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ELECTROPALATOGRAPHIC INVESTIGATIONS OF THREE FINNISH CORONAL CONSONANTS

Introduction

For what has traditionally been called consonant place of articulation, defined in terms of articulatory zones, recent phonologically motivated classification systems usually assume the active articulator(s) employed in producing a consonant to constitute an additional, more fundamental grouping factor. Such articulator-based classification systems usually include the labial, coronal, dorsal, radical and laryngeal articulators as determinants of place features (as against manner of articulation or phonation type features); within each articulator feature, further subdivisions can be made according to the articulatory zone(s) involved (see e.g. Kenstowicz 1994).

In Finnish, as in the majority of the world's languages (Maddieson 1984), the largest number of manner distinctions is accomplished by the coronal articulatory gesture. Depending on which synchronic variant of Finnish one is talking about, the number of consonant phonemes varies between a minimum of 11 (/p t̪ k s m n l r ʋ j h/) and a maximum of 17 (with /b d g f ʃ ŋ/ in addition to those just mentioned), and the number of coronal consonant phonemes varies between five and seven.

The maximum system of coronal consonants is /t̪ d s ʃ n l r/; of these /ʃ/ is clearly the most marginal one and will not be discussed further here. The phonemes /t̪ s n l r/, traditionally referred to as the dentals, have been in the language from times immemorial and occur in all synchronic variants of Finnish. But /d/ is a relative newcomer and in many ways an odd fellow in the company. In the 16th century, when Finnish began to be written down, the predecessor of modern /d/ was still pronounced as [ð], and scribes usually spelled this consonant as either <d> or <dh>. When Finnish texts were read aloud, often by people whose native tongue was Swedish or who knew Swedish, <d> and <dh> were rendered as they would be in Swedish, i.e. as a stop rather than a fricative. Gradually /d/ was established into what is now modern Standard Spoken Finnish. Meanwhile /ð/ has virtually disappeared from all dialects, in which it has been replaced by some other consonant or by zero. Thus /d/ has developed as a result of a spelling pronunciation, with an amount of foreign influence, and probably for most speakers it still does not belong to the childhood native dialect.

Material and analysis

Data for each of the coronals /t̪ d s n l r/ were obtained at once, but so far the raw data have been analysed and results will be summarized for /t̪ d n/ only. Within this subset the task of the coronal gesture is roughly the same: to form a complete closure against the roof of the mouth. Five speakers of Finnish produced ten repetitions of each of $V_1C(C)V_2$ items in which C was (single or geminate) /t̪/, /d/ or /n/, V_1 was one of /i ɑ u/, and V_2 was similarly one /i ɑ u/ (thus altogether 2700 items relevant here were produced and analysed).

The Reading EPG2 model of dynamic palatography was used, with an artificial palate having 62 silver electrodes in 8 sagittal and 8 transverse rows according to a scheme of placement based on anatomical landmarks that enables comparisons of contact patterns to be made across speakers. The frontmost row (which contains only 6 electrodes) corresponds to the dental place of articulation, the next three rows are alveolar, and the backmost row lies close to the border between the hard and soft palate; for a more detailed account see Lindblad, Lundqvist 1996. The equipment only registers whether or not a given electrode has been contacted, but it is possible to make inferences concerning the part of the tongue that is involved. The contact patterns were registered at a rate of 100 Hz (i.e., once every 10 ms).

The EPG results were not printed on paper, as is usual, but the result files were instead converted to text files enabling outputs of corresponding form to be inspected on computer screen. Preliminary inspection of the outputs suggested that a change in the front-back location of the contact pattern often occurred during the temporal course of an occlusion.

To reduce the original data and to quantify them, six numerical parameters were extracted from each token, namely the anterior (Ant) and posterior (Pos) edge of the linguopalatal contact area at each of three temporal measurement points: at the beginning of the occlusion (Beg), at the moment of maximum contact (Max), and at the end of the occlusion (End). Thus e.g. the value of parameter Ant/Beg yields the anterior EPG row of a contact pattern at the temporal onset of the occlusion; the rows were numbered from 1 to 8, starting from the frontmost row. Especially by comparing parameter values at Beg and End, information of eventual changes of contact pattern during occlusion should be captured. In clear cases determining the edges of the contact pattern was straightforward. For example, in a token in which all electrodes in row 2 but none of those in row 1 indicated contact, the anterior edge could clearly be determined to be row 2. In less clear cases, in which there was contact in all electrodes in a given row and in the majority of those in the next row, more subtle criteria were adopted and systematically adhered to.

Summary of results

For limitations on space, the statistical analyses performed on the data will not be reported here; hopefully, the complete results will be presented elsewhere. Three-way analyses of variance were first performed separately for each of the six parameters, with consonant type, V_1 and V_2 as independent variables. These ANOVAs and subsequent post hoc analyses indicated that /t̪/ was significantly different from /d/ and /n/ in 50 out of the 54 comparisons (six parameters × three V_1 contexts × three V_2 contexts), which warrants a separate treatment of /t̪/ and the other two consonants.

Results for /t̪/

The V_1—V_2 interaction never reached significance, and therefore the V_1 and V_2 effects are presented separately. Table 1 shows the means obtained for /t̪/ in the three V_1 contexts.

Table 1

The means obtained for /t̪/ as a function of V_1 (in each V_1 context, N = 300)

V1	/i/	/ɑ/	/u/
Ant/Beg	1.04	1.02	1.06
Pos/Beg	1.84	2.02	2.31
Ant/Max	1.00	1.00	1.00
Pos/Max	3.11	3.38	3.38
Ant/End	1.02	1.02	1.03
Pos/End	1.56	1.48	1.58

The only significant V_1 effects were that Pos/Beg was most front after /i/ and least front after /u/, and that Pos/Max was more front after /i/ than after /ɑ/ and /u/. Table 2 shows the means obtained for /t̪/ in the three V_2 contexts.

Table 2

The means obtained for /t̪/ as a function of V_2 (in each V_2 context, N = 300)

V2	/i/	/ɑ/	/u/
Ant/Beg	1.02	1.03	1.06
Pos/Beg	1.98	2.07	2.11
Ant/Max	1.00	1.00	1.00
Pos/Max	3.26	3.34	3.27
Ant/End	1.01	1.00	1.03
Pos/End	1.59	1.48	1.54

In all six parameters all vowel comparisons failed to reach significance. In summary, /t̪/ was invariably dental, only the posterior edge varied slightly as a function of V_1 at Beg and Max, but V_2 had no effect.

Results for /d/ and /n/

For /d/ and /n/, too, the V_1—V_2 interaction always failed to reach significance, and the V_1 and V_2 effects are therefore presented separately. Table 3 shows the means obtained for /d/ and /n/ in the three V_1 contexts.

Table 3

The means obtained for /d/ and /n/ as a function of V_1 (for both consonant in each V_1 context, N = 300)

	/d/			/n/		
V_1	/i/	/ɑ/	/u/	/i/	/ɑ/	/u/
Ant/Beg	1.70	2.86	3.51	1.80	2.81	3.68
Pos/Beg	2.42	3.44	3.95	2.55	3.34	4.08
Ant/Max	1.37	2.09	2.34	1.55	2.01	2.39
Pos/Max	2.69	3.42	3.63	2.87	3.33	3.67
Ant/End	1.42	2.04	2.23	1.90	2.30	2.46
Pos/End	1.90	2.49	2.62	2.23	2.55	2.73

To make a sweeping generalisation, /d/ and /n/ were statistically non-distinct except after /i/, in the parameters Ant/Max, Ant/End and Pos/End. Thus /d/ and /n/ tended to be distinct toward the end of the occlusion, particularly with respect to the anterior edge of the occlusion, /d/ being more front than /n/, especially in the /i/ context. The V_1 context effects on both consonants were strong and systematic, although they diminished toward the end of the occlusion.

Table 4 shows the means obtained for /d/ and /n/ in the three V_2 contexts. This time /d/ and /n/ were statistically non-distinct at Beg and Max. At End, the /d/—/n/ difference was significant except in the /i/ context, /d/ again being more front than /n/ Except in Pos/Beg, the means obtained in the /i/ context were reliably smaller than those in the other two vowel contexts.

Table 4

The means obtained for /d/ and /n/ as a function of V_2
(for both consonant in each V_2 context, N = 300)

	/d/			/n/		
V_2	/i/	/ɑ/	/u/	/i/	/ɑ/	/u/
Ant/Beg	2.60	2.79	2.69	2.65	2.90	2.73
Pos/Beg	3.21	3.33	3.28	3.28	3.37	3.32
Ant/Max	1.75	2.05	2.00	1.73	2.16	2.06
Pos/Max	3.17	3.32	3.26	3.15	3.38	3.33
Ant/End	1.71	1.96	2.03	1.82	2.34	2.49
Pos/End	2.14	2.41	2.47	2.11	2.60	2.80

One aspect of the results is that both /d/ and /n/ usually exhibited fronting of the contact pattern during the occlusion. The fronting (or eventual backing) of the occlusion, from Beg to End, was computed for each token of /d/ and /n/ in each of the three V_1 and V_2 contexts, separately for the anterior and the posterior edge of the occlusion. Fronting of the anterior edge, or Front/Ant, was computed as the value obtained in Ant/End subtracted from that in Ant/Beg, and fronting of the posterior edge, or Front/Pos, as the value in Pos/End subtracted from that in Pos/Beg. The mean values of Front/Ant and Front/Pos as a function of V_1 are shown in Table 5, and as a function of V_2 in Table 6.

Table 5

The mean fronting of contact during occlusion of /d/ and /n/ as a function of V_1

	/d/			/n/		
V_1	/i/	/ɑ/	/u/	/i/	/ɑ/	/u/
Front/Ant	0.28	0.82	1.29	–0.10	0.51	1.22
Front/Pos	0.52	0.95	1.33	0.32	0.80	1.35

Table 6

The mean fronting of contact during occlusion of /d/ and /n/ as a function of V_2

	/d/			/n/		
V_2	/i/	/ɑ/	/u/	/i/	/ɑ/	/u/
Front/Ant	0.89	0.84	0.66	0.83	0.56	0.24
Front/Pos	1.07	0.92	0.81	1.17	0.78	0.51

The pattern of fronting of the occlusion as a function of V_1 differed in two important ways from the pattern of fronting as a function of V_2. Firstly, fronting was always, for both /d/ and /n/ in both Front/Ant and Front/Pos, reliably least extensive after /i/, medium after /ɑ/ and most extensive after /u/ (i.e., when the vowels acted as V_1). Precisely such rank order of preceding vowel context effects is of course expected: minimum fronting after the most front vowel, maximum fronting after the most back vowel. But one would expect, on the assumption that there is no fronting of the occlusion independent of the vocalic context, the minimum fronting after /i/ to be realised as negative fronting (i.e., as effective backing of the occlusion). Yet /d/ exhibited positive fronting in both parameters in this context, and /n/ did so in Front/Pos. When /i/, /ɑ/ and /u/ acted as V_2, the rank order tended to be the reverse, fronting being most extensive before /i/ and least extensive before /u/. Such a reversal too is to be expected. But the reversal was not perfect: especially for /d/, the V_2 contextual effects were small, and only partly and marginally significant (with only the means in the /i/ and /u/ contexts being marginally significantly different).

Secondly, as concerns the /d/—/n/ difference (in effect the more extensive fronting of /d/ over /n/), in Front/Ant the difference was significant after /i/ but not before /i/, it was marginally significant both after and before /ɑ/, and it was non-significant after /u/ but significant before /u/. That is, the fronting effects of the extreme front and back vowels were reversed depending on whether these vowels acted as V_1 or V_2. In Front/Pos there was a partial reversal in the same direction: here the /d/—/n/ difference was marginally significant after /i/ (but non-significant after /ɑ/ and /u/), and it was marginally significant before /u/ (but non-significant before /i/ and /ɑ/). In other words, the relatively greater frontness of /d/ over /n/ was increased as a function of the frontness of V_1, a factor that *per se* disfavours fronting of the occlusion, and as a function of the backness of V_2, another factor that by itself is disfavourable to such fronting.

Thus in contexts that were likely to be most favourable to fronting, namely after /u/ as V_1 and before /i/ as V_2, /d/ and /n/ were non-distinct. In these contexts, both consonants seemed to take as it were a free ride on the natural fronting provided by the vowel context. But in contexts that were likely to be most adverse to fronting, after /i/ and before /u/, the fronting of /d/ was greater than that of /n/, significantly in Front/Ant (a difference of 0.38 rows after /i/, 0.42 rows before /u/) and almost significantly in Front/Pos (a difference of 0.20 rows after /i/, 0.30 rows before /u/). In the more neutral contexts, before and after /ɑ/, the fronting of /d/ was almost significantly greater than that of /n/ in Front/Ant (a difference of 0.31 rows after /ɑ/, 0.28 rows before /ɑ/), but in Front/Pos the smaller differences in the same direction failed to reach significance. Thus while /n/ too was prone to fronting in all but the most adverse context, the fronting of /d/ was on the whole more extensive, and it occurred even in the most adverse context.

A. Sovijärvi (1963) has presented drawings based on stationary X-ray pictures of a small number of speakers, but to my knowledge dynamic palatography has not been previously used to study Finnish coronals, and thus the present findings concerning vowel context effects on constriction location are novel, as are those concerning fronting in /d/ and /n/. For /d/, however, such fronting has been anticipated as a potential explanation of voicing, i.e. as a means of preventing an equalization of air pressures below and above the glottis (Suomi 1980 : 104—105). I have also argued that Finnish /d/ is a flap-like resonant rather than a true obstruent, and that the /t̠/—/d/ opposition is fundamentally not a voicing opposition (Suomi 1980). While the present results are not at variance with these conjectures on the nature of /d/, more research is needed.

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