ASSIMILATION AS A CONTINUOUS COARTICULATORY PROCESS: FIRST ARTICULOGRAPHIC RESULTS

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ABSTRACT

Alveolar to velar assimilation in stop place of articulation was studied in German utterances by spectrographic analysis and by recording tongue movements with an electromagnetic articulograph. Spectral and positional differences between the stop consonants and between different speaking rates were analyzed. Increased speaking rate for the alveolar stops clearly resulted in positional changes of the tongue towards a position appropriate for velar stops but still significantly different from the latter. This seems to be in accordance with the view that assimilation is a continuous coarticulatory process.

1. INTRODUCTION

In 1988 Nolan [2] reported an EPG study on English alveolar to velar assimilation of stop place of articulation in utterances of the form "... bed girls ..." (vs all velar "... beg girls ..."). Assimilation resulted in EPG patterns with reduced as well as with a total loss of alveolar contact. This finding seemed to be in accordance with the view that assimilation is rather a continuous coarticulatory process than a process of featural change (cf. also [1]).

Since despite the lack of alveolar contact even those 'totally' assimilated items could be discriminated from the all velar utterances better than chance with the following pilot experiments we wanted to study the differences in tongue *movement* in alveolar to velar assimilation.

2. PROCEDURE

Two male German speakers read ten utterances of the type "Wir wollen zu Bett gehen" (vs all velar "Wir wollen zu Beck gehen") ten times at two different speaking rates (normal/fast) in randomized order. Besides the audio signal tongue movements were recorded with the help of an electromagnetic articulograph (AG100, Carstens Medizinelektronik; cf. [3]) via three coils placed on the midsaggital line of the tongue: (1) as far back as possible (back coil), (2) ca. 0.5 cm behind the the tip of the tongue (front coil), and (3) midway between the others (mid coil).

Besides spectrographic analysis of formant frequencies in the middle of the preceeding vowel and at implosion of the alveolar/velar stop, and of acoustic segment duration, the position of the three coils (as their x/y–coordinates on the midsaggital plane) were determined at the following points in time: (1) in the middle of the preceeding vowel, (2) at the beginning of stop closure, (3) at the first stop release (if present[1]), and (4) at the second stop release.

3. RESULTS

In contrast to the English study the auditory analysis of our data revealed that there is only a weak tendency for assimilation in this German material constructed in parallel. One of the speakers almost never produced perceivable assimilations. For the numerical analysis we therefore chose the item with the most occurences of assimilation, i.e. "Er wird es bald kriegen" (vs all-velar "Er wird das Balg kriegen").The mean coil position at the four points in time for both subjects and both places of articulation are seen in Figure 1. The differences in coil placement for the two subjects are clearly seen besides the differences in stop place of articulation.

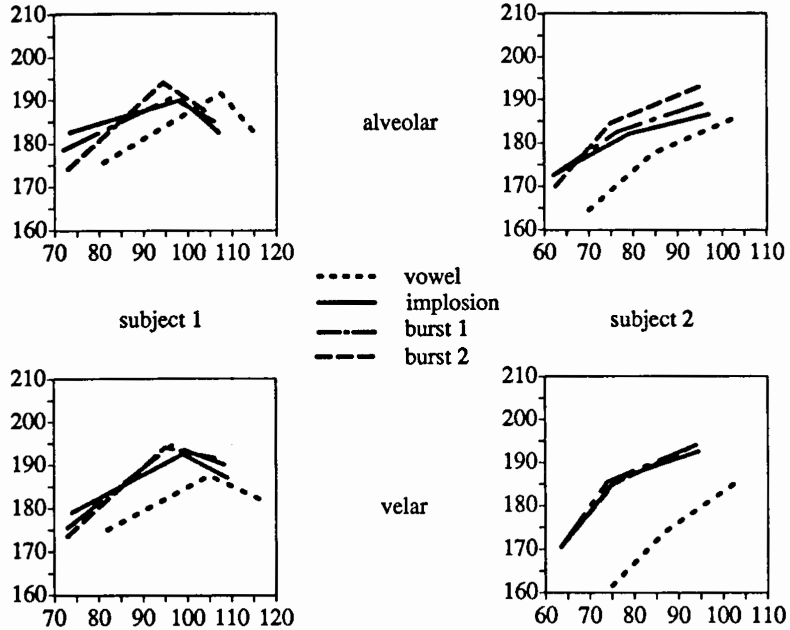

Figure 1: Mean 'tongue contours' at four different points in time for alveolar/velar stop production for both subjects (x/y coil positions in mm).

For the statistical analysis the positional data as well as the measured frequencies for the second and third formants at implosion were subjected to separate two–factorial analyses of variance (with the factors speech rate and place of articulation). There was no influence of speech rate on the formant frequencies at implosion for either speaker. The only significant effects were a higher F2 ($p < .001$) and a lower F3 ($p < .001$) for velars. The positional data showed significant effects only for one speaker (S1). His mean coil positions and standard deviations are shown in inTable I and II. The differences in tongue contour are also shown in Figure 2.

The analyses of variance showed significant interactions between the factors speech rate and place of articulation only for the y–position of the mid and back coil at the first stop release: while for alveolar/velar utterances at fast rate of speech coil 2 is on the average 4.7 mm higher ($p < .001$) than in the case of normal rate of speech, no such rate effects are seen for the all velar utterances. A parallel effect is seen for the y–position of the back coil at the first stop release: the value for the fast alveolar utterance is on the average 3.9 mm higher than for the utterance at normal rate. At the same time the differences between fast alveolar/velar and all velar utterances always remain significant ($p < .01$; $.001$).[2]

4. DISCUSSION

These results (cf. Figure 2) can be summarized as follows: Whereas tongue position

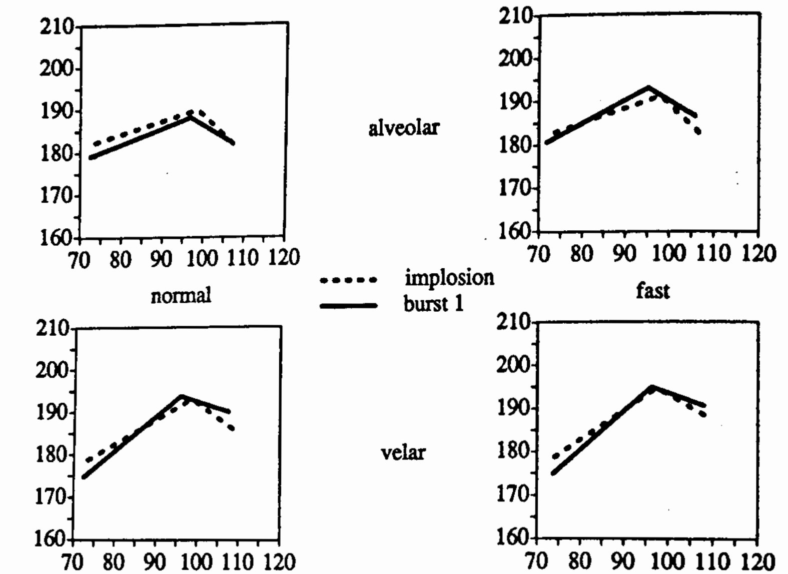

Figure 2: Mean 'tongue contours' at implosion and first burst for alveolar/velar stop production at normal vs fast rate of speech for subject 1 (x/y coil positions in mm).

Table I:
Mean coil postion at implosion (a) and at stop release (b) in cm
(1st line: x, 3rd line: y, 2nd/4th line: standard deviations) at slow rate for S1
(a: alveolar, v: velar)

(a)

coil 1 a	coil 1 v	coil 2 a	coil 2 v	coil 3 a	coil 3 v
7.36	7.34	9.84	9.87	10.74	10.90
.13	.13	.10	.15	.08	.15
18.23	17.87	18.99	19.30	18.17	18.57
.21	.26	.15	.10	.10	.16

(b)

coil 1 a	coil 1 v	coil 2 a	coil 2 v	coil 3 a	coil 3 v
7.24	7.24	9.67	9.60	10.61	10.76
.13	.10	.08	.15	.07	.11
17.91	17.47	18.81	19.37	18.26	19.00
.16	.22	.13	.10	.13	.12

Table II:
Mean coil postion at implosion (a) and at stop release (b) in cm
(1st line: x, 3rd line: y, 2nd/4th line: standard deviations) at fast rate for S1
(a: alveolar, v: velar)

(a)

coil 1 a	coil 1 v	coil 2 a	coil 2 v	coil 3 a	coil 3 v
7.36	7.40	9.81	9.76	10.71	10.84
.05	.16	.11	.13	.12	.11
18.29	17.87	19.10	19.46	18.23	18.83
.13	.24	.12	.10	.11	.11

(b)

coil 1 a	coil 1 v	coil 2 a	coil 2 v	coil 3 a	coil 3 v
7.17	7.37	9.53	9.64	10.59	10.81
.08	.16	.05	.13	.07	.16
18.06	17.49	19.29	19.49	18.64	19.06
.19	.26	.12	.07	.05	.11

at implosion and the first stop release does not change dramatically with speaking ratefor the all velar utterances, the back of the tongue clearly adopts a higher position in the fast alveolar/velar utterances. But on the other hand this higher position does not reach the configuration of the all velar utterances. This clearly seems to be in accordance with the view that assimilation rather is due to a continuous coarticulatory process than a process of featural change.

5. FURTHER EXPERIMENTS

In a second pilot experiment these effects were studied in more detail with another male German subject. Here, additionally, we wanted to study the influence of context on alveolar/velar assimilation: Besides preceding /_ald/g/ as in the experiments above ("bald/Balg") simple /_ad/g/–endings ("Tat/Tag") were used with following accented vs unaccented /ge/ ("**ge**ben" vs "gestanden" or "gehalten"; accented syllables bold).

6. NOTES

* The experiments reported here were conducted in the course of an experimental workshop. I am indepted to my students S. Burger, P. Janker, L. Kuffer, C. Mooshammer, D.Stein and A. Zimmer for help in carrying out the experiments and part of the analyses.

1 This was almost always the case. For the statistical analyses only items showing two stop releases were used.

2 Besides these interactions there is a further for the x–position of the mid coil at the first stop release, only showing a marginal ($p < .05$) fronting effect (.5 mm) for fast alveolars (all other simple effects being not significant). Another interaction – not of relevance here – is seen for the y–position of the back coil at implosion: Here the simple effect of speaking rate for alveolars is not significant, the one for velars showing on average a 2.5 mm higher position for the fast rate ($p < .001$).

The other main effects – not of relevance here – are: mid coil, y–position at implosion, 1.4 mm higher at fast rate ($p < .01$) and 3.3 mm higher vor velars ($p < .001$); front coil, y–position at the first stop release, 5.1 mm higher for alveolars ($p < .001$); back coil, x–position at the first burst, 1.9 mm more back for velars ($p < .001$).

6. REFERENCES

[1] ENGSTRAND, O. & KRULL, D. (1988), "Discontinuous variation in speech", *Phonetic Experimental Research at the Institute of Linguistics University of Stockholm PERILUS, VIII*, 48–53.

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