AN EMMA INVESTIGATION OF LINGUAL ASSIMILATION AND COARTICULATION IN A SELECTED SET OF CATALAN CONSONANT CLUSTERS

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ABSTRACT

This paper investigates lingual activity for clusters consisting of consonants specified for adjacent places of articulation. Data on assimilatory and coarticulatory processes are interpreted in terms of the articulatory requirements involved in consonantal production.

INTRODUCTION

The investigation of sequences of consonants produced with the same articulator or with adjacent articulators is justified by the diversity of processes affecting their realization. This paper analyzes movement data for Catalan clusters with lingual consonants produced at adjacent articulatory zones, i.e., dental /t̪/ and /d̪/, alveolar /n/, /l/, /ɾ/ (a tap) and /z/, postalveolar /ʒ/ and alveolopalatal /ʎ/.

(a) Clusters /nd̪/ and /ld̪/.

In the clusters /nd̪/ and /ld̪/, alveolar C1 undergoes place assimilation thus becoming dental. Moreover C2=/d̪/ is realized as a stop (as opposed to an approximant as in the intervocalic context) in line with C1 exhibiting a lingual closure at the same (dental) location [1].

(b) Clusters /ɾd̪/, /zd̪/ and /ʒd̪/.

This paper investigates whether the tongue tip for C2=/d̪/ reaches the dental zone, remains at the alveolar zone (as for C1) or is found at an intermediate location. According to lingual movement data for Spanish [4] there is enough time for the tongue tip to reach the teeth for C2 in the cluster /ɾd̪/ because the tap C1 is produced with a fast apical movement; on the other hand, high lingual requirements for the fricative /z/ in the cluster /zd̪/ prevent the tongue tip from achieving a dental constriction for C2.

C2=/d̪/ is realized as an approximant in the three Catalan clusters /ɾd̪/, /zd̪/ and /ʒd̪/ in agreement with C1 not exhibiting a lingual closure at the same place of articulation as C2 [1].

(c) Cluster /ʎd̪/.

Catalan /ʎ/ is an alveolopalatal lateral consonant. The fact that C2=/d̪/ is realized as a stop in the cluster /ʎd̪/ implies that, analogously to /nd̪/ and /ld̪/, the two adjacent consonants share a lingual closure at the same articulatory location [1]. This paper investigates this issue as well.

METHODOLOGY

Tongue tip (TT), tongue blade (TL) and tongue dorsum (TD) movement data were collected for one Catalan speaker (the author) using an electromagnetic midsagittal articulometer (EMMA) [2]. Acoustic data were also recorded. The speaker read ten times a list of nonsense symmetrical sequences /pa'Cap/ and /paC'Cap/ embedded in the Catalan phrase 'jo guixo___ si vols' ("I chalk ___ if you want"). VCV sequences included the single consonants /t̪/, /d̪/, /n/, /l/, /ɾ/, /z/, /ʒ/ and /ʎ/. Clusters were composed of each non dental consonant followed by C2=/d̪/: /nd̪/, /ld̪/, /ɾd̪/, /zd̪/, /ʒd̪/, /ʎd̪/. The selection of stop /t̪/ and approximant /d̪/ in intervocalic position allows characterizing fine differences in closure and constriction location for C2 in the six clusters above.

A helmet with three magnetic transmitters was mounted on the head of the speaker and small transducer coils were attached to the three lingual articulators in the midsagittal plane. Coils were also placed on the bridge of the nose and on the upper incisors for head movement correction. The magnetic fields from the transmitters induce voltages in the transducers which can be converted to distance with the appropriate software. Data were digitized at sampling

rates of 625 Hz for movement and 10 kHz for speech. The movement data were rotated with respect to the occlusal plane, corrected for head movement, and extracted separately for the X (horizontal) and Y (vertical) dimensions in conjunction with derived velocities. Articulatory trajectories were labelled TTX, TTY, TLX, TLY, TDX and TDY.

A routine allowed calculating zero crossings in the velocity traces. X and Y position maxima during the consonantal period were identified at velocity minima for each articulatory trajectory; when velocity minima were not available, representative displacement points were measured at the midpoint of the acoustic waveform event associated with a single consonant or with C1 and C2 in consonant clusters. Inspection of composite X-Y temporal trajectories were used to identify one position maximum for single consonants and for the clusters /nd̪/, /ld̪/ and /ʎd̪/, and two maxima for the clusters /ɾd̪/, /zd̪/ and /ʒd̪/ (i.e., a more retracted one for C1 and a more fronted one for C2).

Statistical analyses (ANOVAs with repeated measures and Fisher post hoc tests) were performed in order to find out whether single consonants and clusters could be differentiated on the basis of X and Y position maxima. Significant effects were established at the $p<.05$ level of significance.

RESULTS

Regressive assimilation

According to Figure 1, the clusters /nd̪/ and /ld̪/ are articulated at the dental zone as shown by their TTX maximum being as front as that for /t̪/ and /d̪/. This finding confirms that C1 assimilates to C2 in place of articulation. TLX and TDX maxima also occur at a fronter position for dentals and clusters than for alveolars. TTY maxima for clusters are in agreement with C2 being a stop since they are as high as for /t̪/ (at the upper incisors) and much higher than for the approximant /d̪/ (at the lower incisors).

C1 exerts some effects on C2. There are indeed some differences in lingual configuration between /nd̪/ and /ld̪/ with the latter cluster exhibiting a significantly more posterior TTX, TLX and TDX maxima and lower TLY and TDY maxima; this finding accords with Catalan velarized /l/ involving active tongue predorsum lowering. Also, in comparison to /t̪/, /nd̪/ shows more anterior TLX and TDX maxima, a higher TLY maximum and a lower TDY maximum. All these differences are significant and cannot be assigned to differences in tongue blade position between single /n/ and a dental stop (notice that single /n/ occupies a backer and lower TL maximum than single /t̪/). Instead it appears that the two stops reinforce each other in the cluster giving rise to an increase in closure degree.

Progressive coarticulation

Clusters /ɾd̪/, /zd̪/ and /ʒd̪/ show two TT, TL and TD locations connected by lines in Figure 2, i.e., a more retracted one for C1 and a fronter one for C2. Data will be reported separately for C2 of /ɾd̪/ (a), for C2 of /zd̪/ and /ʒd̪/ (b), and for C1 of the three clusters (c).

(a) Data reveal a significantly fronter and lower TT maximum for C2=/d̪/ in the cluster /ɾd̪/ than in the clusters /zd̪/ and /ʒd̪/. The absence of significant differences in TTX maxima between C2=/d̪/ of /ɾd̪/ and single /t̪/ and /d̪/ indicates that the former realization is truly dental. A significantly lower TTY maximum for C2=/d̪/ of /ɾd̪/ than for dental /t̪/ is consistent with the former consonant being realized as an approximant; moreover, the fact that this position is significantly higher than that for single /d̪/ suggests that C1=/ɾ/ affects tongue tip location for C2=/d̪/ (notice that the TTY maximum for single /ɾ/ is also higher than that for single /d̪/).

Differences between /t̪/, /d̪/ and C2=/d̪/ of the cluster /ɾd̪/ at TL and TD are similar to those found at TT.

(b) TTX and TTY maxima for C2=/d̪/ in the clusters /zd̪/ and /ʒd̪/ are not significantly different. TTX maxima are significantly more posterior than those for single dentals (/t̪/, /d̪/) and for C2=/d̪/ of the cluster /ɾd̪/. In spite of being an approximant, the TTY maximum for C2=/d̪/ of /zd̪/ and /ʒd̪/ is significantly higher than that for single /d̪/ and for C2=/d̪/of /ɾd̪/ and as high as that for /t̪/; this accords with single /z/ and /ʒ/

exhibiting a higher TTY maximum than single /ɾ/. It can thus be concluded that C1 fricative prevents C2 from achieving a dental place of articulation and that the precise constriction place for C2=/d/ is related to the place of articulation for fricative C1.

Analogously to the TT data, C2=/d/ of /zd/ and /ʒd/ shows a highly similar laminodorsal position. TL and TD values for these clusters are significantly more posterior than those for /t/, single /d/ and C2 of /ɾd/, and higher than those for /t/ which should be attributed to /z/ and /ʒ/ occupying a higher laminodorsal position as well.

(c) There are some interesting C2-to-C1 effects in the clusters /ɾd/, /zd/ and /ʒd/.

According to Figure 2, the TT maximum for C1 in clusters does not coincide exactly with that for the same consonant in the isolated condition: in comparison with the latter, the former can be significantly more retracted (/ʒ/), more anterior (/z/) and higher and more anterior (/ɾ/). Moreover, the consonants /z/ and /ɾ/ show highly similar TL and TD maxima when produced in isolation and before /d/ (the only significant difference affects TLY maximum for /ɾ/ in the cluster /ɾd/ as opposed to single /ɾ/); however, the laminodorsal position for /ʒ/ in the cluster /ʒd/ is significantly backer and lower than that for single /ʒ/.

Cluster /ʎd/

Figure 2 indicates that the cluster /ʎd/ exhibits the same TTX and TTY maxima as single /ʎ/; in comparison to /t/, these TT maxima are fronter but neither higher or lower. The presence of a dental location for single /ʎ/ is presumably a secondary articulatory attribute occurring when the alveolopalatal closure extends over the entire alveolar zone [3]. In the cluster /ʎd/, however, it may very well be the output of a regressive assimilatory process through which C1 and C2 become homorganic. The existence of C2-to-C1 effects in laminodorsal position support this interpretation: in comparison with /ʎ/, TL and TD maxima for /ʎd/ are significantly lower and non-significantly more fronted than those for single /ʎ/.

CONCLUSIONS

Data reported in this paper confirm that C1 assimilates in place to C2 in the clusters /nd/ and /ld/. C1 preserves its place of articulation in the clusters /ɾd/, /zd/ and /ʒd/. The tongue tip for C2=/d/ reaches the dental zone after the tap /ɾ/ but not so after a lingual fricative in agreement with the articulatory requirements for the production of C1 (/ɾ/ is produced with a rapid tongue tip movement; /z/ and /ʒ/ require a highly precise tongue body positioning). While exhibiting dental contact in both contextual conditions, /ʎ/ is primarily alveolopalatal in intervocalic position and undergoes presumably regressive place assimilation in the cluster /ʎd/. Consonants which are resistant to assimilatory processes (/d/ in /nd/ and /ld/) and to coarticulatory phenomena (/z/ in /zd/, /ʒ/ in /ʒd/) are also affected by the adjacent consonant in the cluster.

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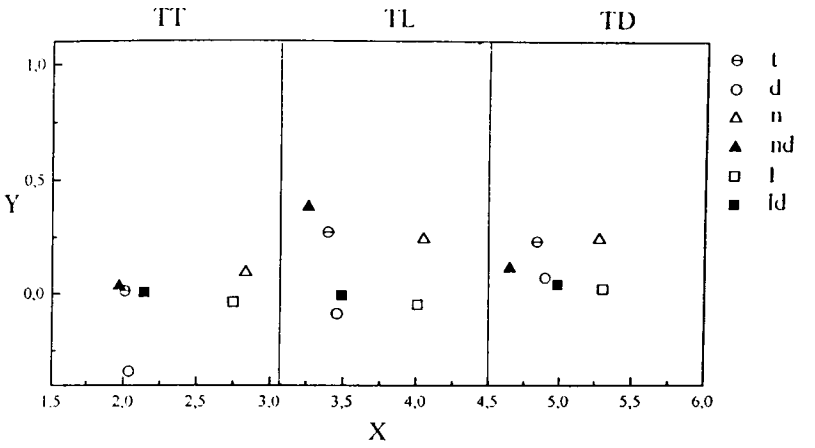

Figure 1. TT, TL and TD position maxima (in cm) along the vertical (Y) and horizontal (X) dimensions for single /t/, d/, /n/ and /l/ and for the clusters /nd/ and /ld/.

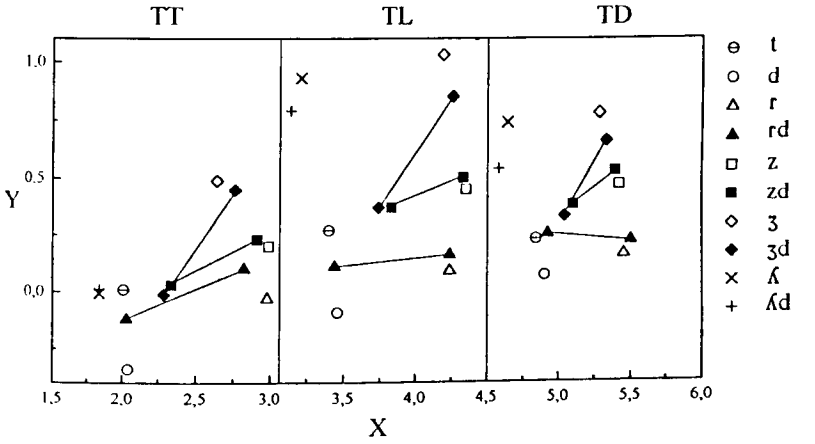

Figure 2. TT, TL and TD position maxima (in cm) along the vertical (Y) and horizontal (X) dimensions for single /t/, d/, /ɾ/, /z/, /ʒ/ and /ʎ/ and for the clusters /ɾd/, /zd/, /ʒd/ and /ʎd/. The clusters /ɾd/, /zd/ and /ʒd/ show two maxima (C1 maximum on the left, C2 maximum on the right) which have been connected by a line.