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TONGUE CONTACT, ACTIVE ARTICULATORS, AND COARTICULATION

Bruce Connell

Phonetics Laboratory, University of Oxford, 41 Wellington Sq. Oxford OX1 2JF UK

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ABSTRACT

This paper is based electropalatographic data from Ibibio. At issue is the hypothesis proposed by Recasens [7], [8] that coarticulation varies monotonically and inversely with the degree of tongue dorsum contact. Some support for the monotonic/inverse hypothesis is found, however it is also found some modification is needed in order to take adequate account of the relationship between coarticulation and active articulator.

I. INTRODUCTION

Recent years have seen considerable progress on questions related to coarticulation. In particular, studies employing electropalatography as a research tool have made an important contribution. Among these, Recasens' work on Catalan (e.g. [8], [9], [10]) deserves particular mention. In this paper, Ibibio consonants are investigated using this technique, with a view to examining coarticulation in this language in light of specific generalized claims found in Recasens [8], [9]. Of particular interest is the question of whether there is a relationship between the degree of coarticulation and the amount of contact of the tongue dorsum for a given articulatory gesture, the claim being that a monotonic and inverse relation exists between the amount of tongue dorsum contact and the degree of coarticulation. This proposal has also found support from Farnetani [5], and on first examination it seems to be a reasonable one. Recasens compared articulations involving different parts of the tongue: dorsal (palatal and alveolo-palatal) articulations and laminal (alveolar) ones. (The alveolo-palatals of Catalan, [ɲ] and [ʎ], involve contact with both the blade and the dorsum.) Given the greater mass of the tongue dorsum, it is not surprising that consonants involving it in their articulation might show smaller coarticulatory effects than those produced with the blade of the tongue, and it is generally accepted that the tongue dorsum moves at a slower rate than the tongue tip or blade [7]. However, further reflection raises doubts on two counts. First, we know from allophonic variation and diachronic change that velars, which normally involve a relatively high degree of dorsal contact, may also be subject to a substantial amount of coarticulatory influence, yet the hypothesis suggests these should be relatively stable. Second, and more specifically, Recasens work examined consonants involving varying degrees of tongue dorsum contact at different places of articulation, i.e. using different active articulators. A more appropriate test of the hypothesis would be to examine articulations using the same active articulator, but involving greater or lesser degrees of dorsal contact. The alveolar stops of Ibibio allow for such a test, and through this some support for the monotonic/inverse relationship hypothesis is found. Comparison of consonants across places of articulation, however, suggests that the relation between coarticulation and tongue dorsum contact is not as straightforward as first though, and that for a fuller understanding of coarticulatory phenomena account need also be taken of factors omitted from Recasens' equation.

Finally, in discussing coarticulation, a distinction needs to be drawn between what have been termed spatial and temporal coarticulation [1]. The present paper is limited in scope to spatial aspects of coarticulation, i.e. whether or to what extent the vowel context in a VCV sequence affects the location of linguo-palatal contact. Moreover, due to space limitations, the discussion is restricted to symmetrical vowel contexts. More detailed discussion is found in Connell [3].

II. METHODOLOGY

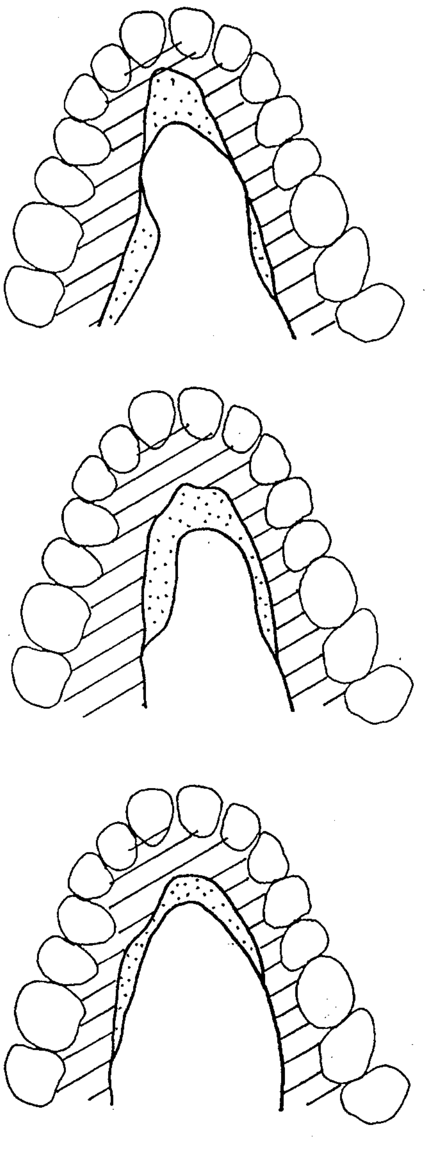
Electropalatographic research was conducted using the Reading EPG2 system. This system uses an acrylic artificial palate (0.8 mm thick) containing 62 silver electrodes as contacts. These electrodes are arranged in eight rows, the front-most row having six electrodes and all others having eight. Further details concerning the Reading system may be found in Hardcastle *et al* [6], however it bears mentioning here that the eight rows are not equally spaced along the length of the palate. Rather, on the palate used, the front five rows (dental to post-alveolar) span approximately 18 mm, while the posterior 3 rows (palatal to velar) cover approximately 28 mm, giving considerably greater spacing between the posterior rows. It should also be pointed out that the artificial palate does not cover the entire velar region, but extends back only to the anterior portion of it. (All discussion of articulatory regions follows Catford's [2] use of terminology.)

The objective was to examine Ibibio consonants as they are realized in stem-initial position, which is normally an intervocalic environment in Ibibio. The consonants [t d s n ɲ k k͡p] were recorded in all possible VCV combinations, using the vowels [i a u] and also controlling for tone (i.e., all VCV sequences were repeated with both high and low tones). This gave a total of 18 tokens of each consonant (9 vowel contexts x 2 tone contexts) per reading; four repetitions were recorded. In almost all cases it was possible to find natural language data to fulfil these requirements; for the few cases where it was not possible, nonsense sequences were substituted. Tone was found to have no discernible effect on consonant articulation and so results were pooled across tones, giving a total of eight tokens of each consonant in each vowel context.

Measurements of these utterances for a number of articulatory parameters were then done, using the EPG system described above. Among the parameters examined were duration of the onset phase (or closing gesture), the medial phase (complete or maximum closure), and the offset phase (or opening gesture). The onset phase was delimited by the commencement of consistent movement (i.e. as represented by an increase in contact) towards the alveolar ridge and the attainment of either complete closure or maximum contact, whichever was less. The medial phase was considered achieved with activation of either a complete row of electrodes or two overlapping rows of electrodes or maximum contact, and was considered released when this complete row was broken. The offset phase began at this point and was judged to be completed when movement away from the consonantal constriction had finished. It is linguo-palatal contact characteristics during the medial phase which are of interest in this report; a more detailed study is presented in Connell [3].

III. RESULTS

I first present results of comparisons made between [t] and [d]. Figure One shows palatograms based on the 8 tokens for these consonants in each of the symmetrical vowel contexts [i__i], [u__u], and [a__a]. Comparing the two consonants, it is clear that [t] involves greater contact of the dorsum than is involved in the articulation of [d]. The monotonic hypothesis therefore predicts that [d] should be subject to greater coarticulatory effects than [t]. Confirmation of this can be seen in Fig. 1 by examining the variation in place of linguo-palatal contact for the two consonants across vowel environments. Here we see that, as expected, the location of contact for [d] varies considerably according to context, involving dental contact in the context [i__i], but being more retracted for the other two environments. On the other hand, [t] remains relatively stable across the three environments. Another possible measure of coarticulatory influence is the amount of variability seen within a given vowel context for each consonant, and here again [d] appears to be the more affected, as indicated by the dotted region on each of the palatograms. Due to space limitations, palatograms for [s] and [n] are not presented

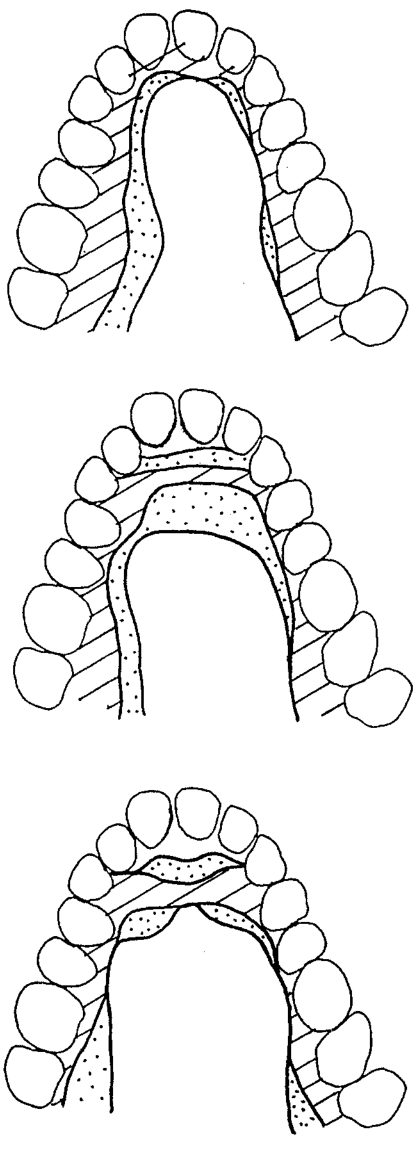


[iti]

[utu]

[ata]

Figure 1a: Palatograms for [t]. Minimum and maximum areas of contact are indicated by the dotted and shaded areas, respectively. Contact in the dotted region implies contact in the shaded area.



[idi]

[udu]

[ada]

Figure 1b: Palatograms for [d]. The shaded area marks the normal area of contact, the dotted area additional possible range of contact.

here, but evidence from these buttresses that of [t] and [d]. That is, like [t], [s] involves a relatively high degree of linguo-palatal contact, but exhibits almost no variation in contact location across vowel contexts, whereas [n] demonstrates the same movement as seen for [d].

Figure Two presents palatograms for [k] in the same set of symmetrical vowel contexts; as before, these are based on eight tokens each; palatograms for the velar element of [kp], not presented, are in agreement with those for [k]. Due to the nature of the artificial palate, examination of constrictions in the velar region cannot be as conclusive as that of articulations anterior to the velar region, at least with regard to degree of contact, for two reasons. First, it must be expected that there is contact posterior to the artificial palate which, as mentioned, extends only to the beginning of the velar region. Second, as explained, rows of electrodes on the of palate used are more widely spaced in the posterior region than elsewhere, therefore estimating the amount of contact between rows introduces a larger margin of error than for the anterior portion of the palate, where the rows are quite close together. However, even taking these factors into account, it is apparent from the palatograms for [k] that a substantial amount of tongue contact is involved in its production - this is abundantly clear from the palatograms for [iki]. Again, then, following the monotonic hypothesis, we should expect little in the way of coarticulatory influence from vowel environment. In this instance, however, the expected stability does not obtain, as in the [i__i] context, [k] is advanced to the extent that it may fairly be called a palatal stop. On the other hand, it should also be observed that at least as revealed by the artificial palate, there is little difference between the [u__u] and [a__a] environments. Finally, for [k], it may be observed that for [iki], as was the case for [d], there is a certain amount of variability across tokens, which may be also taken as a measure of coarticulatory influence. This variability is greater in the [i__i] context than in the others.

As a final test case, palatograms for [ɲ] are presented, in Figure Three. Again it is clear that production of this consonant involves substantial dorso-palatal contact, greater than that for [k].

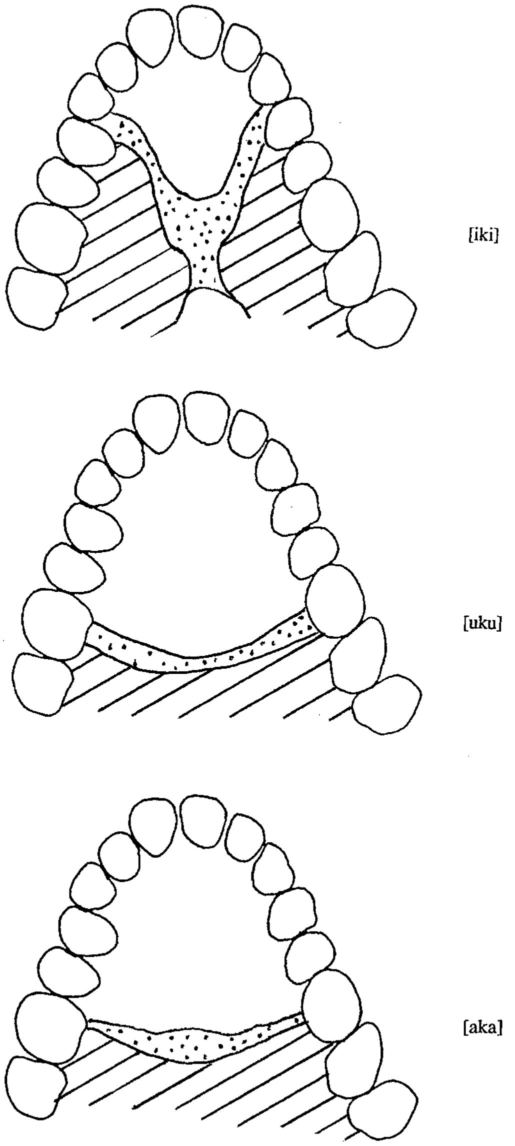


Figure 2: Palatograms for [k]. The shaded area marks the normal area of contact, the dotted area additional possible range of contact.

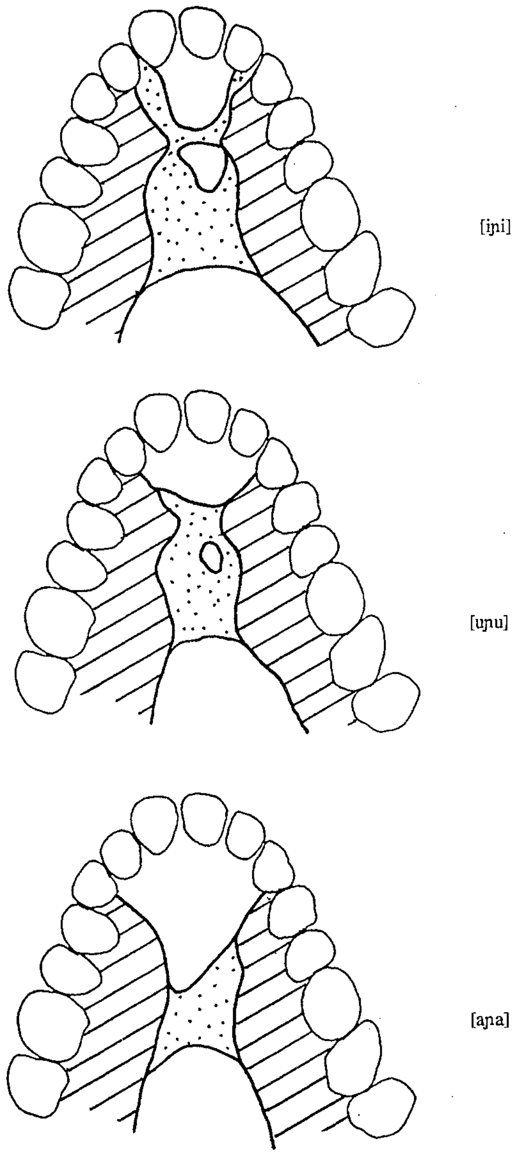


Figure 3: Palatograms for [ɲ]. The shaded area marks the normal area of contact, the dotted area additional possible range of contact.

Movement of the location of this contact according to vowel context is also apparent, [iɲi] often being more advanced than either of the other two contexts, and [aɲa] being somewhat retracted relative to [uɲu]. This movement is not as substantial as that seen for [k], or for [d]. One of the striking features of this consonant is the frequent absence of contact along the midline of the palate. This is a characteristic which spans vowel contexts, but it also appears that the amount of contact along the midline is determined by context; not surprisingly [i_i] involves greatest contact here, and the low vowel environment [a_a], least. Substantial variation within vowel contexts for [ɲ] were also observed, although these did not appear to be greater or lesser for any particular context.

IV. DISCUSSION AND CONCLUSIONS

Overall comparison of the palatograms presented in Figs. 1, 2, and 3 show that the amount of dorsal contact for the consonants examined decreases along the hierarchy [ɲ] > [k] > [t] > [d]. The monotonic/inverse hypothesis therefore suggests that the reverse hierarchy should obtain regarding amount of coarticulation. What the Ibibio evidence shows however is that contrary to expectation and with regard to movement of contact location, [t] is the least influenced of the consonants examined here, followed by [ɲ], [k], and [d]. This would appear to falsify the hypothesis. The prediction of Recasens' hypothesis is borne out though when place of articulation (or more accurately, the active articulator) is taken into account. That is, of [t] and [d], it is the former which involves greater dorsal contact, but it is the latter which is subject to greatest coarticulatory effects; a corresponding relation exists between [ɲ] and [k]. In other words, Recasens' hypothesis is supported if we narrow the view to look at consonants produced with the same active articulator, but involving greater or lesser degrees of contact, whether this is the blade or the dorsum of the tongue. To look across active articulators, comparing laminal articulations with dorsal ones, introduces a complexity, in that while the articulation with the least amount of dorsal contact, i.e., [d], is the most influenced by coarticulatory effects, that with the second smallest tongue dorsum contact, [t], is the least affected.

These findings do not necessarily negate Recasens' conclusions, but rather, suggest a refinement of his hypothesis is in order, to take greater account of characteristics of individual articulators. It is reasonable to expect that, if coarticulation is governed by mechanical constraints, as Recasens and others have suggested, then variation should be seen in the amount and nature of coarticulation between adjoining or overlapping gestures executed by the same active articulator and adjoining gestures executed by different active articulators. (In this case, then, dorsal palatal and velar consonant gestures together with dorsal vocalic gestures, as opposed to laminal alveolar gestures together with dorsal vocalic gestures.) This is exactly what obtains in Ibibio. In the case of laminal-dorsal interactions, when coarticulation effects are manifested (i.e. with [d]), it is primarily with regard to movement of the location of contact. This movement seems principally to be introduced by the high front vowel environment. On the other hand, with dorsal-dorsal interactions there is not only movement of contact location, but also apparently less contact in environment involving low vowels, e.g. [aɲa]). Due to the restrictions introduced by the artificial palate, it is not readily clear whether the same effect is manifested with [k]. This allows for comment on a related issue often raised in the literature ([1], [4], [8], [9]) in the literature, that of whether a hierarchy of vowel influence on consonants can be established. It is apparent from the Ibibio data that it is not possible to establish an overall hierarchy, but that reference needs to be made to the nature of the coarticulatory effect in question. This becomes even more apparent when temporal coarticulation is taken into consideration.

In summary, the Ibibio data have given cause to reconsider the monotonic and inverse relationship between tongue dorsum contact and degree of coarticulation. Support for the hypothesis has been found, in that is clear that the inverse relation holds, though it does not appear that the relation is monotonic, as claimed. However, rather than negate Recasens' overall conclusions, the Ibibio data arguably provide even stronger support that coarticulation is governed by to a considerable extent by mechanical constraints. Finally, it should be reiterated that only spatial coarticulation has been examined in this paper; as shown in Connell [3], a somewhat different picture obtains when temporal aspects of coarticulation are taken into account, suggesting that these two need to be distinguished when considering the monotonic/inverse hypothesis.

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