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The aim of this paper is to show how the investigation of a borderline and apparently minor area of phonetics may help to shed light on certain indistinct areas in phonological theory.

1. Postal's puzzle

Postal (1968: 82) rightly lists as one possible universal markedness convention the following constraint on labial and apical segments:

'*Labial consonants are normally non-Apical* (*i.e. are formed with the lower lip as moving articulator*). Hence there are no languages with only apico-labial (i.e. formed with the tip of the tongue against the upper lip) consonants, although languages with no Apical labial consonants are found everywhere.'

What is not quite so obvious is the actual reason for the markedness of apico-labials. In footnote 25 (to the above quotation), Postal ventures a series of comments about this and comes to the conclusion that, since the notions of ease of articulation and acoustic distinctiveness cannot be invoked to back up their marked status, the puzzling lack of such sounds in phonological systems might be (and I paraphrase) an accidental universal rather than one constrained by an explanatorily adequate theory of general phonetics. The footnote runs:

'In fact there is only one language, Bororo, a South American Indian Language, which is known to have Apico-labial segments at all. In view of the extreme ease with which these can be made, the distinctive acoustic result, etc. it is difficult to see general phonetic grounds for the rarity of such segments. That is, on grounds of Markedness, one would not expect the Marked Apico-labials to be relatively rarer with respect to Unmarked labio-labials, labio-dentals, etc. than Marked lamino-dentals are with respect to Unmarked apico-dentals. But this is overwhelmingly not the case. It is possible, therefore, that this is a real case where the class of languages thus far examined, or, more likely, the class actually existing today is, in at least one respect, highly skewed with respect to the class of all possible languages.'

(The reference should be to Umotina, not Bororo, cf. Martin

(1956 : 683) ; presumably the error stems from Hockett (1955 : 99), who cites a personal communication from Lounsbury.)

2. Types of evidence for markedness

In view of this strong claim, based on what is after all rather inexplicit evidence in a marginal area of phonology, it seems advisable to look at the intrinsic evidence for the markedness of apico-labials more closely. Later on in his book (169 ff.) Postal adduces six types of evidence : (1) relative generality of distribution among the entire class of languages ; (2) relative frequency and differential predictability within particular languages ; (3) appearance in position of neutralization ; (4) facts of phonological change and dialect variation concerning the loss of non-normal types by merger with normal types ; (5) evidence from physiological and perceptual investigations ; (6) evidence from first language learning and language pathology. In the case of apico-labials, types (2), (3), (4), (6) are excluded by virtue of the negative results of (1), leaving (5) as the only appropriate field for further study ; this is, in any case, aetiologically the most important type of evidence.

I propose, therefore (ignoring the Umotina language for the purposes of the present discussion, since I have been unable to find any further information about it), simply to discuss the remarks made by Postal on the articulatory ease with which apico-labials are produced and then, after describing the results of an auditory discrimination test intended to reveal some of their auditory properties, to show that the distributional facts can be explained without making unlikely assumptions about the relation of the class of existing languages to the class of all possible languages.

3. English apico-labials and articulatory icons

In children's speech in various parts of Britain apico-labials are, in actual fact, rather frequent, which would at first glance appear to confirm Postal's contention that they are easy to articulate. I use the word ' frequent ' advisedly, since they are by no means numerous in the vocabulary of the language. I refer to three utterance-types on the border between paraphonology and gesture, namely : (1) ' pretend spitting ', a voiced stop intended as an insult ; (2) a voiced stop with forward movement of the tongue and friction against the teeth, used as an expression of revulsion ; (3) a nasal, used to express defiance (' so there ! '). But it is obvious that these ' utterances ' have further properties which make their status as utterances appear somewhat doubtful, and their apico-labiality at best secondary. The first sound is primarily a physiological mechanism for removing foreign bodies from the tongue ; its value as an insulting gesture is secondary, being directly linked with taboos on

ejected matter, with vocalization as an optional and practically fortuitous characteristic. The second is very similar in origin, being associated with the removal of unpleasant food from the mouth. The third type is a little more specific, being practically a ' synonym ' for sticking one's tongue out; it seems likely that the voicing and nasalization have the metalinguistic function of calling attention to the gesture itself. There has been little systematic discussion in the literature about the semantics of paraphonology, but it seems fairly clear that as signs defined on the articulatory level they have a purely iconic character, an icon being (Morris, 1946: 191) ' any sign which is similar in some respects to what it denotes ' in varying degrees. They are of course neither visual nor auditory icons, the most frequently cited types, but are rather based on kinaesthetic sensory structure. What is common to both sign and denotation in this case is that both are gestural. The point of this observation is to show that the ease of articulation of the apico-labials is strongly shored up in each case by their non-linguistic isomorphic ' referents ', and must be seen relative to these rather than as some absolute property which articulations are supposed to have.

The status of apico-labials in more central linguistic systems is a different matter. Postal does in fact (171) suggest that there is an articulatory bar involved: ' if we consider the normality of Apicality in the dental position, but its unnatural character in labial, palatal and velar positions, we cannot fail to be struck by the fact that the dental region is the closest to the tip of the tongue *starting from the rest position of the apparatus* '.

Should apicality indeed be marked in non-dental regions for this physiological reason, one might attempt to explain the paraphonological apico-labials formally by the simple expedient of allowing iconic kinaesthetic reference to be stronger than the physiological constraints—provided one considers such phenomena to fall under the domain of phonetic theory. Since iconic referential phenomena also play a role in other aspects of phonology (in intonation, onomatopoeia, and other areas of paraphonology), one might consider extending the class of environment types used in markedness conventions to incorporate special semantic contexts of this type. This is a far-reaching claim, necessitating a careful justification which it would be premature to attempt to provide at present. Similar considerations may, however, apply to other, also relatively marginal segment types such as clicks: these occur in a highly restricted distribution with linguistic function, but are frequently found in paraphonological systems. Precisely what the environments for these conventions (affective expression; appraisive comment; exhorting beasts of burden, etc. !) might be in systematic terms, one can hardly surmise.

4. Auditory considerations

There is surely more to the issue than articulatory ease alone, however; this barrier by itself would not seem to be sufficient to mark apico-labials heavily enough to prevent their occurrence in natural languages. I am not in a position to examine directly the acoustic properties to which Postal refers in passing, but in the following I shall describe and discuss an attempt to chart their auditory properties.

5. A discrimination test

A sound discrimination test involving symbol identification was administered to a group of 14 (mainly native speakers of German; few had had any phonetic training, all were also rather fluent in English). The test was a simplified version of the Miller and Nicely (1955) perceptual confusion test. It differs from both Miller and Nicely, and Peters (1963), not only in relative simplicity, but also in that non-native sounds were used; unlike the latter, more complex judgements were required of the subjects. The notion of 'confusion matrix' derives from the former study, and that of 'auditory space' in the sense used here was introduced by Peters.

Subjects were required to identify consonants spoken in open monosyllables with the vowel [ɑ:]; the consonants were dictated from a tape-recording in order to cut out extraneous clues as far as possible; each occurred five times in random order. The data from each subject were pooled, resulting in a total of 70 observations for each consonant, 1,050 altogether. The consonants used, and the partly *ad hoc* symbolism, are given in Table 1. A more complete test would have included other dentals,[1] particularly labio-dentals, but considerations of fatigue among the subjects prevented the use

TABLE 1

Sounds and symbols used in the test

	bilabial		apico-labial		apico-dental	
	voiced	voiceless	voiced	voiceless	voiced	voiceless
stop	b	p	ʙ	ʀ	d	t
fricative	β	ɸ	8	ꜰ	ð	θ
nasal	m		ᴍ		n	

[1] As a matter of descriptive convenience, anterior articulations without upper-lip participation are referred to as dentals. This includes labio-dentals and alveolars.

of a larger sample, and it is likely that the labio-dentals in particular would have swamped some of the other labials and obscured the interesting patterns which did in fact appear in this pilot survey.

6. Results

Scores for correct and incorrect identifications are pooled in a confusion matrix (Table 2). The left hand column contains the

TABLE 2

Confusion matrix showing sounds spoken, symbols written, uncertainties (?) and identification index (II)

Sounds spoken	Symbols written: p	b	ᵖ	ᴮ	t	d	ɸ	β	ꜰ	s	θ	ð	m	ᴍ	n	?	II
p	55		13													2	·79
b		52		17				1									·74
ᵖ	41	1	26	1			1										·37
ᴮ		30		15		11	1	2		4	2	3				2	·21
t					67	1										2	·96
d					1	65						4					·93
ɸ			4				15	2	37	5	7						·21
β		2		8	1		4	24	2	18		7				4	·34
ꜰ		1		1			13	4	28	7	14	1				1	·40
s							4	11		10	3	40				2	·14
θ			1				13	1	30	5	18	1				1	·26
ð		1		2			2		7	6	6	46					·66
m													50	17	1	2	·71
ᴍ		1											22	29	17	1	·41
n													1		69		·99

Overall: ·54

sounds spoken, the top row the sounds heard; the main diagonal gives the number of correct identifications; the other entries in each row indicate the frequencies of the misidentifications. An identification index (Miller and Nicely: 'articulation score') was obtained by dividing the entries on the main diagonal by the number of observations for each sound (= 70 for individual sounds, 1,050 overall); this is given in the right-hand column. A similarity index was also worked out for each misidentification type by dividing its

frequency by 70, and used in Table 3 to give a picture of the distance between various items in auditory space. The items are listed in column 2 in rank order. The third column contains the identification indices, and the other columns show the similarity indices in order

TABLE 3

Similarity matrix, showing items in rank order of identification indices, and distances in ' auditory space '

			Similarity indices																			
			·6	–	·55	–	·5	–	·45	–	·4	–	·35	–	·3	–	·25	–	·2	–	·15	–	·1	–	·05	–	0
1	n	·99																							m	
2	t	·96																							d?	
3	d	·93																					ð		t	
4	p	·79																	ᴘ						?	
5	b	·74															ʙ								β	
6	m	·71															ᴍ								?n	
7	ð	·66																			ꜰ		θ8		ʙɸ b	
8	ᴍ	·41												m			n								?b	
9	ꜰ	·40															θ		ɸ		8		β		bʙ ð?	
10	ᴘ	·37			p																				bɸ ʙ	
11	β	·34													8						ʙð		?ɸ		bꜰ t	
12	θ	·26							ꜰ										ɸ				8		ᴘβ ð?	
13	ɸ	·21				ꜰ															θ		ᴘ8		β	
	ʙ	·21							b										d				8		ðβ? θɸ	
15	8	·14			ð														β				ɸ		θ?	

of decreasing magnitude. In this way distance in auditory space is reflected in terms of proximity between items on the left of the rows and items in the rows, though not between the non-leftmost items in the rows. Note also that auditory space as presented here is non-Euclidean in that the distance relation in any given row is not symmetric; this is presumably due to the ' space-bending ' properties of the native sounds. For example, from the confusion matrix it can be seen that when the apico-labial nasal [ᴍ] was spoken, it was correctly identified 29 times out of 70, giving an identification index of ·41; [m] was heard 22 times, giving a similarity index of ·31, while [n] was heard 17 times, a similarity index of ·24. These figures, transferred to the similarity matrix,

provide an indication in visual terms that [m] is pretty close to [M] in auditory space, with [n] somewhat further away. Starting with [m], the result is confirmed, the asymmetry being probably induced by its nativeness. The dental [n] seems to be relatively isolated, resulting in 99% identification. In terms of auditory space, therefore, [m] and [M] are rather closely bunched together, with [M] also not very far away from [n].

Despite the small sample, the matrices show a number of clear patterns ; the bunching according to manner features, with slightly more scatter among voiced items, accords with the results of Miller and Nicely, and Peters. The influence of extraneous factors such as unfamiliarity with the symbols, or similarities between them, may thus have been rather low. Self-observation also provides a rough corroboration. Marginal confusions of voiced and voiceless sounds may have been due to this, and it is possible that it may have been one of the factors influencing the low discrimination between the sounds [ɸ] and [θ]. Predictably, the familiar sounds were identified much more consistently than the exotic sounds, though the fairly consistent tendencies towards hearing familiar sounds as exotic are evidence that the swamping effect was not absolute ; it would be interesting, for those with access to different nationality groups, to see if different patterns result for native speakers of other languages. It should be stressed that these factors tend to work against a straightforward interpretation of the similarity matrix in terms of auditory phonetic similarity ; many of these factors could be reduced by testing other nationality groups, using other symbols, ensuring more practice and a larger sample, etc. Nevertheless, the clear patterning and the correspondence with self-observation are strong indications of the ' reality ' of the table. The ' similarity indices ' should of course only be taken as giving relative values, not absolute distances.

Of the native sounds, the dentals were most easily identified, indicating a tendency of bilabials and apico-dentals to bunch together. Identification of stops was more reliable than that of fricatives, with the nasals acting rather like the stops (owing perhaps to their sharing of a feature like [— continuant]) and the voiceless stops faring better than the voiced. These results, interestingly enough, tally with predictions made by markedness theory : the unmarked member of each opposition was identified more easily than the marked member. The apico-labials fared rather badly.

Among the stops and nasals, the apico-labials are rather close to the bilabials in auditory space ; the bilabials appeared very frequently for the apico-labials, but the reverse substitution also took place quite often. The two categories appear to be practically indistinguishable, the bias towards the familiar sounds being

expected. The voiced apico-labial stop is more ambivalent than the voiceless and the nasal is even more so.

For the fricatives the results were rather different. Both voiced and voiceless apico-labials were extremely ambivalent with regard to bilabials and dentals, though in different ways. An unexpected result is the dominance of [F] and the accompanying low ranking of [θ]; it may be possible to account for this in terms of the poor transmission characteristics of the anterior voiceless fricatives, resulting in low identifiability, plus a tendency to opt for the unfamiliar when in doubt. In the case of the fricatives, the voiced items were more easily distinguished than the voiceless. The bilabial tended to be confused with the apico-labial, but the latter tended to be identified with the dental, a phenomenon which I can only ascribe to a decision to choose the more unfamiliar symbol ('8') when faced with an unfamiliar sound ([β]). An extremely interesting observation is that the voiced apico-labial fricative has the opposite tendency from that observed for the stops: it appears to be hardly distinguishable from the dental; the reverse substitution was also made fairly frequently (with the alternation of [F] and [θ] being possibly due to unfamiliarity with the symbols).

Table 4 shows the more important of these relations, the rows showing the distance between the positions of articulation in terms of a coarse measure obtained by adding the simplicity indices of the

TABLE 4

Chart of reciprocal distances in 'auditory space' in terms of articulatory positions (reciprocal distance = (distance$_{xy}$ + distance$_{yx}$); sums less than ·15 omitted; sums accurate to ·05; brackets enclose identification indices)

Increase in indeterminacy	bilabials		apico-labials		apico-dentals
	p (·79)	·7	P (·37)		t (·96)
	b (·74)	·6	B (·21)	·15	d (·93)
	m (·71)	·5	M (·41)	·2	n (·99)
	ɸ (·21)	·65	F (·40)	·6	θ (·26)
		·25			
	β (·34)	·4	8 (·14)	·55	ð (·66)

pairs involved for both directions (in steps of ·05). Thus the figure of ·7 obtained for [p] and [P] is the sum of ·15 between [p] and [P] and ·55 between [P] and [p]. The table reflects the increasingly indeterminacy of the apico-labials from top to bottom, starting with the practically indistinguishable apico-labial and bilabial stops and finishing with the fricatives, the apico-labials being indeterminate between bilabials and dentals, even tending slightly towards the latter.

7. Discussion

In addition to the slight physiological barrier involved in their production, apico-labials possess a number of unusual auditory characteristics. First, all of them are practically indistinguishable from less exotic sounds; this could be accounted for by Fry's dictum (1960 : 29): ' The perception of speech or speech-like sounds is dominated by the phonemic grouping to which the listener is accustomed ', though other considerations are needed to account for the behaviour of the voiceless fricatives. More serious is the fact that the voiced sounds in particular tend to be ambivalent between two distinct classes of articulations, bilabial and apico-dental. The auditively indeterminate character of apico-labials would in itself be sufficient to make them unsuitable for use as distinctive features (cf. Postal's own comments on nasals and the influence of their perceptual qualities on their markedness status, p. 171), while the slight physiological barrier mentioned by Postal would prevent their occurrence as conditioned features under all but the most extreme circumstances (e.g. as icons, cf. § 3 above). But even more interesting is the way in which the apico-labials seem to change their allegiance as far as natural classes defined in terms of orthodox articulatory features are concerned, according to whether they are continuant or non-continuant; the phenomenon is most extreme in the case of the voiced continuants. If continuant, apico-labials tend to be indistinguishable on the auditory level from dentals (or coronals, in the current terminology); if non-continuant, they tend to be associated with the labials (non-coronals). Yet apico-labials are also ' produced with the blade of the tongue raised from its neutral position ' (Chomsky and Halle, 1968 : 304) and should thus be counted as coronal. This seems to lead to the conclusion that the feature Coronal should not be taken quite literally, and that either it is an inappropriate criterion for the classification of anterior articulations, or it is only appropriate for anterior continuants. In the latter case it would need supplementing by another feature such as Labial and a general convention for non-continuants:

(1) [+ labial] → [− coronal]

But this is merely shorthand for a description of a particular state of affairs, and hardly an explanation ; it is in fact merely a restatement of Postal's convention, which was the starting-point of this paper, with a more explicit recognition of the feature Labial. Whichever solution is chosen, it is hardly satisfying to attempt to account for the tangle of facts on the articulatory level alone. This conclusion is supported by Ladefoged's criticism of the feature Coronal on systematic grounds (1972 : 6) : [— coronal] cannot have a scale as phonetic correlate in articulatory terms since it refers to labial sounds if in the context [+ anterior], but to velar and uvular sounds in the context [— anterior].

Affricates were not checked, but they appear impressionistically to be even more indeterminate, thus confirming the tendency reported above ; their indeterminacy may be traced to a conflict between their auditory and articulatory properties : while apico-labial stops and fricatives have different allegiances in auditory space, the affricates share a feature with each, [— continuant] with the stops and the fricative feature [+ delayed release] with the fricatives. Only one apico-labial liquid is feasible (with various colourings), and this is indistinguishable from [l] ; the apico-labial glide is practically identical to [w] ; both are considerably more difficult to produce than their conventional equivalents.

8. Phonetic levels

The first of the phenomena described above is clearly a type of so-called ' articulatory ambiguity ' (actually the term ' auditory ambiguity ' would be more appropriate since one auditory structure is assigned to two articulatory structures). The second may be termed ' auditory overlapping ', the third, and most important, ' auditory class overlapping ' ; all three can be explicated in exactly the same way as structurally analogous phenomena in other parts of a systematic description : by mapping structural types at one level of representation on to structural types at another, in various ways ; these relations are shown in Fig. 1. The phenomena illustrate an important facet of phonetic theory which has been extensively discussed in the course of development of distinctive feature theory, the question of articulatory, acoustic and auditory correlates. It is important for generative phonology by virtue of claims made about perceptual correlates (Chomsky and Halle, 1968 : 24 ff., 293 ff.), but also on the grounds of phonetic plausibility (Ladefoged, 1972 : 7) ; it is important in traditional auditory general phonetics (Pike, 1943 : 14 ff. ; implicitly in Jones, 1967 : 36 ff.) because of the frequent use of articulatory terms as convenient labels for perceptual items (cf. also Ladefoged, 1960). If the auditory

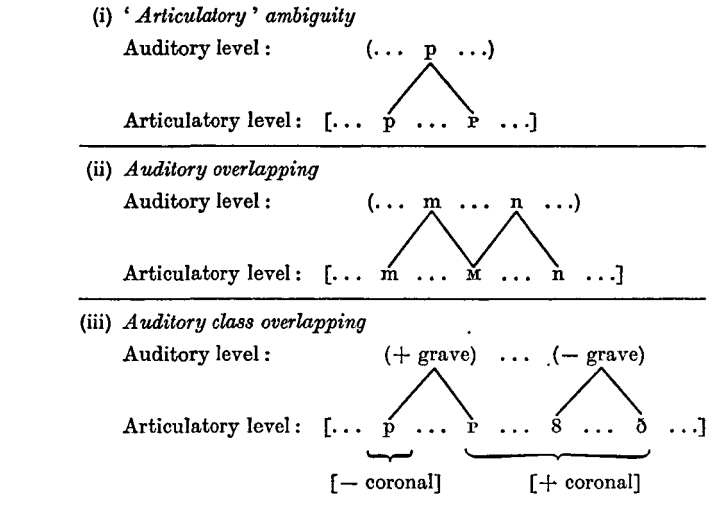

FIG. 1. Types of mapping between phonetic levels of representation.

and the articulatory levels are kept conceptually distinct, as particularly the third of these phenomena indicate they must (despite the claims of reconstructive theories of speech perception such as the motor theory, analysis-by-synthesis, or even the simple ' native grid ' notion), then Postal's puzzle can be solved in relatively conventional terms, by introducing global conditions on the mapping between different levels. Auditory ambiguity and its consequences can be captured by the convention:

(2) If an equivalence class of articulations exists which is defined with respect to an auditory configuration, its articulatorily least marked member is a possible segment.

Until the notions of ' rest position ' and ' articulatory base ' have been explicitly incorporated into phonetic theory (cf. Chomsky and Halle, 1968: 295), physiological interpretations of ' markedness ' will remain a trifle speculative, of course. Auditory overlapping, though covered *a fortiori* by this convention, may be covered more generally by the formulation:

(3) If overlapping equivalence classes of articulations exist which are defined with respect to distinct auditory configurations, the articulations contained in the intersection of these classes are not possible segments.

Auditory class overlapping, which cuts right across ' native grid ' perception, requires a more specific condition:

(4) If a member of an articulatory natural class exists which is mapped on to the auditory correlate of a distinct articulatory natural class, it is not a possible segment.

It might be necessary to introduce a rather obvious rider ' provided that the articulatory natural classes are otherwise well-motivated in terms of the phonologies of natural languages ' in order to avoid the postulation of *ad hoc* articulatory features and conventions in preference to the more general solution. It would clearly be necessary to extend the set of articulatory features by the addition of a feature Labial (or its equivalent on a scale) and perhaps a more radical relational conception of features of the traditional IPA type rather than unanalysed complex features like Anterior, Coronal, etc.

A plausible interpretation of the conventions (2)–(4) might be given in terms of Ladefoged's ' cover features ' (1972 : 4), i.e. ' cover terms for disjunctive sets of the values of the prime features . . . defined within the theory of linguistics '. Many, if not all cover features (pp. 7–8), may be associated with ' auditory/acoustic ' features, the ' prime features ' being articulatory ; the conventions would represent some of the statements linking cover features and prime features. In this way the supposedly more abstract cover features can be given a more direct measure of psychological reality ; their apparently derived status also turns out to be an illusion under this interpretation, since auditory features are logically prior to articulatory features in that what cannot be heard cannot be used in language, and their explanatory value (which Ladefoged questions on p. 8) is restored. Despite Ladefoged's reservations on the score of the unfalsifiable nature of auditory features, at least circumstantial evidence can be obtained from perceptual investigations ; in addition, since acoustic analyses of speech signals may legitimately be regarded as models of the physical aspect of the process of transduction performed by the ear, a relation confirmed by Ladefoged's comments on the acoustic properties of auditory features (p. 8), his measurability criterion is applicable here too. In fact, phenomena of the type discussed here, particularly ' articulatory ambiguity ', are definable in terms of equivalence classes of articulations defined for particular formant patterns (cf. Fant, 1968 : 218, on the work of Schroeder and Heinz). This is not to say, of course, that there is a simple relation between linguistically relevant auditory space and acoustic structure. In any event, these considerations are sufficient to make Postal's claim that apico-labials are acoustically distinctive appear rather unlikely, a matter which is open to testing by those with the means to do so.

9. Conclusion

It seems to me that an explanation for the near-zero distribution of apico-labials in language systems is more convincing when formulated in terms of the three auditory constraints sketched above plus a physiological barrier, than when formulated in terms of either the physiological constraint alone or purely in extensional terms as a merely ' widespread ' (Hockett, 1966 : 5 f.) accidental universal. Though apico-labial articulations clearly lie within the ' articulatory possibilities of man ' (Catford, 1968 : 327), they are clearly incompatible with his auditory possibilities (Catford lists them without further comment). Even if the present discussion has raised at least as many questions as it has claimed to answer, at least it has shown that the powerful claim presented in Postal's footnote has more to do with the inadequacy of an absolute criterion of ' ease of articulation ' and the inaccuracy of the observation about the distinctiveness of apico-labials than with the unnaturalness of natural languages which was suggested there.

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