

EFFECTS OF VOICING ON /t,d/ TONGUE/PALATE CONTACT IN ENGLISH AND NORWEGIAN

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ABSTRACT

Our paper addresses the question of cross-linguistic similarities and differences in the articulatory patterns of plosives. An EPG investigation of the English and Norwegian plosives /t/ and /d/ shows a larger contact area between tongue and palate for /t/ than for /d/ in both languages. The investigation also shows a more laminal articulation, larger contact areas, for both plosives in Norwegian compared to English. We suggest that the same general phonetic-physiological factors may explain the larger contact areas for /t/ than for /d/ in both languages. The oral air pressure is stronger during the articulation of /t/ than of /d/. In order to prevent air from escaping between the tongue and the palate, a firmer contact is needed for voiceless than for voiced plosives. The larger contact areas for the Norwegian plosives compared to the English ones are interpreted as the result of different phonological patterns in the two languages.

1. INTRODUCTION

Our investigation aims to clarify two questions:

- (i) Are the contact patterns between tongue and palate the same for both members of pairs of voiced/unvoiced lingual plosives in different languages?
- (ii) If voiced and unvoiced plosives are seen to have different contact patterns between tongue and palate: Are the differences language specific or can they be accounted for in terms of general phonetic-physiological conditions?

Figure 1:

EPG palate										
ROW										
1	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	ALVEOLAR
3	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	POST-ALVEOLAR
5	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	PALATAL
8	0	0	0	0	0	0	0	0	0	VELAR

0 = filled electrode . = unfilled electrode

The investigation is part of a larger cross-language project carried out in collaboration with William Hardcastle and Fiona Gibbon, Queen Margaret College, Edinburgh [1]. We have used EPG (Reading EPG3) – electropalatography – as a technical aid in our investigation. Electropalatography is a recording technique where the informant carries an artificial acrylic palate, with implanted electrodes, which is connected to a PC. When the tongue touches the palate, the contact patterns are displayed on the computer screen and recorded (see Figure 1).

2. DATABASE

Our database consists of a set of Norwegian data and a set of English data. The data have been collected from three East Norwegian informants and from three informants representing the same spoken variety of British English. We have concentrated our investigation on the consonant pairs /t/ and /d/. The Norwegian part of the database consists of eight words, constructed so that /t/ and /d/ appear both in initial and final position in connection with a narrow and an open vowel: *din, tin, lid, lit, da'n, ta'n, bad, mat*. (All the words are pronounced with long vowels.) The words were produced in the frame *Jeg sa _ 'a vet du*. The words were read ten times in random order. Then a print-out was made of the EPG-frames of each word. The English database was collected in the same way with the test words *dean, teen, lead, leet, darn, tarn, bard, mart* which were produced in the frame *It's a _ again*. The English and Norwegian words were chosen to be as phonetically similar as possible.

2.1 Data reduction

The basis for the analysis are the individual EPG-frames. The analysis covers the EPG-frames which display the closing stage of the plosive, beginning with the first registered complete closure up to, and including, the last registered complete closure. (By complete closure we mean that at least one of the rows in the EPG-frame is completely filled, i.e., has all its electrodes activated.) Within these limits, the unit which forms the basis for comparison and statistical analysis is the frame(s) which show(s) maximum lingual-palatal contact. In cases of incomplete closure, the frames with maximum constricture form the basis for the analysis. As a measure for the area of contact in the frame with maximum contact, we have chosen as the unit of measurement the number of filled electrodes in the first four rows of electrodes (see Figure 2 and Figure 3).

Figure 2:

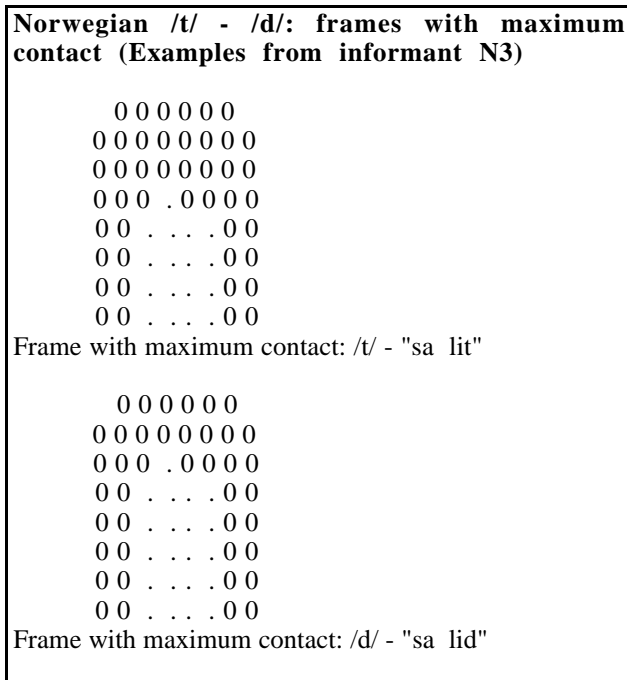
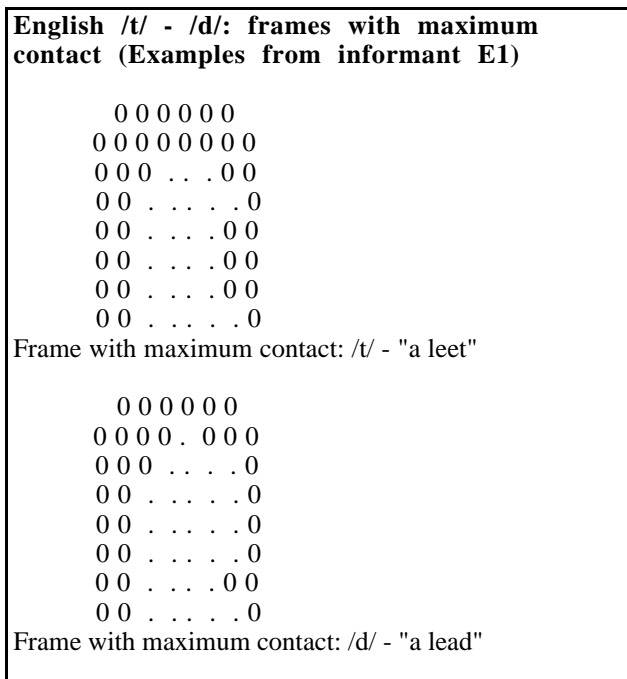


Figure 3:



3. RESULTS

The test words can be transcribed phonemically as /ta:n/, /da:n/, /ti:n/, /di:n/, /ma:t/, /ba:d/, /li:t/, /li:d/ in both languages. Our analysis is, as indicated above, based on the number of filled electrodes in the first four rows in the EPG frames with maximum contact for /t/ and /d/, sampled from three Norwegian informants, N1, N2, N3, and three English informants, E1, E2, E3.

We compared the EPG frames with maximum contact for pairs of words: /ta:n/ compared with /da:n/, /ti:n/ compared with /di:n/, /ma:t/ compared with /ba:d/, and /li:t/ compared with /li:d/.

A comparison of the /t/ frames with maximum contact between the word pairs /ma:t/-/ta:n/ and /li:t/-/ti:n/ was also made.

The difference between /t/ and /d/ in each pair of words, and the difference between initial and final /t/, in the speech sample from each informant was tested by means of Wilcoxon's test (Mann - Whitney) for the comparison of two samples. The significance level was set at 7%.

The analysis of the frames from the English sample revealed the following: The number of filled electrodes was similar in the majority of the frames. When there was a significant difference, there were more filled electrodes in the /t/ frames than in the /d/ frames. But a significant difference was only found in the comparison between /li:t/ and /li:d/ and only in the samples from two of the informants, E1 and E2. The comparison between the /t/ frames with maximum contact between the words /ma:t/-/ta:n/ and /li:t/-/ti:n/ showed more contact for /t/ in final than in initial position. The difference was significant for both pairs of words in the sample from E1 and significant for the pair /li:t/-/ti:n/ in the samples from E2 and E3.

The analysis of the EPG frames from the Norwegian sample showed the same general result as the analysis of the English sample: When there was a significant difference between the number of filled electrodes for /t/ compared with /d/, there was more contact for /t/ than for /d/. All in all, there were more significant differences in the Norwegian than in the English data. In the Norwegian data, though, there were differences between the individual informants:

The sample from informant N1 showed a significant difference in favour of more contact for /t/ than for /d/ in all pairs of words, but there was no significant difference between final and initial /t/ in the sample from this informant.

The analysis of the frames from informant N2 showed very little difference between pairs of frames. There was a significant difference, however, between initial and final /t/, in both pairs of words, with more contact in final than in initial position.

The sample from informant N3 showed a significant difference in favour of more contact for /t/ than for /d/ in the word pairs /li:t/-/li:d/ and /ma:t/-/ba:d/. There was also a significant difference in favour of more contact for final than for initial /t/ in the word pair /ma:t/-/ta:n/.

Let us return to the frames from informant N2. These frames revealed no significant difference in contact patterns for /t/ compared to /d/. Informant N2 differed in this respect from the two other Norwegian informants. It is noteworthy in this connection that a very large number of frames had all thirty electrodes in the first four rows of the EPG palate filled. In other words, informant N2 articulated both plosives with complete, or almost complete, closure in the alveolar and post-alveolar area (see Figure 4).

4. DISCUSSION

4.1 Previous research

Dagenais & al. [2] conducted a similar EPG investigation based on American informants' articulation of CV syllables, using a different EPG system with a slightly larger artificial palate than our EPG3. They also used a different method for measuring the contact area.

While our results show a larger contact area between tongue and palate for /t/ than for /d/, their investigation found the opposite: a larger contact area for /d/ than for /t/.

The differences in results may partly be due to differences in methods and EPG equipment. However, our investigation suggests that the same general phonetic-physiological factors may explain both types of results, but that phonological differences between languages may lead to different, language specific articulatory patterns.

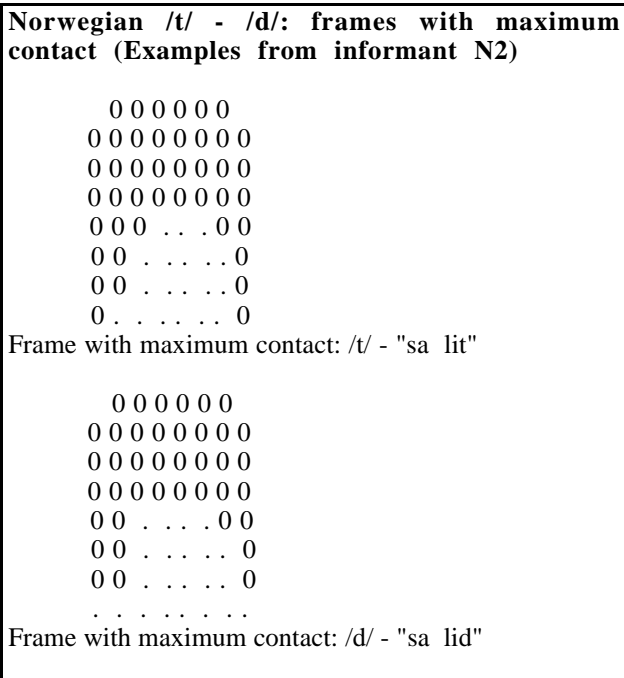
4.2 Our results

We see the evidence for more contact during the articulation of /t/ than of /d/ as linked up with the increase in oral air pressure during the articulation of voiceless stops, compared to voiced ones. In order to prevent air from escaping between the tongue and the palate, which would cause a fricative instead of a plosive articulation, a firmer contact is needed for voiceless than for voiced plosives.

The fact that the difference is most marked in final position following a stressed vowel can be accounted for by assuming that the air pressure is strongest in this position (a testable assumption).

The fact that the difference is more marked in the Norwegian than in the English data can be accounted for in terms of a difference in the phonological structure of the two languages. There is a major phonological distinction between Norwegian and English in relation to anterior oral plosives: In Norwegian there is a distinctive opposition between laminal and apical articulation: the laminal /t/, /d/ in opposition to the apical /t/, /d/, as exemplified in minimal pairs like *hatt* /hat/ "hat" vs. *hardt* /haʔ/ "hard" and *ha det* /ha:de/ "have (inf.) it" vs. *har det* /ha:de/ "has (pres.) it". There is no such opposition in English. The EPG-frames in our investigation clearly show that the Norwegian plosives /t/ and /d/ are more laminal than the corresponding English phonemes as evidenced by the fact that the Norwegian frames frequently display three or four filled rows of electrodes, whereas none of the English frames have more than two rows of filled electrodes (see Figure 2, Figure 3, and Figure 4). A contact area of the size shown in the Norwegian EPG-frames cannot be covered by the apex or the rim of the tongue alone. In addition, to the extent that an apical articulation is also dental, some of the contact between the lower and the upper articulator may be outside of the area covered by the EPG palate.

Figure 4:



Informant N2 reported that when he articulated /t/ and /d/ the tip of the tongue was curled downwards and touched the back of the lower front teeth. Informants N1 and N3 reported a different tongue configuration for the articulation of /t/ and /d/ than N2. N1 and N3 made contact between the tip of the tongue and the back of the upper front teeth. This shows that there are possible individual differences with regard to tongue configuration in the articulation of the Norwegian plosives, differences which cannot be recorded by means of EPG. This demonstrates one of the limitations of the EPG palate as an instrument for the analysis of lingual articulation. The EPG palate covers only parts of the possible passive articulators and it records contact in an on/off fashion, that is, it does not record degrees of contact, only whether there is contact or not. These limitations must be taken into account when evaluating the results of EPG analyses.

3.1 Summary of our results

By way of summary we can say that our analysis indicates the following:

1. There is a clear tendency in the direction of more lingual-palatal contact during the articulation of /t/ than of /d/. The difference is more marked in the Norwegian than in the English data.
2. There is more lingual-palatal contact for /t/ in final than in initial position. This holds for both languages.

5. CONCLUSION

Our results, then, indicate that contact patterns between tongue and palate are not the same for voiced and voiceless plosives. This difference can be related to a general phonetic factor: the stronger air pressure for voiceless plosives requires a stronger contact between tongue and palate for these sounds. However, this contact is not necessarily made in the same way in different languages, or, indeed, between speakers of the same language, so that the EPG patterns may differ both between speakers of the same language and between speakers of different languages. With a laminal articulation, the area of contact measured on the EPG palate is in general larger for /t/ than for /d/. With a more apical articulation, the difference may be smaller, both because only the size of the contact area and not the strength of the contact is measured by means of EPG, and also because some of the contact area for an apical articulation may be outside of the area covered by the EPG palate.

6. REFERENCES

- [1] Marchal, A., Hardcastle, W. J. (1993) ACCOR: Instrumentation and Database for the Cross-Language Study of Coarticulation, *Language and Speech*, 36, 137-153.
- [2] Dagenais, P. A., Lorendo, L. C., McCutcheon (1994) A study of voicing and context effects upon consonant linguapalatal contact patterns, *Journal of Phonetics* 22, 225-238.