

# Acoustic data on variation in the Swedish postalveolar sibilant across boundaries

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## Abstract

The claim that postalveolarization across word boundaries in Swedish is a non-obligatory process is examined for the postalveolar sibilant in an acoustic study of Standard Swedish. An internal group exclusively showing a postalveolar and a boundary group with a range from a laminal dentoalveolar to a postalveolar are distinguished. For the boundary group, data on fricative resonant frequency and on duration are analysed further. The presence of a distinct rhotic appears to be not exclusively correlated to fricative quality, and a rhotic may appear also with a postalveolar. It is suggested that a dentoalveolar following a rhotic may be typically apical rather than laminal unless specifically to mark the juncture. The data do not seem to support the claim that the choice of outcome is influenced by speech tempo.

## Introduction

The Standard Swedish apical posterior coronals that contrast with plain dentoalveolars are perhaps best described as postalveolar (but often termed ‘retroflex’ or ‘supradental’). Their diachronic source is sequences of rhotic plus plain dentoalveolar (consequently, they do not occur in word-initial position in isolated words). Postalveolars also appear across word and morpheme boundaries where a final lexical /r/ of one element meets with an initial dentoalveolar of the next. At word boundaries, postalveolars interchange with sequences of rhotic plus dentoalveolar (cf. e.g. [Garlén, 1988](#)).

Among Swedish phonologists in general, postalveolars in all positions are viewed phonologically as the product of synchronic derivational rules of assimilation and deletion on underlying phonematic sequences of /r/ plus dentoalveolar (e.g. [Elert, 1957](#); [Eliasson, 1986](#); [Riad, 2010](#)). Norwegian phonologists, on the other hand, tend to treat the same phenomenon differently, with the corresponding internal postalveolars as phonematic for Norwegian (e.g. [Kristoffersen, 2000](#)). This is also the approach used in UPSID ([Maddieson, 1984](#), following [Vanvik, 1972](#)).

The original motivation behind the sequence analysis seems to have been one of inventory economy and – either implicitly or explicitly – of the now widely rejected principle of *biuniqueness*, which rests on the theoretical presumption that sounds should map to uniquely predictable underliers (i.e., identical phones in a given context represent the same phoneme) and manifests itself as a desire for derivations to work both ways: postalveolars in every position, seeing as they pass for identical, must then all have the same underliers.

Representing all postalveolars as phonological sequences of rhotic plus dentoalveolar is complicated by the independent existence, root-internally, of phonetic sequences of rhotic plus dentoalveolar, e.g. *absurd* [ap 'søɹd]. The suggested distribution that sequences occur for voiced dentoalveolars after short vowels may be historically relevant but is not synchronic, as seen in e.g. *imorn* [ɪ 'møɹ:], *Ursula* [ 'ø.ɹsøla].

This is resolved (e.g. in [Eliasson, 1986](#)) by exploiting an abstract analysis of Swedish quantity, wherein for underlying forms of stressed short vowels followed by two consonant phonemes, an otherwise redundant geminate may be added at will to the notation: the postalveolarization rule, then, is taken not to apply with such a geminate /r/. Apart from this being the only case where such arbitrary gemination would be distinctive, it appears to be contradicted by cases like *perception* [p<sup>h</sup>æ.ɹsep 'xu:n] and *piercad* [ 'p<sup>h</sup>e:ɹsɑd].

Word-internal postalveolars evidently do not exhibit the same degree of variation as those that occur across word boundaries. The variable appearance at boundaries of a simple postalveolar on the one hand and a sequence of rhotic and dentoalveolar on the other has been ascribed to the non-obligatory nature of the postalveolarization process across a word boundary, referring to the application of the above rule. Some factors controlling the choice of sequence vs. postalveolar have been suggested ([Witting, 1959](#); [Gårding, 1967](#); [Malmberg, 1968](#); [Eliasson, 1986](#); [Kuronen, 2003](#)), including grammatical-lexical context, phonetic context, speech tempo, and style.

## The study

This paper presents an empirical study of the acoustic quality of Swedish postalveolars with reference to morphosyntactic position. The study focuses on the sibilant postalveolar because of its acoustic and perceptual qualities (it is, presumably, the most perceptually salient postalveolar and it is also the one most amenable to acoustic analysis), as well as its high distributional frequency.

The acoustic quality of eligible sibilants is gauged by measuring the lowest resonance frequency of sibilant fricatives. While this is a simplification of spectral properties, it is taken to be indicative of perceived quality and indirectly of tongue position, with apical postalveolars perceived as low-pitched and laminal dentoalveolars as high-pitched.

An analysis of each sibilant token based on the correlation between morphosyntactic context and its lowest resonance frequency was performed. The analysis also considered the duration of the sibilant as well as the preceding rhotic (when present).

## Method

The material consists of scripted and unscripted Standard Swedish from broadcasts of radio news programmes *Lunchkot* and *Studio Ett*, as well as unscripted material from the *Swedish Map Task Corpus* (Helgason, 2006). The radio data comprises 10 male and 11 female speakers, with 1 male and 2 female speakers in the SMTC data.

Eligible sibilants were identified on the basis of the occurrence of sequences of <r> and <s> in the orthographic transcription, though certain common cases with no trace of rhotic (especially the copula *är*) were excepted. The eligible cases were then classified into 13 morphosyntactic categories based on morphological and syntactic criteria (but as is shown below, these 13 categories can be collapsed into just two basic categories).

Sections of fricative noise corresponding to eligible sibilants, and the duration of any discrete appertaining rhotic, were labelled in *WaveSurfer* (Sjölander & Beskow, 2000). The frequency of the lowest resonance of the sibilant was measured using *Praat* (Boersma & Weenink, 2001).

## Results

Figure 1 shows the frequency spread of the lowest resonance frequency for the tokens in each morphosyntactic category.

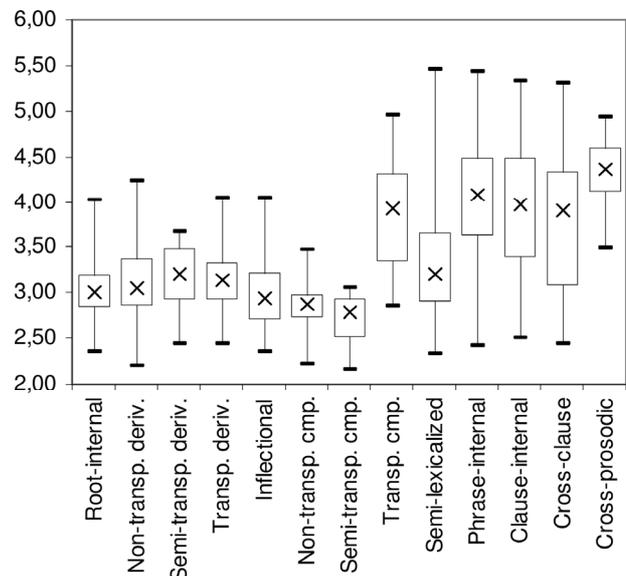


Figure 1. Spread of measured resonance frequencies within each morphosyntactic category.

Two fairly distinct groups of data emerge. Tokens in morpheme-internal position and across most morpheme boundaries have a lower frequency range than those across word boundaries. That is, the former (internal group) is consistently produced as [ʃ], while the latter (boundary group) ranges from [s] to [ʃ].

Token resonance frequency for the two groups is plotted against the total duration of sibilant plus any preceding rhotic in Figure 2.

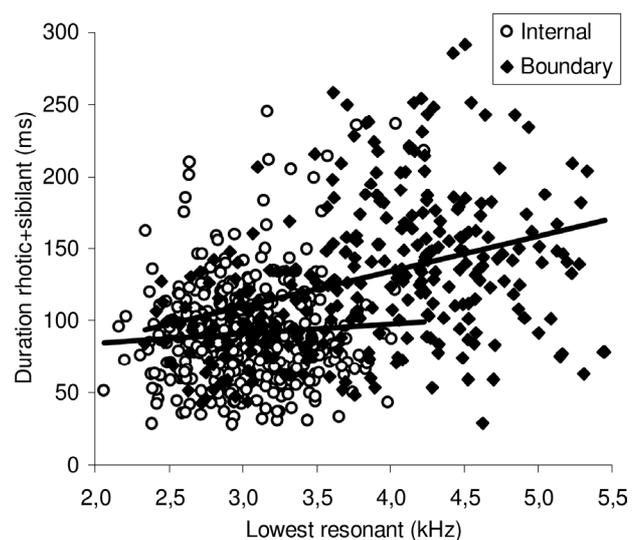


Figure 2. Fricative quality for each token, measured as the lowest resonance frequency (in kHz), plotted against the total duration of rhotic (when present) plus sibilant in internal and boundary groups.

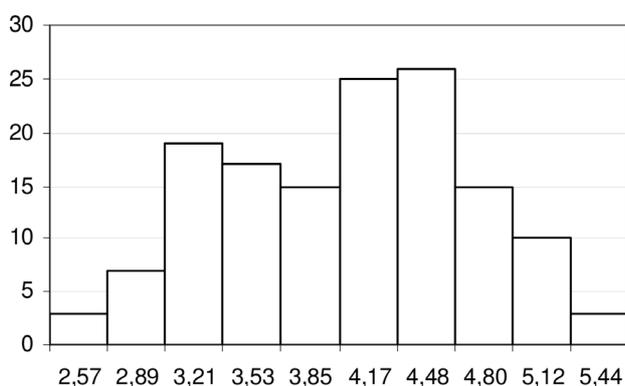
## Analysis

The durational data, supported by spectrographic evidence, indicate for the boundary group that a rhotic can also occur with a postalveolar, i.e. [ɹʃ]. The rhotic may also be completely absent before a laminal dentoalveolar sibilant. This is common with plural and present suffixes in *-r* and with frequent function words (e.g. *för*, *var*, *hur*).

Transparent (i.e. non-lexicalized) compounds pertain to the boundary group and inflections to the internal group, as seen in *Figure 1*. The low mean for semi-lexicalized phrases may suggest some orthographically multi-word units (e.g. *år sen*) in fact pertain to the internal group.

Data on sibilant duration does not show any convincing evidence of connection between duration and resonant frequency, which would have been suggestive of outcome choice influenced by speech tempo (i.e., that postalveolars are more frequent in faster speech).

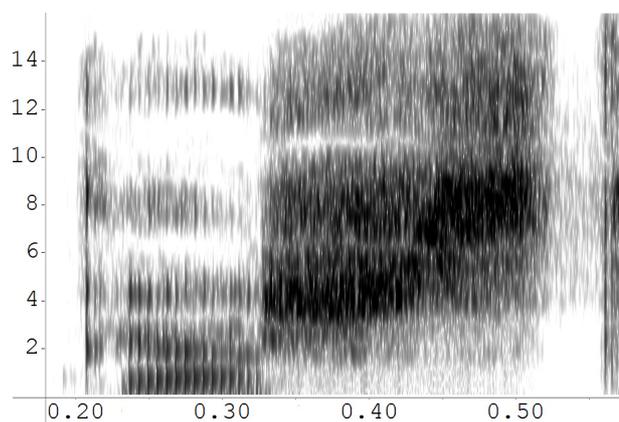
*Figure 3* shows the distribution of boundary group resonant frequencies for female speakers. A bimodal distribution can be observed, the lower frequency peak indicating postalveolars and the higher peak indicating dentoalveolars.



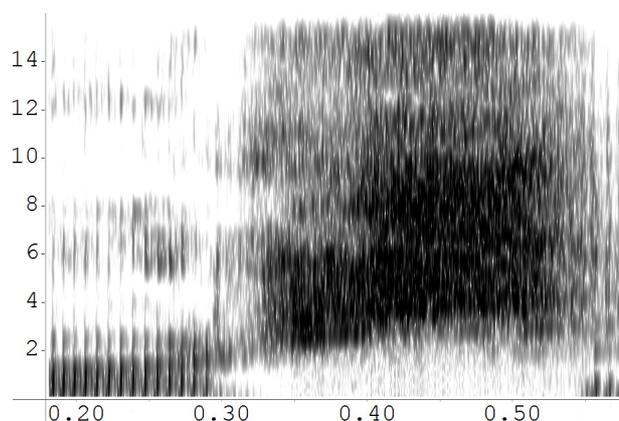
*Figure 3. Distribution of sibilant frequencies (kHz) in the boundary group for female speakers.*

## Discussion

Considering frequency as a function of morphosyntactic condition, two major groups of data emerge, referred to here as the internal group and the boundary group. For the internal group, a postalveolar is obligatory and contrasts sequence of rhotic plus dentoalveolar. The boundary group has a more variable distribution with regard to lowest resonance frequency, as well as, semi-independently, the relative presence (or absence) of a rhotic preceding the sibilant, where the rhotic also varies both in duration and intensity.



*Figure 4. Spectrogram of [ɣaʃst] in the utterance (da)gars st(ämma) showing juncture marking.*



*Figure 5. Spectrogram of [œɹʃsi] in the utterance (f)ör si(na) showing probable repair.*

It may be hypothesized that, among dentoalveolars in the boundary group, an apical realization [ʃ] is more common, as the sibilant is usually coarticulated with the rhotic, while a laminal [ʃ̺] is used as a cue for marking the juncture. *Figure 3* may hint that dentoalveolars more commonly exhibit lower frequencies, and thus are apical. This use of laminal is similar to one way of marking juncture as seen in *Figure 4*, where an internal postalveolar transitions into a laminal sibilant, [ʃ̺], across a boundary, as opposed to collapsing sibilants into a single postalveolar sound.

Several variations of this use of transition exist. A sibilant following a final, internal postalveolar, as opposed to a simple rhotic, is more likely to be postalveolar, suggesting that when it is not, this is a marker. *Figure 5* shows lexical /ɹ#s/ as [ɹʃ̺], possibly as a kind of boundary repair, with a similar transition from postalveolar to apical dentoalveolar within the sibilant, while lexically it is past the boundary.

It appears that pragmatic features (as in juncture marking, speech tempo) may make significant use of and interact with the variation in a phonologically meaningful way. This may include influence on coarticulation in apical vs. laminal boundary dentoalveolars. The boundary postalveolar, however, patterns largely with the internal postalveolar, not indicating juncture.

The pragmatic aspect of the boundary group can be seen as a correlate of the H&H continuum (cf. Lindblom, 1990), reflected in the choice of postalveolar vs. dentoalveolar, where the latter might function as a juncture marker in its own right, seeing as hyperspeech possibly favours separation of gestures. (Figure 3 shows dentoalveolars to be more common, but this could be attributed to style.) The choice of outcome is likely based on a complex of factors, where speech tempo could play a role in that faster and thus less enunciated speech implies hypospeech (i.e., postalveolar).

From the point of view of Articulatory Phonology (cf. Browman & Goldstein, 1992), the relationship between [ɹs] and [ʃ] can be described as different phasings of the same gestures, illustrated in Figure 6. Linked to this is how a postalveolar gesture may or may not span over a stretch of concurrent gestures.

	[ɹs]		[ʃ]
PLACE	postalv	dental	postalv
MANNER	approx	sibilant	sibilant
GLOTTIS	voice	spread	spread

Figure 6. Schematic gestural scores of [ɹs] and [ʃ].

Variation can be expressed as different constraints on the range of allowed outcomes, which may be seen in terms of phasing and degree of activation (of the same component gestures), modification of both of which the boundary variation is contingent on (though it is unclear how they relate).

Boundary behaviour (as apparent occasional absence of the historical process) can be viewed as an overlay effect on an otherwise continuous progression of speech, arising out of analogical pressure from the different connected contextual forms. A realization [ɹʃ] could likewise stem from analogical influence of the lexical /r/. Affixes, on the other hand, remain unisolable, meaning in gestural terms that they are simple specifications of gestures, with the implication that the relation of forms can be described non-linearly.

Change in variational constraints could be understood to reflect postalveolar diachrony within an H&H model. If obligatory internal postalveolar was, historically, preceded by a stage of variation (as possibly still seen in the lateral), the development can be conceived in terms of drift of the variation spectrum.

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