

## Place of articulation for coronals in some Swedish dialects

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### Abstract

*A listening test was carried out to test the hypotheses that, in the Swedish dialects 1) /d/ is frequently produced at an alveolar place of articulation whereas /t/ tends to be consistently dental; 2) the sonorant coronals /n/ and /l/ pattern with /t/ in being dental rather than alveolar; 3) alveolar /d/ productions have shorter closure duration than dental /d/ productions; and 4) /d/, unlike /t/, is frequently approximantised. The speech material consisted of the above coronal consonants produced in /N/\_V/ context by male speakers of 31 Swedish dialects. The hypotheses were essentially supported by the data. Aerodynamic considerations suggested that the different /t/ and /d/ patterns may reflect alternative solutions to the conflict between stop production and voicing.*

### 1 Introduction

Stop articulation is known to provide an unfavourable condition for voicing. The reason is that the sub- and supraglottal pressures are rapidly equalised when air is trapped in the closed mouth cavity. However, there are several means of resolving the conflict between stop articulation and voicing. For example, voicing can be enhanced by actively expanding the volume of the supraglottal cavities (Ohala & Riordan 1979; Ohala 1983). Alternatively, voiced stops may be changed to voiced approximants as observed by Engstrand and Lacerda (1996) in a Swedish speaker.

Stop voicing may also be related to closure duration and articulator mobility. These factors may be mutually dependent assuming that smaller and faster articulators can produce shorter closures than more massive and slower articulators (Ohala 1983). In particular, if voiced stop closure duration tends to be short in order to accommodate voicing, this would suggest that the tongue tip is more effective than the blade in producing voiced coronal stops. It should also be noted that apical articulation tends to exhibit a greater degree of retroflexion than does laminal articulation (Stevens et al. 1986). In relation to stop voicing, this may entail the further advantage that a concomitant tongue body lowering would contribute to expanding the supraglottal cavity.

The influence of these factors on the articulation of voiced and voiceless coronal stops is largely unknown. However, informal listening suggests that place of articulation tends to differ in voiced and voiceless coronals in many languages and dialects. While voiceless /t/ is usually heard as being dental, its voiced cognate /d/ frequently appears to have a more alveolar place of articulation. Informal observations further suggest (cf. Engstrand & Lacerda 1996) that voiced stops are realised as approximants more frequently than are voiceless stops.

These considerations are of a certain interest to phonetic typology and dialectology, as well as to speech production modelling in general. However, relevant articulatory measurements on an extensive speech materials are hard to come by. For screening purposes, it is thus of some interest to determine to what extent variability in coronal articulation can be detected auditorily. The present experiment (cf. Livijn & Engstrand 2001) was designed to

test auditorily the hypothesis that, in the Swedish dialects, /t/ is usually produced at a dental place of articulation, whereas its voiced cognate /d/ tends to be articulated at a more alveolar place of articulation. For reasons discussed above, /d/ productions are also expected to have shorter closure duration than /t/ productions, and alveolar /d/s may be found to display shorter closures than dental /d/s.

The sonorant consonants /n/ and /l/ are not subject to the same aerodynamic constraint on voicing as are the stops. Under the main hypothesis, that /t/ and /d/ will differ in place of articulation for aerodynamic reasons, there is no particular basis for expecting these sounds to go with either /t/ or /d/. However, if /n/ and /l/ pattern with /t/ (in being dental rather than alveolar), the fact that the place of articulation for /d/ would differ from the remaining coronal consonants would require explanation. On the other hand, if /n/ and /l/ pattern with /d/, this would suggest that different places of articulation among the coronals are conditioned by other factors than stop voicing.

Approximantisation can be considered an alternative method of preserving voicing in voiced stops, as noted above. An additional expectation would thus be that /d/ tends to be approximantised. To sum up, then, the present experiment was carried out to collect data relevant to the following hypotheses:

- Hypothesis 1: /t/ is produced at a dental rather than alveolar place of articulation in the Swedish dialects, but /d/ frequently displays a more alveolar place of articulation;*  
*Hypothesis 2: Alveolar /d/ productions have shorter closures than dental /d/ productions;*  
*Hypothesis 3: /n/ and /l/ pattern with /t/ in tending to be dental rather than alveolar; and*  
*Hypothesis 4: Voiced stops are frequently realised as voiced approximants.*

### 2 Method

Four words containing the coronal consonants /t/, /d/, /n/ and /l/ in /N/\_V/ context were drawn from recordings with three male, upper middle age speakers of 31 Swedish dialects spoken in a broad central Swedish region extending from West to East into parts of the Swedish speaking areas of Finland. The words were *gata* /gɑ:tɑ/ 'street', *bada* /bɑ:dɑ/ 'bathe', *panna* /pɑ:nɑ/ 'forehead' and *tala* /tɑ:lɑ/ 'speak'. Each speaker usually produced each word three times. All four words have the so-called grave tonal word accent, but *panna* has the VC: quantity pattern, whereas the remaining words have the V:C pattern (these patterns, however, may shift between the dialects).

Two listeners (the authors) used a forced choice design to judge the stimuli as either dental or alveolar. Specifically, the task was to associate each test consonant with a) a dental similar to that used by both listeners in their normal production of the test words, or b) with an alveolar as used by both speakers in their respective [t], [d], [n] and [l] productions. For the stops, the listeners were also to determine whether it was a phonetically full stop or an approximant. The test was carried out individually in front of the computer screen. The listeners could go back and forth in the material until they were confident in their judgements. After the individual sessions, the listeners went through the material jointly; most of the relatively few discrepancies could be resolved in that session.

### 3 Results and discussion

Table 1 presents an overview of the listener responses. For each consonant, the data columns show number and percentage of dental, alveolar and approximant responses as indicated in the top row. The 'dental' and 'alveolar' columns contain full phonetic stops only; the approximant realisations were not formally judged in terms of place (although a subsequent count suggested that they were almost exclusively dental). In addition, a 'retroflex' column has been included in the table since several speakers used a strongly retroflex /l/ realisation. The rightmost column shows, in absolute and relative numbers, the degree of listener agreement with respect to all four variables.

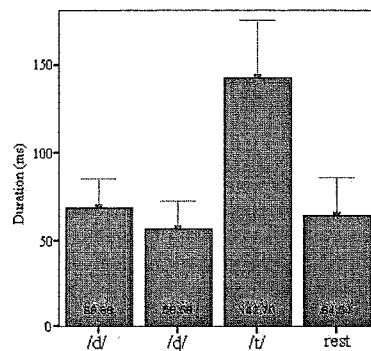
**Table 1.** Distribution of listener responses and degree of listener agreement with respect to four articulatory variables (percentages rounded to integers).

	Dental	Alveolar	Approx.	Retroflex	Agreed
/d/	41	26	14	0	81
/d/ (%)	48	30	16	0	94
/t/	86	0	0	0	86
/t/ (%)	99	0	0	0	99
/n/	71	13	0	0	84
/n/ (%)	82	15	0	0	97
/l/	51	2	0	34	87
/l/ (%)	59	2	0	39	100

The table shows, for example, that 48 percent of the /d/ tokens were judged as dental, 30 percent as alveolar, and 16 percent as approximant. Listener agreement for /d/ reaches 94 percent. For /t/, both dental responses and listener agreement reached almost 100 percent. Of the /n/ stimuli, 82 and 15 percent were judged as dental and alveolar, respectively, with a 97 percent listener agreement. Finally, /l/ was heard as dental in 59 percent of the cases, marginally as alveolar, and as strongly retroflexed in 39 percent of the cases; the two listeners agreed on these judgements to 100 percent. The average listener agreement was 98 percent across all four consonant types.

In essence, the results corroborated Hypothesis 1, which stated that /t/ is predominantly produced at a dental place of articulation, whereas /d/ frequently displays an alveolar place of articulation. This effect was clearly dialect-specific in that it occurred frequently in some dialects but not in others. The results also supported Hypothesis 3, that the sonorants /n/ and /l/ tend to pattern with /t/ in terms of a dental place of articulation. There was, however, the important exception that several speakers were found to use the strongly retroflex variant of /l/.

Hypothesis 2 reflected the expectation that alveolar /d/ would display shorter closures than dental /d/. Figure 1 shows closure duration and standard deviations (ms) for dental and alveolar /d/ and dental /t/. Closure duration for /t/ is included for comparison. The rightmost bar shows the mean duration of the stimuli on which the listeners did not agree. Even though the difference between the dental and alveolar /d/s was not great (69 vs. 57 ms), it was highly significant (one-tailed t-test,  $p < 0.00125$ ). As expected, /t/ closures were much longer than /d/ closures.

**Figure 1.** Closure duration and standard deviations (ms) for dental and alveolar /d/ and dental /t/. The rightmost bar refers to stimuli where the subjects did not agree.

Hypothesis 4 stated that voiced stops, in contrast to their voiceless cognates, would frequently be approximantised. This expectation was supported by the data in that 16 percent of all /d/s, but no /t/s, were judged to have an approximant manner of articulation.

#### 4 Summary and conclusions

A test was conducted to collect auditory place judgements for consonants produced by speakers of 31 Swedish dialects. The consonants were /t/, /d/, /n/ and /l/, all appearing in a vowel-symmetrical V\_V context. Two listeners were to judge, for each token, whether it was produced at a dental or alveolar place of articulation and, for the stops, whether they were full stops or approximants. In addition, data were reported on stop closure duration in /t/ and /d/. The results largely corroborated the hypotheses that 1) /t/ was consistently dental whereas /d/ was alveolar in some dialects; 2) /n/ and /l/ tended to pattern with /t/ in terms of a dental place of articulation, but /l/ was frequently retroflex; 3) alveolar /d/s had shorter closures than dental /d/s; and 4) /d/s, unlike /t/s, were realised as approximants to a substantial extent. However, even if there was a tendency for /d/ to change to an approximant manner of articulation, this effect was less prominent than that previously observed by Engstrand and Lacerda (1996). This was probably due to a difference in speaking-style since, in contrast to the present study, Engstrand and Lacerda's data came from spontaneous speech.

More speech material needs to be analysed in order to substantiate the conclusions reached in this study. For the time being, however, it is tentatively concluded that enhancement of voicing may be a crucial factor behind the tendencies observed in the present material.

#### 5 Acknowledgements

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