German. A second aim was to test whether young and old speakers differ in their extent of neutralization and tend to a more standard-like pronunciation. We analyzed contrast maintenance by means of the vowel-to-stop duration ratio. An acoustic analysis of *leiden-leiten* revealed that old East Franconian speakers neutralized the voicing contrast either completely or to a greater extent than young East Franconian speakers. Young East Franconian speakers preserved the voicing contrast, although to a lesser extent than the Standard German speakers. A forced choice perception experiment showed that young but not old East Franconians perceived the lenis/fortis contrast. The results point to a sound change in progress in which a phonemic [± voice] stop distinction is developing in East Franconian.
Index Terms: fortis/lenis contrast, apparent-time study, incomplete neutralization, categorical perception, German dialects

1. Introduction

Standard German distinguishes between phonological voiced and voiceless stops. This contrast is commonly referred to as fortis/lenis contrast since voiced and voiceless stops differ in particular with respect to articulatory force and timing [1] and only to a lesser extent in vocal-fold vibration. The contrast is maintained by means of aspiration, voice onset time, formant transitions, fundamental frequency, and the vowel-to-stop duration ratio (henceforth, $V/(V+C)$) [2]. In particular, the latter parameter was shown to be an important cue for distinguishing intervocalic fortis and lenis stops that are nasally released (e.g. in /C_1VC_2ən/-words): [3] found $V/(V+C)$ duration ratios of 0.7 and below 0.6 to be clear indicators of lenis and fortis stops, respectively.

This phonemic opposition is neutralized towards the fortis component in syllable-final position. Thus, the near minimal pairs *radeln* (/ʁaːdəln/, 'to cycle') and *raten* (/ʁaːtən/, 'to guess') differ with respect to the voicing of the intervocalic stop both in the underlying as well as the surface form, but *Rad* and *Rat* are considered homophonous at the surface structure, although they differ underlyingly in voicing. Acoustic analyses, however, revealed that the fortis/lenis contrast is only partially neutralized in production since underlying voiced stops retained some of their acoustic characteristics, e.g. longer vowel durations compared to those of vowels preceding fortis stops [4]. The syllable-final voicing contrast was also found to be only incompletely neutralized in perception [5].

Due to a number of sound changes during the Middle High German period (1050-1350), the intervocalic voicing contrast is neutralized towards lenis in many High German dialects (see [6]). In dialects in which the so-called High German lenition occurs, *baten* (/baːtən/, *requested* 1. pl.) and *baden* (/baːdən/, *to bath*) are both realized as [baːdən]. In East Franconian, which is spoken in Central Germany, the intervocalic voicing opposition is neutralized towards lenis in initial, prevocalic as well as in intervocalic position [7]. Lenition is a common sound change that has been observed in a number of languages (e.g. the shift from Latin lenis stops to voiced fricatives in the Romance languages, see [1]). This change may be due to internal factors [8] such as synchronic variability [1]. Recent studies on dialect levelling in Standard German, however, have shown that speakers of a younger generation use less dialect features and tend to a more standard-like pronunciation than older speakers [9, 10]. External factors, such as the prestige of dialects, may cause sound changes in the opposite direction [11]: in the case of intervocalic lenition one could predict an increase in contrast maintenance in younger generations.

The aim of the present study is to test whether East Franconian speakers only incompletely neutralize the voicing contrast when they produce a variety of Standard German. A second aim was to test whether young and old East Franconian speakers differ in their extent of contrast preservation based on the assumption that younger speakers tend to a more standard-like pronunciation. The hypotheses tested in this experiment were formulated as follows:

H1 East Franconian speakers tend to neutralize the intervocalic lenis/fortis contrast towards lenis in production more than Standard German speakers.

H2 In production, old East Franconian speakers show a greater tendency for neutralization than young East Franconians.

H3 There is a categorical shift in the perception of the lenis/fortis contrast in young Franconian listeners, but only a gradual change in old Franconian listeners.

2. Method

We tested our hypothesis in an apparent time study including an acoustic analysis and a forced-choice identification experiment.

2.1. Participants

The production and perception data of 32 East Franconian speakers were recorded. They were all raised in the East Franconian dialect area and all of them have spent most of their lives

there and speak the local variety. Each of the speakers was assigned to one of two age groups: 16 subjects between the age of 15 and 25 years were in the young group (average age of 22.6 years, 3 male, 13 female) and 16 subjects who were between 51 and 74 years old belonged to the old group (average age of 59 years, 4 male, 12 female). In addition, five speakers of Standard German were acoustically recorded and served as a reference group. They were born and educated in Northern Germany and were between 25 and 52 years old (average age of 37.2 years, 4 male, 1 female). None of the subjects reported any eye-sight, speaking, reading or hearing disorders.

2.2. Materials

2.2.1. Production

The test words belonged to the minimal pair *leiden* (/laɪdən/, 'to suffer') and *leiten* (/laɪtən/, 'to direct') which were produced in two conditions. First, the target words were read in isolation together with 24 other German trochaic verbs which served as distractors. All verbs contained an intervocalic stop followed by an /ən/-sequence (which is a frequent infinitive ending in German). In the second condition, the two test words were embedded in a short story. The purpose of using two conditions was to test for differences depending on context and speech style (read speech in isolation vs. context).

2.2.2. Perception

A continuum between *leiden* and *leiten* was created as follows: a male Standard German speaker produced 10 repetitions each of *leiden* and *leiten* respectively; for obtaining reliable endpoints, we calculated for *leiden* and *leiten* the mean $V/(V+C)$-ratios and selected the *leiden*-token with an $V/(V+C)$-value nearest to the mean of all *leiden*-tokens ($(V/(V+C))_{\text{lenis.m}}$) as the lenis endpoint. The mean $V/(V+C)$-duration-ratio of all *leiten*-tokens ($(V/(V+C))_{\text{fortis.m}}$) served as the intended value at the fortis end of the continuum, which was produced by shortening the duration of the vowel of the chosen *leiden*-token to a duration value calculated by (see the detailed description in [5]):

$$V_{\text{fortis}} = (V+C)_{\text{lenis}} \cdot (V/(V+C))_{\text{fortis.m}} \quad (1)$$

The calculation by means of Eq. (1) ensured that the total $V+C$ duration of both endpoints remained constant. The difference $V/(V+C)_{\text{lenis.m}} - V/(V+C)_{\text{fortis.m}}$ was divided by 6 to obtain the step size for the intermediate steps, resulting in a 7 step continuum with step size 0.014 (which corresponds to a vowel shortening of 4 ms) from *leiden* (Stimulus 1) to *leiten* (Stimulus 7). The resulting $V/(V+C)$-values can be found in Table 1. Stimulus preparation was done by using the *manipulation* and the *overlap and add* functions in *Praat*. The f0 contour was stylized with a f0 maximum on /laɪ/ followed by a fall, and kept identical for all stimuli.

Table 1: $V/(V+C)$ *duration ratios for each Stimulus number.*

Stimulus	$V/(V+C)$
1	0.749
2	0.735
3	0.721
4	0.707
5	0.693
6	0.679
7	0.665

2.3. Experimental set-up

Both experiments were run in one session per speaker in quiet rooms at the subjects' houses using a Packard Bell EasyNote TJ65 laptop computer and a Sennheiser pc165 USB Headset.

The recordings were made using the *SpeechRecorder* Software version 2.2.8 [12]. First, seven repetitions each of the isolated words were presented in random order in quick succession on a computer screen. The subjects were instructed to read as fast as possible in order to avoid hyperarticulated speech. Subsequently, the stories were presented on the screen and read twice.

The perception experiment was conducted using *Praat*'s *ExperimentMFC*-script. Each stimulus was repeated ten times, resulting in 70 synthetic stimuli for the identification task. Subjects were asked to rate the stimuli in a two-alternative forced choice identification task. After the participants had made their judgements, the next stimulus was presented automatically.

2.4. Data analysis

Praat was used for manual segmentation of the speech signals. The onset of the pre-stop vowel was placed at the beginning of a period with a greater amplitude of the oscilogram compared to the preceding segment. The vowel offset corresponded to the onset of the stop and was located at the end of a period with a considerably higher amplitude. The offset of the stop was marked at the beginning of the first noticeable period with a major displacement as during the stop closure. In tokens with an oral release, the aspiration was separated by the offset mark of the stop.

The *Praat*-files were then converted into an *Emu* format and duration measurements of the speech material were carried out in *EMU-R* [13]. All further statistical analyses including those of the perception data were done in *R*.

3. Results

3.1. Speech recordings

Due to the lower number of speakers within the Standard German speaking group (N=5), we conducted a *repeated-measures MANOVA* for the Franconian speakers only. The $V/(V+C)$ ratio served as the dependent variable, AGE (between-subject factor with two levels: old vs. young), CONTRAST (within-subject factor with two levels: lenis vs. fortis) and CONDITION (within-subject factor with two levels: story vs. isolation) were the independent variables, and SPEAKER was entered as a random factor. The *RM-MANOVA* revealed a significant main effect for CONTRAST ($F[1,30] = 72.0, p < .01$), a significant CONTRAST×AGE-interaction ($F[1,30] = 23.1, p < .01$) and a significant CONTRAST×AGE×CONDITION-interaction ($F[1,30] = 5.1, p < .05$). Bonferroni-corrected post-hoc-*t-tests* revealed significant differences between lenis and fortis stops within the young group both in the story ($t[15] = 6.1, p < .01$) and the isolated condition ($t[15] = 7.5, p < .01$); for old East Franconians, lenis and fortis stops differed significantly only in the isolated condition ($t[15] = 4.9, p < .01$), but not in the story condition.

A *paired t-test* for the 5 Standard German speakers' data (averaged over all repetitions of /laɪdən/ and /laɪtən/, respectively, per speaker and per type), revealed a significant difference between lenis and fortis ($t[4] = 4, p < .05$) for the tokens read in isolation. The tokens embedded into the story dif-

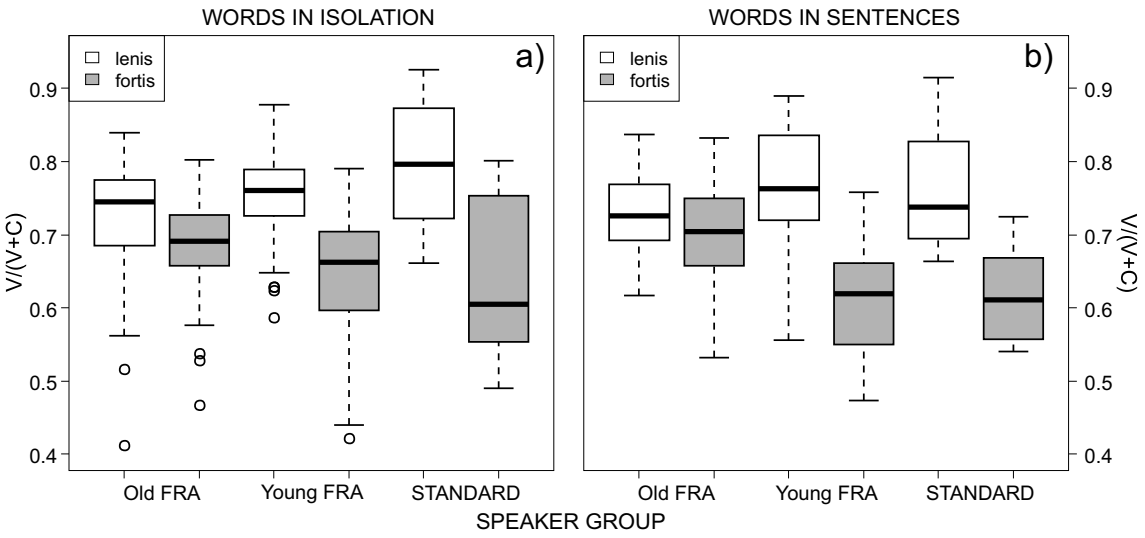

Figure 1: *$(V/(V+C))$ duration ratios for lenis (white) and fortis (grey) stops in isolated words (a) and in words embedded into sentences (b) separately for old and young East Franconian (FRA) as well as Standard German speakers.*

fered as well significantly ($t[4] = 3.5, p < .05$). So, for all speaker groups except the old East Franconians reading a story, $V/(V+C)$-values for /laɪdən/ and /laɪtən/ differed significantly (see also Figure 1).

In order to determine the degree of neutralization, we calculated the difference between the mean $V/(V+C)$ duration ratio of each speaker's /laɪdən/-tokens minus the mean $V/(V+C)$-value of each speaker's /laɪtən/-tokens by means of the formula in (2) (see Figure 2).

$$(V/(V+C))_{\text{lenis.m}} - (V/(V+C))_{\text{fortis.m}} \tag{2}$$

Due to the uneven numbers of speakers within the groups, we separated the data by type (story vs. isolation) and used *t-tests* to compare the means of the values from young or old East Franconian speakers with those of the Standard German speakers. In the isolated condition, there was a significant difference between old East Franconians and Standard German speakers ($t[4.4] = -2.8, p < .05$) on this measure as well as in the story condition ($t[4.6] = 2.7, p < .05$). However, there was no such significant difference between young East Franconian and Standard German speakers, irrespective of the condition. A *RM ANOVA* with $V/(V+C)_{\text{lenis.m}} - V/(V+C)_{\text{fortis.m}}$ as the dependent variable, AGE (between-subject factor with two levels: old vs. young), CONTRAST (within-subject factor with two levels: lenis vs. fortis) and CONDITION (within-subject factor with two levels: story vs. isolation) as the independent variables, and SPEAKER as a random factor was conducted to test for differences on this measure in East Franconian speakers only. It revealed a significant main effect for AGE ($F[1, 30] = 23.1, p < .01$) and a significant AGE×CONDITION interaction ($F[1, 30] = 5.1, p < .05$). However, Bonferroni-corrected post-hoc *t-tests* showed significant differences between the AGE-groups for both story ($t[20.8] = 4.5, p < 0.01$) and isolated condition ($t[24.5] = 4.0, p < 0.01$).

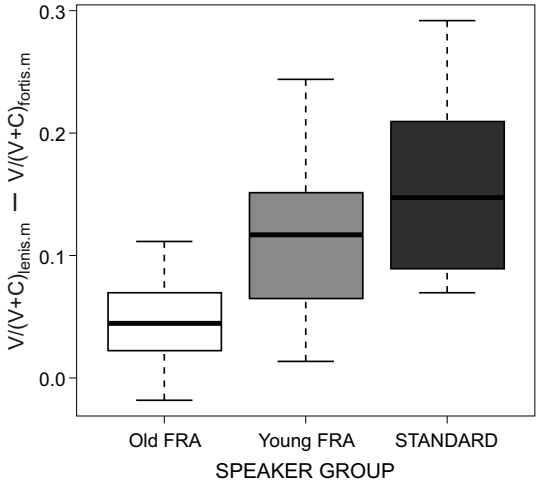

Figure 2: *Mean $V/(V+C)$ duration ratio differences between lenis and fortis intervocalic stops shown separately for old (white) and young (grey) East Franconian(FRA) and Standard German (dark grey) speakers*

3.2. Forced-choiced identification test

Figure 3 presents the psychometric response curves to the *leiden-leiten* continuum fitted to the response data of 16 old and 16 young Franconian listeners using a *generalized linear mixed model (GLMM)* with the stimulus response as the dependent variable, the STIMULUS NUMBER (7 levels: Stimulus 1, 2, ...7) as the independent variable, and with the LISTENER as a random factor. The result of this operation was to fit a logistic function to the stimulus responses (separately by listener) using the relationship

$$p = \frac{e^{(mx+k)}}{1+e^{(mx+k)}} \tag{3}$$

where p was the predicted proportion of /laɪdən/ responses ($0 < p < 1$), the coefficients m (the *slope*) and k (the *intercept*) were calculated separately for each listener, and x was the stimulus number 1, 2, ...7. As the mean of the calculated

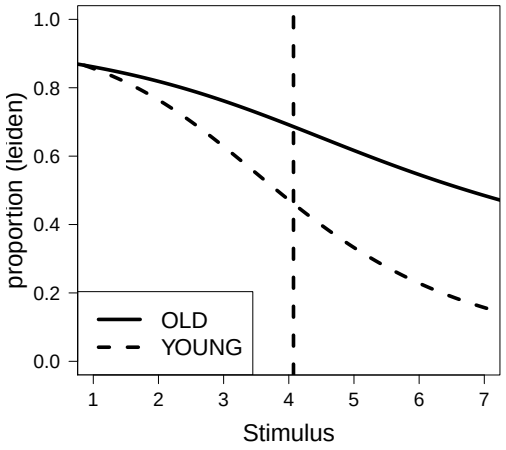

Figure 3: *Proportional distribution of /d/ judgements for old (solid) and young (dashed) East Franconian listeners. The vertical dashed line shows the mean category boundary between lenis and fortis for the young group.*

50% cross-over boundaries, calculated by $-m/k$, was beyond the last stimulus for the old listeners (i.e. there is no meaningful boundary for the old) we will not report statistics on this point. Yet we conducted a *t-test* to compare the slopes (m) of the response curves which revealed a significant difference ($t[30] = 3.5, p < .005$), i.e. the curve for the old is much more shallow. The young listeners' curve is more S-shaped and there is a clear category boundary between lenis and fortis.

4. Discussion and Conclusions

There were three main findings from this study. The first was that the /t, d/ contrast tends to be completely neutralized in production for Old Franconian speakers. The second was that the degree of contrast for Young Franconian speakers was intermediate between those of the other speaker groups: thus, as opposed to the Old East Franconians, they contrasted /t, d/ in production although not to the same extent as did the Standard German speakers. The third finding was that perception and production were matched. Thus, young Franconians distinguished perceptually between post-vocalic /t, d/ whereas old Franconians did not.

These results suggest a sound change in progress in which a post-vocalic voicing contrast is developing in Franconian under the influence of the standard variety. The main exception to this finding was that old East Franconian speakers did show evidence of a /t, d/ contrast in producing isolated words. However, we attribute this to a hyperarticulated speaking style [14]; and moreover, it was still the case for these materials that the /t, d/ distinction was not as great as it was for the younger East Franconian speakers, i.e. old East Franconian speakers only incompletely maintained the voicing contrast (cf. [4]).

The findings are, in general, consistent with a model in which phonological categories are probabilistically associated with the speech signal [15]. Thus, it is evidently not the case that neutralization is categorical: the sound change in progress results instead in a gradual change by which a phonological contrast is evolving in young East Franconian speakers that is not (yet) as marked as it is for Standard German speakers. Such findings would be very difficult to accommodate in a model that specified a phonemic contrast as either present or absent (neutralized).

Finally, it is also clear that this sound change in progress affects both production and perception [16]. A further issue to be explored is whether perception and production change at the same rate [17]. If changes to perception lead those in production, then the young East Franconian and Standard German listeners might perceive the /t, d/ contrast to the same extent, even though the degree of contrast for young East Franconian speakers in production has been shown to be somewhat less than for Standard German speakers in this study. We are currently exploring this issue with a larger group of listeners.

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