

## **Two sources of voicing neutralization in Lithuanian**

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### **Abstract**

This study compares two processes that result in voicing neutralization in Lithuanian: regressive voicing assimilation in obstruent clusters and final devoicing of obstruents. Acoustic data is analyzed to assess the behaviour of three acoustic cues to obstruent voicing (i.e. closure and preceding vowel duration and voicing during closure) in both neutralizing environments. The results show that, although both processes result in incomplete voicing neutralization, they use the acoustic cues differently. This suggests that final devoicing and voicing assimilation have different acoustic realizations, supporting their analysis as two different processes.

Key words: neutralization, voicing assimilation, final devoicing

### **Introduction**

Previous experimental studies on voicing neutralization have primarily focused on final devoicing (e.g. Dinnsen and Charles-Luce 1984, Port and Crawford 1989). Their main finding is that neutralization may be incomplete and that several factors, including semantic and pragmatic, play a role in determining the degree of neutralization. However, less attention has been paid to another potential source of voicing neutralization, namely, voicing assimilation (but see Slis 1986, Charles-Luce 1987, 1993, Burton and Robblee 1997). This study compares neutralization through final devoicing and voicing assimilation in order to evaluate whether both processes lead to a similar degree of neutralization. Lithuanian is used for this purpose because it displays both processes. Word final obstruents undergo devoicing. Regressive voicing assimilation occurs in obstruent clusters, such that the voicing of the last member determines the voice realization of any preceding obstruents. Sonorants do not participate in the process. They do not trigger or undergo voicing assimilation (Mathiassen 1996). Thus, an acoustic experiment was designed to analyze voicing neutralization in Lithuanian as manifested in three temporal intervals that have been previously established as cues to obstruent voicing: preceding vowel duration, closure duration and amount of voicing during closure. More precisely, longer vowel duration and voicing during closure are associated with voiced obstruents, and longer closure duration is correlated with voiceless ones.

### Methodology

Two sets of nonsense words were constructed according to Lithuanian phonotactics: one for voicing assimilation and another for final devoicing. Stimuli in the voicing assimilation condition consisted of bisyllabic words of the form tV1C1C2a, with stress on the first syllable. V1 could be any of the long vowels from the Lithuanian inventory /i:, e:, æ:, a:, o:, u:/. The medial cluster C1C2 could be /kʒ/ and /gʒ/ for the assimilatory contexts, and /kʃ/ and /gʃ/ for the non-assimilatory contexts (i.e. where underlying stop voicing is expected to match its surface realization). Some sample tokens are /ti:kʒa/, /ti:gʒa/, /ti:kʃa/ and /ti:gʃa/. The stimuli for the final devoicing condition were also bisyllabic nonsense words of the shape datV1C1, with stress on the last syllable. V1 could be any of the long vowels in Lithuanian and the last consonant C1 was /k/ or /g/. Some sample tokens are /dati:g/ and /dati:k/. Standard Lithuanian orthographical representations were employed to mark voicing differences. The relevant words were inserted in the carrier sentence *Sakyti \_\_ negalima* “To say \_\_ is not allowed”. Each stimulus was repeated 8 times. Each block of 36 sentences was pseudo-randomised. Five native speakers of standard Lithuanian, one male and four females, were recorded. The sentences were displayed on a computer screen and speakers were asked to read each sentence in a colloquial style. They were cued for each sentence to keep the rhythm constant. Before the actual experiment, speakers were given some practice tokens.

The data was analyzed using synchronized waveforms and spectrograms to measure the duration of the vowel, stop closure and voicing during closure. The vowel was measured from the onset of the first glottal pulse to the offset of the last one in the waveform, before voiceless stops. Preceding voiced stops, the end of the vowel was determined by a drop in amplitude and a change in waveform shape, or where the formant structure ended. Stop closure duration was measured from the end of the preceding vowel to the closure release or the beginning of frication, when there was no clear release. Beginning of frication corresponded with the start of aperiodic energy. The duration of voicing during closure was calculated from the beginning of the closure to the end of the last visible glottal pulse.

### Results

For the assimilation condition, three-factor (vowel quality, underlying stop, following fricative) repeated measures ANOVAs were performed for each temporal interval. For the final devoicing condition, two-factor (vowel quality, underlying stop) repeated measures ANOVAs were carried out for each temporal interval. Repetitions per test word were averaged within subjects, and the significance level was set at  $p < .05$ . Only main effects of

underlying voicing and following fricative (in the assimilation condition) are discussed. Also, none of the analyses showed an interaction between vowel quality and underlying stop, indicating that all vowel qualities behave similarly with respect to underlying stop voicing for all dependent variables and conditions.

Let's begin with the assimilation condition. For vowel duration, there is a significant effect of underlying stop ( $p=.035$ ) so that vowels before underlying voiceless stops are shorter than before voiced ones, and of following fricative ( $p<.001$ ), so that vowels are longer in the voiced assimilation context than in the voiceless. There is a significant effect of underlying stop ( $p=.02$ ) and of following fricative ( $p=.01$ ) on closure duration. The closure for underlying voiceless stops is longer than for voiced ones, and closure duration is longer in the voiceless assimilation context than in the voiced. As for voicing duration, there is a main effect of underlying stop voicing ( $p=.035$ ) and of following fricative ( $p<.001$ ). Voicing is longer for underlying voiced stops than for voiceless ones. Voicing lasts longer in the voiced assimilation context than in the voiceless. There is no significant interaction between underlying stop and following fricative for any of the intervals.

Moving on to the final devoicing condition, the results indicate that underlying stop has a significant effect on vowel duration ( $p=.02$ ) and closure duration ( $p=.036$ ) but not on the amount of voicing during closure.

Table 1. Mean vowel, closure and voicing duration (ms) across speakers and vowel qualities for the assimilation condition.

	Following /ʒ/			Following /ʃ/		
	Vowel	Closure	Voicing	Vowel	Closure	Voicing
Underlying /g/	167	52	49	150	58	15
Underlying /k/	163	56	38	144	60	0

Table 2. Mean vowel, closure and voicing duration (ms) across speakers and vowel qualities for word final obstruents.

	Vowel duration	Closure duration	Voicing duration
Final /k/	145	91	0
Final /g/	166	77	33 (st.dev.=35 due to one subject)

Finally, in order to obtain a direct comparison between final devoicing and voicing assimilation, a separate two-factor (vowel quality, underlying stop) repeated measures ANOVA on each temporal interval was conducted for those tokens where voicing assimilation resulted in devoicing (/gʃ/ & /kʃ/). The results show that underlying stop is a significant factor only for

voicing during closure ( $p=.044$ ). For vowel and closure duration, it fails to reach statistical significance indicating that these two temporal intervals are similar for the stops in the /gʃ/ & /kʃ/ tokens.

### **Discussion and conclusion**

The results suggest that voicing neutralization from either assimilation or devoicing may be incomplete in Lithuanian. This is line with previous findings for other languages. More interestingly, our data suggest that neutralization due to final devoicing and due to voicing assimilation have different acoustic realizations, as shown by the way in which each acoustic correlate is employed in each case. Charles-Luce (1987) also found that neutralization applied to a different degree depending on whether it was the result of assimilation or final devoicing in Catalan. In the present study, at least for voiceless assimilation, neutralization seems to apply to a greater extent than in final devoicing. Only one acoustic cue differentiates underlying voiceless and voiced stops in this context, as opposed to final devoicing where two acoustic cues differentiate the voicing contrast in the surface realization.

These experimental results lend some support to the analysis of voicing assimilation and final devoicing as two distinct processes that lead to two different representations of voicing and thus, two different realizations. More precisely, I argue for an account of (incomplete) voicing neutralization in Lithuanian which distinguishes between final devoicing and voicing assimilation, as opposed to a unifying analysis, whether phonological or phonetic, for both processes, for instance, through a single feature-value change or unspecification of voicing features.

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