PHONETICS AND PHONOLOGY

The Special Status of Coronals

Internal and External Evidence

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CORONAL PLACES OF ARTICULATION

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1. INTRODUCTION

Coronal consonants are probably universal in the world's languages. Maddieson's (1984) statistical sample contains no languages without at least some coronal consonant, and only one language without coronal obstruents.[1] A number of typological observations support the special status of coronal consonants. First, coronals include more contrasts of both place and manner than do other consonant classes. For example, with respect to manner, affricates and liquids are most often coronal. With respect to place, Maddieson's survey recognizes five primary places of articulation that are commonly classified as coronal (dental, alveolar, palato-alveolar, retroflex, and palatal), and only five other primary places (bilabial, labiodental, velar, uvular, and pharyngeal), so that coronals account for half of the primary places of articulation.

Second, coronals account for a high proportion of consonants in languages. [illegible] nal. Also, Maddieson found that across the languages in the sample, the preferred inventory of stops and affricates contains three stop places of articulation (dental or alveolar, labial, and velar), plus one affricate place of articulation (palato-alveolar). Thus, two of these four stop–affricate place categories are coronal. Further, if a language has four (rather than three) stop places, then again two of the four are usually coronal.[2]

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Thus, there are more coronal consonant types, and languages use them more. Put simply, coronals are special phonologically because there are so many of them. Presumably, this sheer preponderance of coronal consonants is a factor in the status of coronals as the usual unmarked or unspecified place of articulation: If half of the consonants in a language are coronal, then any given consonant is more likely to be coronal than any other place class. In phonetic terms, coronals are special because they can be made in so many ways. The tongue blade seems to lend itself to a greater variety of articulations than do other speech articulators.

In this article, the variety of possible coronal places of articulation is examined. We consider traditional place of articulation distinctions plus some manner distinctions that are generally used to make fine place distinctions. Some of the other manner distinctions found among coronals, such as lateralization, stridency, trill–tap, gradations of stricture, various release types, and certain secondary articulations, are not discussed here. The article is organized as follows. In Section 2, some necessary terminology is reviewed, and anatomical definitions are discussed. In Section 3, various coronal places of articulation are described. Features that have been used to characterize these places are considered in Section 4. Section 5 provides a summary discussion.

2. TERMINOLOGY

2.1. Tongue

Coronals can be defined as segments produced with the blade (including the tip) of the tongue. It was noted above that among the generally recognized coronal places of articulation are dental, alveolar, palato-alveolar, retroflex, and palatal. (Palato-alveolar refers to the place of English [š] (IPA [ʃ]), while palatal refers to the place of the front glide [y] (IPA [j]). American usage of "palatal" often encompasses both of these.) The IPA also includes another place using the tongue blade, alveolo-palatal. Ladefoged and Maddieson (1986) add two less-common coronal places, linguolabial and interdental. These places of articulation lie from front to back in the mouth, from the upper lip (linguolabials) to the hard palate (palatals), that is, virtually the entire span that can be touched or approached by the tip or blade of the tongue.

What part of the tongue counts as the blade? Different sources give different answers to this question. Catford (1977:143) notes that there are two traditions: one from British phonetics, which he adopts, in which the blade is "the part that lies opposite the teeth and alveolar ridge when the tongue is at rest," that is, just the tip plus 10–15 mm; and one from American speech science (see Daniloff, 1973:173) in which that part is called the tip, while the blade lies further back. Ladefoged (1982:4) defines the tip and blade as "the most mobile parts" of the tongue, and Ladefoged (1989) defines the blade as the part not attached to the floor of the mouth, roughly corresponding to the part below the alveolar ridge. Ladefoged considers the blade to be a bit shorter than Catford suggests, no more than a centimeter long.

However, linguistically speaking the blade must be taken to extend somewhat further back than Catford or Ladefoged suggest. A sense of the extent of the blade in its linguistic uses can be gleaned from the following point. Alveolar stops and fricatives can be produced with the tongue tip down behind the lower teeth and a part of the tongue further back forming the constriction at the alveolar ridge. The phonological notion "coronal" surely depends on such articulations being made with the blade of the tongue, yet they are formed more than 1 cm behind the tip. Dart's (1988) linguograms agree with this observation. In my own case this suggests a blade length on the order of 15–20 mm. The part of the tongue 1 cm behind the tip reaches only to the upper teeth.

This is a minimum estimate of the extent of the tongue involved in producing coronal consonants, since it is based only on anterior coronals. How much further back on the tongue nonanterior coronals are produced is a circular issue, since it depends on the status of certain articulations as coronal or dorsal. In any event, the maximum estimate for blade length is that part of the tongue in front of the part used to produce velars, that is, some 3 or 4 cm.

To some degree such differences of definition may be a function of the extension of the tongue. The blade can be moved quasi-independently of the rest of the tongue (e.g., protruded, curled, wiggled). If the tongue is at rest in the mouth, this movable part will appear quite small; but if the tongue is extended out of the mouth or stretched in any other way, it will appear quite large because it is stretched. Thus, if one considers the blade to be the part of the tongue that can be grasped in one's hand, and if one protrudes one's tongue to grasp it, then the blade will appear to be much longer than 10–15 mm. Perhaps in articulations with the tongue tip down, the tongue blade similarly stretches itself.

The definition of tongue tip also requires mention. Catford (1977) distinguishes between the [illegible] seems just as valid to follow Ladefoged (1989) in considering the tip to include both of these at once, since in practice it is nearly impossible to use the very tip of the tongue without also involving a couple of adjacent millimeters.

Thus, we will consider the blade of the tongue to be, conservatively, the movable part extending from 1 to 2 cm behind the tip, and we will consider the tip to include a small rim around the edge of the tongue. Articulations with the tip are called apical; those with the blade are called laminal. Articulations made with both at once can be called apicolaminal. Traditionally, laminal refers only to the

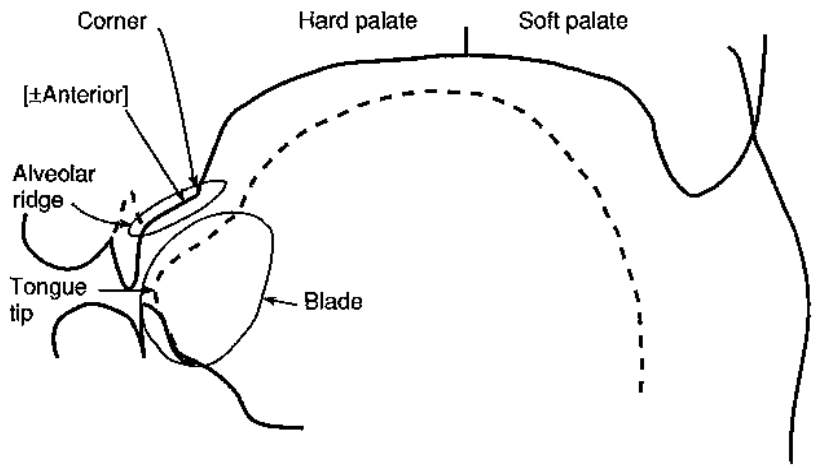

Figure 1. Overview of relevant anatomical distinctions: tongue tip and blade; alveolar ridge, corner, hard palate, soft palate; dividing point between [+anterior] and [−anterior].

top surface of the blade, while sublaminal refers to the lower surface. These points are summarized in Figure 1.

Apical versus laminal is sometimes equated with another descriptive parameter, the position of the tongue tip as "up" or "down." The tip is said to be up when it is raised above the lower teeth, so that the view of the tongue from outside the mouth is of the lower surface of the tongue. The tip is said to be down when it is behind or below the lower teeth, so that the view from outside is of the upper surface of the tongue. Individual speakers of English differ especially in whether /s/ is tip up or tip down.

2.2. Palate

As noted earlier, coronal articulations extend from the upper lip to the hard palate. Key divisions along the palate are represented in Figure 1. Behind the upper teeth is the alveolar ridge, a source of some confusion in articulatory descriptions. For phonetic purposes, the alveolar ridge is the entire area from the upper teeth back to the prominence at which the palate starts angling upward toward the roof of the mouth. This prominence is sometimes called the "ridge" but can also be referred to as the "edge," "center," "corner," "turning point," or "protuberance" of the ridge. The alveolar ridge is this whole area, not just the prominence. Catford (1988:86–87) has a helpful discussion of this point.

Given such definitions, we can now proceed to consider the variety of coronal places of articulation available to languages.

3. DESCRIPTIONS OF CORONALS

In this section, the articulations of some of the coronal consonants are discussed. The observations are based on discussions in the literature and on review of published physiological data, especially X-ray tracings but also palatography.

3.1. Anterior Coronals

Coronals that are [+anterior] have their contact or constriction on the front part of the alveolar ridge, on the upper teeth, or, in the case of linguolabials, the upper lip. Linguolabials, interdentals, dentals, and alveolars are variably apical or laminal. Still, one might view linguolabials and interdentals as variants of a basic sound type, sharing an extension and protrusion of the blade, and differing largely in terms of apicality. Linguolabials would be primarily apical, in the sense that the tip is aimed at the upper lip, though it sometimes overshoots. Interdentals would be primarily laminal; in the sense that the blade contacts the teeth, but sometimes the tip does not quite protrude.

Figure 2 shows a dental and an alveolar. Dart (forthcoming) provides details about dental and alveolar articulations, particularly about cross-speaker variability in apicality. In both French and English, speakers vary in the place and the manner of their dentals and alveolars. For example, Dart presents data that refute the claim by Ladefoged and Maddieson (1986:78) that dental sibilants are always apical: 6 of the 14 dentals in her sibilant sample were laminal. See Ladefoged and Maddieson for further discussion of a variety of anterior coronals, especially strident versus nonstrident fricatives.

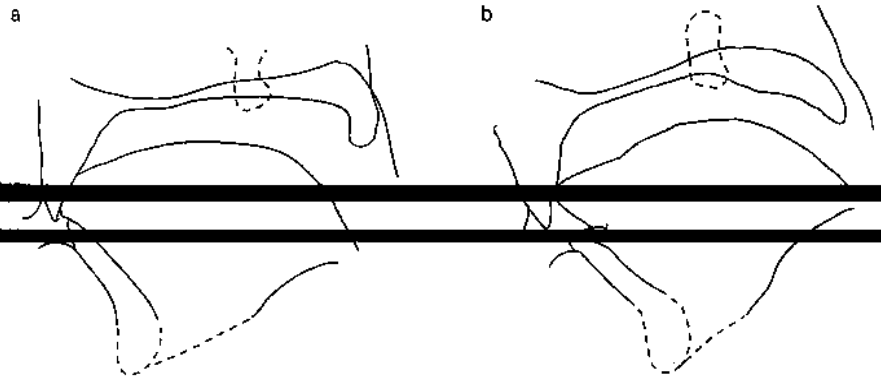

Figure 2. Dental (denti-alveolar) stop (a) and alveolar nasal (b) in French, after Simon (1967). Both are tip up, but the first is apicolaminal while the second is apical.

3.2. Palato-alveolars

Palato-alveolar constrictions (for English [ʃ], see Figure 3) are at or near the corner of the alveolar ridge. The tip may approach the ridge in front of the corner, while the blade approaches the corner; thus, the blade runs parallel to the ridge. In these cases the articulation is both apical and laminal at once, and so the constriction is fairly long (and thus should be counted as primarily laminal rather than apical). However, for speakers with a prominent corner, coming nearly to a point, a laminal constriction can be quite short. Palato-alveolar articulation is most often laminal, sometimes apical. However, even the laminal articulation can have the tip up, that is, raised above the lower teeth. Basically the tip lies behind the upper teeth, but far enough away from them that no dental constriction is formed. The tip is above the lower teeth so that a cavity can occur behind them, under the tongue. Catford (1977:158) shows an articulation of this sort. Palato-alveolars are also reported with a tip-down articulation. However, it seems unlikely that this could ever mean that the tip contacts the lower teeth, since no cavity would be formed under the tongue. More likely, the tip-down palato-alveolars have the tip just below the upper teeth, but free of the lower teeth.

Palato-alveolars also have a somewhat "domed" or convex tongue behind the constriction, which Ladefoged and Maddieson (1986) characterize as a slight degree of palatalization.

3.3. Retroflexes

Figure 4 shows two kinds of retroflexes. Many apical and sublaminal retroflexes (Figure 4a) involve curling back the tongue blade so that its tip or underside forms a constriction along the palate. With just a slight curl, the very tip can touch the rear part of the alveolar ridge, in front of the corner. However, more commonly the constriction is behind the corner; the further back it is, then the more curled and stretched the tongue, the more the underside of the blade is used, and the longer the constriction. Ladefoged and Maddieson (1986) note that

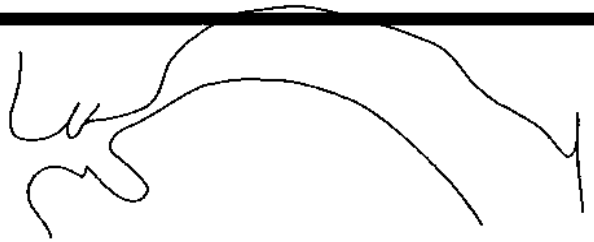

Figure 3. Palato-alveolar fricative in English, after Ladefoged and Maddieson (1986).

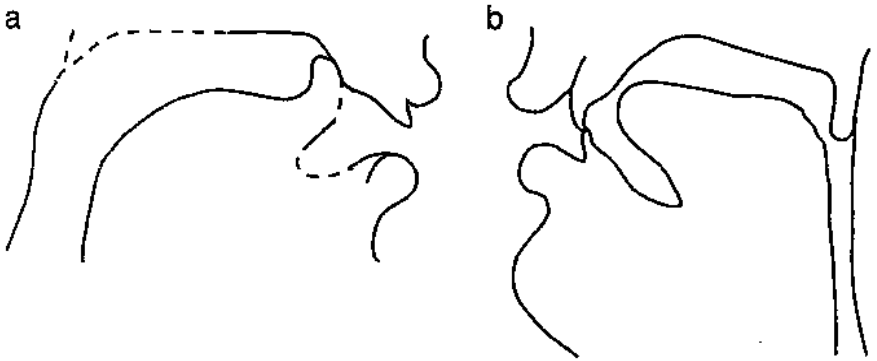

Figure 4. Retroflexes: (a) sublaminal stop in Tamil, after Ladefoged and Maddieson (1986); (b) flat apical fricative in Serbian, after Miletič (1960).

this description applies most clearly to stops; the retroflex fricatives in the languages of India are not as well documented, but they seem not to involve the same kind of curling of the tongue. They have the same place of articulation on the palate as the stops, but the blade is not extended out from the body of the tongue. This makes it difficult to distinguish the tip from the rest of the blade in X-ray tracings. However, it should be noted that several tracings of Russian /š/ and /ž/ (e.g., Oliverius, 1974; Dem'janeko, 1966) are clearly retroflexes of the expected type: apical with the tongue curled back.

A somewhat different kind of retroflex fricative (Figure 4b) is also described by Ladefoged and Maddieson (based on earlier work). These sounds are found in Mandarin Chinese and in Slavic languages, where they are often transcribed as palato-alveolars, though they sound more like other retroflexes.[3] Relative to palato-alveolars, or to the tongue at rest, the entire blade is moved up and back and is positioned just behind the corner of the alveolar ridge. The tip is up, and the tongue is flat from front to back, not domed. Ladefoged and Maddieson categorize them as (laminal) flat postalveolar sibilants, with a sublingual cavity. They describe the constriction as like that of [ʃ], but at the center of the alveolar ridge.

versus Chinese: The former are rounded while the latter have a larger sublingual cavity. (These fricatives are both said to differ from the retroflex fricative of Tamil, which is further back, possibly apical, and has a larger sublingual cavity.)

Although Ladefoged and Maddieson characterize these retroflexes as laminal, data sources show greater variability. The active articulator for affricates is relatively easy to determine from available data. The retroflex affricates in the X-ray tracings of Ladefoged and Wu (1984) are either apical or laminal, though in either case with the tip up. Linguograms and palatograms, along with X-ray tracings, are available for the fricatives and corresponding affricates of Polish

(Wierzchowska, 1965, 1967, 1980) and Serbian (Miletič, 1960). In these records, the stop portions of the affricates are clearly apical, possibly partly sublaminal. The fricatives also appear to be apical, in the sense that the linguograms show no narrowing anywhere along the blade. Since the palatograms show that there is indeed a constriction, it must be the tip forming it. The difference between Slavic and Dravidian fricatives, then, would appear to be in the location (backness) of the constriction, and thus in the size of the sublingual cavity.

3.4. Alveopalatals

Figure 5 shows three kinds of alveopalatals. Alveopalatals, or "prepalatals," probably occur most commonly as nasals and laterals, where they are generally confused with palatals. (For example, Maddieson, 1984, collapses these categories.) They also occur as fricatives and affricates, for example, in Polish and Mandarin [ɕ], where they sound like sharpened palato-alveolars or strident palatals. They most commonly involve the blade approaching the corner of the alveolar ridge. The tip is usually down, pointing to the lower teeth, but often does not touch them; however, tip-up examples can also be found (e.g., Ladefoged and Wu, 1984). In either case there may or may not be a cavity under the tongue. The front of the tongue is raised behind the constriction. Available X-rays of alveopalatals (in Mandarin and Polish) show quite a bit of variation, even within languages.

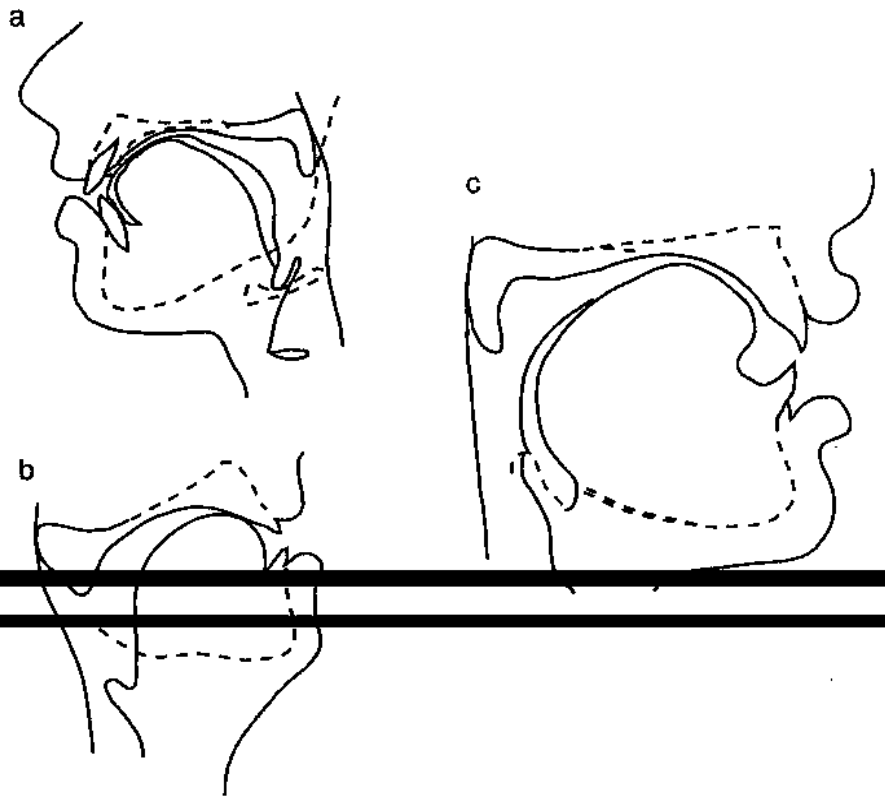

Figure 5. Alveopalatals: (a) Polish fricative, after Wierzchowska (1967, 1980); (b) Polish affricate, from same source; (c) Mandarin fricative, after Ohnesorg and Švarný (1955).

Figure 5a shows a fricative from Wierzchowska (1967, 1980), with a long constriction, the tip behind the lower teeth, and a small sublingual cavity. Figure 5b shows another tracing from the same author, this time of the stop component of an affricate just before the release. Here, the requirement of complete occlusion leads to a raising of the blade, with the tip also raised, resulting in a slightly larger sublingual cavity. Figure 5c shows a Mandarin alveopalatal fricative with an even larger sublingual cavity, one as large as for other nonanterior coronals.

Since alveolopalatals are generally articulated at the corner of the alveolar ridge, they are [−anterior]. Chomsky and Halle (1968) and Halle (1988) give somewhat different descriptions of the Polish alveopalatals, classifying them as [+anterior]. These descriptions are based on figures from Wierzchowska that are not, in fact, alveopalatals. This error is corrected in Halle and Stevens (1989), where the alveopalatals are defined as [−anterior].

See Recasens (in press) for further data and discussion on alveopalatals.

3.5. Palatals

In Chomsky and Halle (1968), hereafter referred to as *SPE*, palatals (such as [j] and [ɕ]) were considered to involve tongue-body articulations, and so were [−coronal], but they were later reclassified as coronals on phonological grounds (see Keating, 1988b, among others, for a summary). Halle and Stevens (1979) proposed a redefinition of coronal to mean the blade or front of the tongue so as to include the palatals. However, this move seems unnecessary, as palatals gener- [illegible] the blade proper, in addition to the front of the tongue.

Figure 6 shows a palatal stop. The [illegible] of palatals seems to be their articulation near a large part of the hard palate, between the alveolar ridge and the roof of the mouth (Keating, 1988a). The tongue is both raised and fronted from its position for [i] vowels so that parts of the blade and the front form a very long constriction. The tip, and the front part of the blade nearest the tip, are not involved and are usually low in the mouth so that there is no sublingual cavity. Palatograms show that the occlusion for stops is about the length of a velar constriction, but quite front; the blade touches just behind the alveolar ridge. Thus, the stop occlusion itself is coronal and nonanterior. At the same time, there is

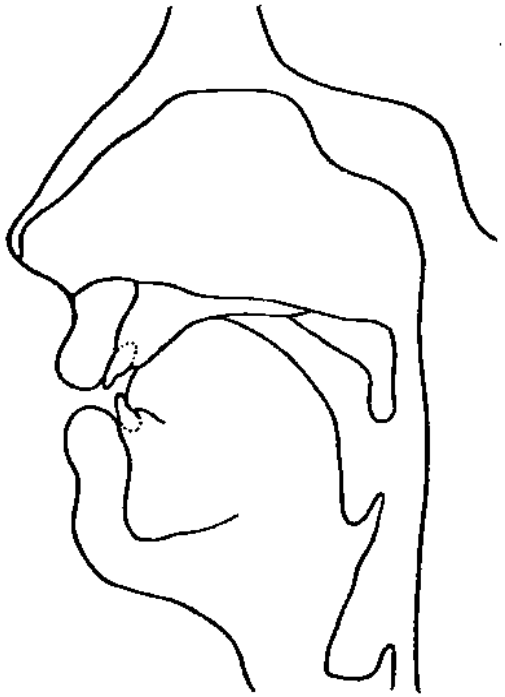

Figure 6. Palatal nasal stop in Czech, after Hála (1962).

extensive side-to-side and front-to-back lateral contact as for [j], and the entire front of the tongue is extremely close to the palate. Nonstops have more open constrictions covering about the same area. See Recasens (in press) for additional data on and discussion of palatals.

One basic observation here is that palatals have a very large constriction area, probably the largest of any outside the pharynx. A second basic observation is that palatals are articulated much further forward in the mouth, and on the tongue, than has often been assumed. Although the palatal place of articulation is next to the velar place, these are very far apart in practice. Palatals are even further forward along the palate than velars fronted in a front vowel context. There is room along the roof of the mouth for three different places of articulation, with fronted velars in between palatals and velars. In Keating (1988a) I proposed that the SPE tongue-body feature values assigned to palatals be used instead for fronted velars. In particular, the value [−back] would refer to a tongue-body articulation on the hard, rather than the soft, palate; thus fronted velars would be [−back] while nonfronted velars would be [+back]. The representation of palatals is discussed below.

3.6. Palatalized Coronals

Thorough coverage of all the secondary articulations that can affect coronals is beyond the scope of this article. However, in the case of palatalization, the secondary articulation can effect a change in the primary place and/or manner of articulation and thus needs to be considered here. As a technical phonetic term, palatalization refers to the superposition of a high front tongue-body position on a separate primary articulation, such as a primary articulation with the tongue blade. However, Bhat (1978) emphasizes that "palatalization" is used as a cover term for any combination of three independent articulatory components: tongue fronting, tongue raising, and spirantization. He points out that the term palatalization, in its wider use, more often refers to restricted changes in certain primary places of articulation, as when velars palatalize to palato-alveolars. It less often refers to a general secondary articulation across all the primary places in a language, as in Russian, where labials, coronals, and velars can all come in surface contrasting pairs of palatalized versus nonpalatalized.

3.6.1. Anterior Coronals

Russian has surface contrasts of plain versus palatalized anterior coronals. Bhat shows that, across languages, anterior coronals are more likely to undergo tongue raising than either tongue fronting or spirantization. Tongue raising of coronals usually results in retracted and laminal articulations. The X-rays of Russian coronals in Oliverius (1974) show this effect quite clearly.

Polish alveopalatals, which are [−anterior], pattern phonologically as palatalized variants of dentals, which are [+anterior]. However, a change in anteriority under palatalization is in accord with the cross-language observations of Bhat (1978).

3.6.2. Nonanterior Coronals

Secondary articulations involving the tongue are very rare with [−anterior] places of articulation. However, surface contrasts do occur: in Russian, between retroflex and palatalized retroflex fricatives, and in Polish, between palatalized retroflex, retroflex, and alveopalatal fricatives. The Russian palatalized retroflex looks straightforwardly like a palatalized version of the plain (curled) retroflex. However, X-rays of Abkhaz reproduced by Ladefoged and Maddieson (1986:77) show that in that language, the alveopalatal looks like a palatalized version of the retroflex, which is of the flat-tongued, apical type. Ladefoged and Maddieson therefore analyze it as such. Furthermore, the palatalized retroflex of Polish shown in Wierzchowska (1965) looks very much like the alveopalatal of Abkhaz, supporting Ladefoged and Maddieson's analysis. By this account, there is no

TABLE 1
TONGUE PROFILE BEHIND CONSTRICTION

Language	Flat	Raised	Palatalized
Polish	ʂ	ʂʲ	ɕ
Abkhaz	ʂ	ɕ	

separate *place* of articulation for alveopalatals; they are collapsed with the retroflexes, and only the palatalization distinguishes the two (see Halle and Stevens, 1989, on equating Russian /šʲ/ with Polish /ɕ/). The change from apical retroflex to laminal palato-alveolar would be a natural concomitant of palatalization. The problem, however, is the fact that Polish also has an alveopalatal, contrasting with its palatalized retroflex. Since the alveopalatal then cannot be just a palatalized retroflex, how are these to be analyzed? Tokens vary, but overall the three Polish fricatives lie on a continuum of tongue-body raising. The retroflexes have a flat tongue, the alveopalatals have a very raised and fronted tongue, and the palatalized retroflexes fall in between. Since the Abkhaz alveopalatal looks somewhat like the Polish palatalized retroflex, the Polish alveopalatal represents a more extreme palatalization. These relations are summarized in Table 1. It might be possible to vary the feature values used to represent the palatalization so as to distinguish these two Polish types, for example, whether both Back and High are used.

It is not clear that palato-alveolars are ever palatalized. Reported cases, as in Slavic, instead seem to involve retroflexes.

4. FEATURES PROPOSED FOR CORONALS

Coronal segments have as their active articulator the tongue blade and therefore can be specified with a positive value for the Coronal feature.[4] To distinguish the various coronal places of articulation, further features are needed. Though the issue is not addressed here, these features must also be capable of expressing the natural class relations among coronals. We consider first some of the standard SPE features (for further related discussion, see Keating, 1988b) and then some others.

4.1. Anterior

The feature Anterior describes the place of articulation, not the active articulator. It divides coronals into more-front and more-back categories, determined by their place of articulation along, for example, the roof of the mouth. The operational definition provided in *SPE* is that alveolars are [+anterior] while palato-alveolars are [−anterior]. The phonetic basis of this division has scarcely been discussed in the literature and has not received a precise articulatory description. It is often described in terms of the alveolar ridge: [−anterior] segments are formed behind the alveolar ridge, or, more exactly, behind the corner of the alveolar ridge. Alveolars are said to be articulated in front of this point and palato-alveolars behind it (e.g., Ladefoged, 1989:48). For speakers with prominent alveolar ridges this would be a clear articulatory distinction and thus a clear boundary between the values of Anterior.

However, examination of X-ray data shows that this characterization is incorrect. Both values of Anterior can be found in front of the corner. Alveolars are articulated on the frontmost part of the ridge. Palato-alveolars are generally articulated at about the corner, either centered there or extending into the part of the ridge in front of the corner (see Ladefoged and Maddieson, 1986:65–67). Some English readers can feel this for themselves by saying *chop*—the stop component of the affricate is not made behind the corner but instead at a point just behind where the /t/ in *top* is made. Both palato-alveolars and retroflexes can be made at or just in front of the corner of the alveolar ridge, so that they are only minimally different in place from alveolars. Thus, palato-alveolars look like alveolars, but with the whole tongue moved back and up just a little; retroflexes can also look like alveolars, but with the blade curled back just a little more. (Sublaminal retroflexes can also be made well behind the corner, of course.) Thus, the true dividing point between the values of the feature Anterior appears to be the midpoint of the part of the alveolar ridge between the upper teeth and the corner. This point is summarized in Figure 1.

Considered only in terms of millimeters of difference between constriction locations, the difference between [+anterior] and [−anterior] can be incredibly subtle. However, the corner of the alveolar ridge provides a more definitive landmark to which the tongue may orient itself for the [−anterior] articulations.

4.2. Distributed

[illegible] used a description of length of the consonant constriction (i.e., a manner property) to represent differences in place of articulation. In *SPE* Chomsky and Halle proposed that this feature subsumes the traditional apical–laminal distinction, with apical articulations having shorter ([−distributed]) constrictions and laminal articulations having longer ([+distributed]) ones. (Sometimes the name apical–laminal is used instead of Distributed, e.g., Clements, 1989.) Chomsky and Halle make clear that there is no intended a priori correspondance between the values of Distributed and place of articulation, for example, both dentals and alveolars can be distributed or nondistributed,

and it is left to the low-level phonetic rules in a language to specify the exact place of articulation of any coronal segment. It is even possible that in some particular case a laminal articulation might be shorter than an apical one (e.g., if a speaker with a very sharp corner of the alveolar ridge made a laminal palato-alveolar, but an apical retroflex with sublaminal contact). In this case, the usual correspondance between Distributed and apical–laminal would be reversed.

In general, dentals and alveolars do differ in other ways besides their place, and apicality is one of the differences observed. With stops, as Ladefoged (1989) discusses, dentals are more likely to be laminal, and alveolars to be apical, and thus Distributed can usually be used to distinguish these places.[5] Ladefoged and Maddieson (1986) report only one case of anterior coronals contrasting in place but not in apicality or any other feature, namely, apical fricatives in certain Amerindian languages. Dart (1988, forthcoming) studied the dental–alveolar stop contrast in Papago, where both places are said to be apical. However, all of the speakers who made any contrast used at least moderately different articulators: Either the only difference was in apicality, or apicality varied along with place (the dentals were tip-down laminals or tip-up apicolaminals). Furthermore, the "alveolar" stops were usually actually postalveolar, so that only the dentals are in fact [+anterior]. That is, the Papago case turns out to support Chomsky and Halle's claim that place alone never distinguishes anterior coronals.

The same result holds of another case presented by Ladefoged and Maddieson. They note that the two apical laterals of Albanian differ not only in place but also in tongue-body backness. However, it appears from their figure that they would also differ in their values for Anterior, as happened in Papago.

In general, the use of the tip versus the blade is often not consistent enough to rely on as the basis of phonological distinctions. It is important to note that while this is a highly salient aspect of coronal articulations, it is largely a matter of speaker choice, not definition of sound types. Dentals, alveolars, and palato-alveolars can be made either apically or laminally, and retroflexes can be made either apically or sublaminally. Dart (1988, forthcoming) shows that French and English, languages without a contrast in apicality, permit great speaker variability in dental or alveolar stops and fricatives. Neither the place nor the api-

points out, an apical versus a laminal articulation will have acoustic effects within the "same" place of articulation category. In particular, the size of any sublingual cavity will vary with the position of the tongue blade, and this in turn will affect the resonance frequencies of obstruent noise.

In its original form, where Distributed describes constriction length quite generally, it is equally well used for other constriction types. Chomsky and Halle employ it to distinguish alveopalatals from other places of articulation in Polish. Alveopalatals have the tongue front raised up behind the blade and so may have

longer constrictions than otherwise similar laminal coronals. Since Chomsky and Halle considered alveopalatals to be [+anterior], they used Distributed to distinguish them from the dentals.[6] With alveopalatals as [−anterior], Distributed would instead distinguish them from the Polish retroflexes.

It is useful to ask how much the coronal articulations actually differ in constriction length, that is, whether the phonetic definition of Distributed in its SPE usage is supported empirically. Chomsky and Halle, after all, rely on very little data in this regard. I therefore measured the length of contacts or constrictions from tracings of a wide set of coronals. To allow comparison across speakers, these were compared with velars where possible. Alveopalatals and especially palatals usually have quite long constrictions, longer than those of velars. Retroflex stops have constrictions about as long as those of velars—longer than expected, given their usual classification as [−distributed]. Beyond this, no clear differences emerge. Though laminal constrictions are longer than the shortest apical constrictions, apicals can also be long. Palato-alveolars can sometimes have among the shortest constrictions, in speakers with sharply defined alveolar ridges. Thus, there appears to be little available physiological support for this phonetic definition of Distributed. This finding supports limiting the feature Distributed (by this or some other name) to the apical–laminal distinction.

4.3. Sublingual Cavity

Stevens and colleagues (Perkell, Boyce, and Stevens, 1979) have called attention to the importance of the presence of a cavity under the tongue blade during the articulation of palato-alveolars, because of its lowering effect on acoustic resonances. The same is true for retroflexes. At first glance, then, the sublingual cavity would seem to be a correlate of [−anterior] segments. However, some [−anterior] coronals lack it. In particular, the absence of a sublingual cavity is a consistent and key characteristic of palatals. Also, Ladefoged and Maddieson (1986) discuss a rare sibilant fricative in Abkhaz, described by Catford, which is palato-alveolar but has the tip down and no sublingual cavity ("hissing-hushing"). The [−anterior] coronals can be arranged in order of increasing size of sub-

palato-alveolar, the apical retroflex to the sublaminal retroflex. Halle and Stevens (1989) discuss the acoustic consequences of such a sublingual cavity in Polish retroflex and alveopalatal fricatives. They estimate the resonance of the cavity at 3,200–3,500 Hz.

Halle (1988) proposes a new tongue feature, Lower Incisors Contact, to encode this property, with this contact implying no sublingual cavity. Halle thus distinguishes alveopalatal from dental–alveolar (all as [+anterior]) and palatal from palato-alveolar (all as [−anterior]). We have already noted that phonetically

alveopalatals are in fact |−anterior|. Thus Lower Incisors Contact plays no contrastive role among the true |+anterior| places (dental and alveolar). Furthermore, most X-rays of Polish alveopalatals show at least a small sublingual cavity, implying no contact between tongue and teeth (see Figure 5). In most alveopalatals, the tongue tip points at, but does not touch, the lower teeth. If anything, then, the presence of Lower Incisors Contact distinguishes most alveopalatals from palatals, taking both as |−anterior| and |+distributed|.

Halle's name for this sublingual cavity feature, Lower Incisors Contact, suggests a correspondance with another traditional phonetic descriptive dimension for coronals, referred to earlier as tip up versus tip down. When there is Lower Incisors Contact, clearly the tip is down. (However, for interdentals, the tip rests on the lower teeth, blocking off any sublingual cavity; yet it might be considered "up.") In contrast, to guarantee a cavity large enough to affect the acoustic output substantially, the tip is best raised above the lower teeth; this is what is observed for most palato-alveolars and retroflexes. In these two cases, then, Lower Incisors Contact correlates well with tip position. The only question is whether there are cases where the tip is down but does not make lower incisors contact. We have suggested that this is the case with some palato-alveolars: They are reported as tip down but nonetheless have a sublingual cavity. Therefore, the feature Lower Incisors Contact, or sublingual cavity, is not exactly equivalent to tip up or down, unless by tip "up" we mean any position above the base of the lower teeth.

Ladefoged and Maddieson (1986) instead equate tip position with apical–laminal: Tip up is apical, while tip down is laminal. However, a similar discrepancy is met here. Tip position does correlate with apicality if the tip is down, for then the articulation must be laminal. But the reverse is not necessarily true. The tip may be raised only to the level of the upper teeth, and so be "up," while the constriction is formed laminally on the palate. Palato-alveolars are an example of this. (The flat retroflexes described as laminal by Ladefoged and Maddieson, 1986, would also be examples, but it was suggested above that these are in fact apical.) Therefore, apical or laminal is not exactly equivalent to tip up or down, unless by tip "down" we mean any position below the base of the upper teeth. In sum, then, none of these descriptive parameters—sublingual cavity, apicality, tip position—quite covaries.

4.4. Tongue Shape Features

Ladefoged and Maddieson (1986) offer additional descriptive parameters for coronals, which provide phonetic detail that is redundant rather than contrastive in nature. One of these is constriction width (from side to side); a narrow constriction, as found for [s] sounds, involves grooving the tongue blade. Another

parameter is pitting of the tongue behind the grooved constriction, again found for [s] sounds. That is, as Ladefoged and Maddieson point out, the grooving and pitting of the tongue in the formation of [s] sounds are important components of their articulation; feature descriptions in terms of Anterior and Distributed (or Laminal) alone do not give a complete phonetic description. The redundant detail is necessary to say exactly how the [s] sound is to be made. I would suggest that these parameters might be related to the feature Strident (or Sibilant): Particular blade and body configurations, appropriate to the given place of articulation, are needed to produce the right kind of airstream jet for stridency. Thus, instead of being features, they are phonetic parameters that are marshaled to help effect (or enhance) a phonological feature value such as [+strident].

Ladefoged and Maddieson also use a new feature, flat versus domed tongue shape, to distinguish retroflex from palato-alveolar fricatives. Both are "post-alveolar" in place, and both are laminal by Ladefoged and Maddieson's account. The problem with using this phonetic parameter as a phonological feature is that the retroflex stops that correspond to the fricatives are domed, not flat, and thus the stops are grouped with the wrong set of fricatives. Instead, as I suggested above, the retroflex fricatives should be considered apical, like the corresponding stops.

Tongue shape features can also enter into the description of palatals. In Keating (1988a) I proposed that palatals are complex segments involving both coronal and tongue-body articulations, with values for the tongue-body features equivalent to palatalization. This complex representation makes the structure of palatals parallel to that of labial-velars, which also combine two major articulations. It also represents the direct articulatory relation between palatals and front vowels. However, another option in the representation of palatals is to treat them as simple coronals, and to introduce at least one additional feature to distinguish them from the other [−anterior] coronals. This in effect is what Halle (1988) does with his new feature Lower Incisors Contact. Actually, both options should be exercised for more complete descriptive coverage. We have already seen that alveopalatals as well as palatals might be viewed as palatalized, or complex, segments with a high-front vowel component. As discussed above, phonetically speaking both are [−anterior] and [+distributed], so some further feature is needed to distinguish them. Halle's sublingual cavity feature could be used in this way, with the palatals as [+lower incisors contact], and the alveopalatals as [−lower incisors contact]. However, it must be noted that in the end, phonological evidence is needed to support the natural classes entailed by such proposals about features.

By using tongue-body features, the proposal here is that palatals, and probably alveopalatals, are treated as palatalized segments. We might ask, palatalized versions of what? We already discussed the palatalization relation between alveopalatals and retroflexes. Palatals, by their feature values, would correspond to the

Abkhaz hissing-hushing category. Both are [−anterior] and have the tongue tip behind the lower teeth with no sublingual cavity. The tongue lowering seen in the hissing-hushing fricative is replaced with extreme tongue fronting and raising in palatals.

5. DISCUSSION

The main points of this article can be summarized by showing how the features discussed above characterize the coronal phonetic categories. Several ambiguities or inadequacies have been found.

Linguolabials and interdentals are both anterior. It was proposed that they differ in tip orientation, with linguolabials apical and tip up, and interdentals laminal and probably tip down.

Dentals and alveolars are also both anterior. When not in contrast with each other, they vary rather freely in apicality and tip position–sublingual cavity. When in contrast, they may be distinguished by apicality, stridency, or a secondary articulation.

Three types of retroflexes were discussed, all [−anterior] and all tip up with a sublingual cavity. The sublaminal retroflexes, attested most clearly for stops, would count as laminal (or [+distributed]) in most feature systems. The other two types of retroflexes are apical, occurring with either domed or flat tongue shapes. This distinction (which is never contrastive) poses a problem for current systems of phonetic description. A possible alternative description would use tongue-body features such as Back.

Palato-alveolars are [−anterior] but vary in tip position and apicality. Most commonly, they are tip up but laminal. It seems likely that all apical palato-alveolars are at the same time also laminal (i.e., apicolaminal), but none having the tip down to the point of lower incisors contact. The laminality distinguishes palato-alveolars from retroflexes.

A secondary articulation of palatalization was invoked to describe the palatals [illegible] differ (though not always reliably) in tip position and presence of a sublingual cavity. The phonetic distinction here is problematic because of variability in the available data.

It can be seen that feature systems must be developed further to account for all of the possible coronal places of articulation. The problems of representation presented here, however, only serve to underline the great variety of coronals encountered in languages.

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NOTES

[1]Maddieson (1984) does not use the term or category "coronal." The observations here are based on his findings but are couched in other terms. It should be noted that labial and velar categories are also almost universal (see Maddieson, 1984:31–32, with Wichita, Hupa, and Aleut in this sample lacking bilabial stops, and Hupa and Kirghiz lacking velar stops).

[2]Maddieson describes the same data differently because he classifies palatals and palato-alveolars as tongue-body articulations. However, both of these are now standardly considered coronal by phonologists.

[3]Contrasts between retroflexes and palato-alveolars are rare.

[4]In *SPE* this meant a [+coronal] feature value; in more recent feature hierarchies, it means the presence of a Coronal articulator node.

[5]Surprisingly, Chomsky and Halle (1968:314) describe dentals as most usually [−distributed], but I believe this is not common usage.

[6]Thus Distributed can be seen to be a relative property in *SPE:* When dentals form a phonological contrast with alveolars, they might be [+distributed], but when they contrast with alveopalatals, they are [−distributed].

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CORONALS AND THE PHONOTACTICS OF NONADJACENT CONSONANTS IN ENGLISH

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1. INTRODUCTION

Much recent work on underspecification has focused on the status of coronal consonants. One question this work addresses is whether or not coronal consonants lack the Place Node. (I assume here a theory of feature geometry like that proposed in Sagey, 1986, in which the Place Node dominates the articulator nodes Labial, Coronal, and Dorsal.) The conclusions reached about the status of coronals are quite varied. Some researchers such as Paradis and Prunet (1989a,b) have concluded that ([+anterior]) coronal consonants are different from labials and dorsals in that as a principle of grammar they lack the Place Node. Other researchers, such as Avery and Rice (1989), contend that whether or not coronal consonants in a language lack the Place Node depends on the phonemic inventory of that language, while still other researchers such as Clements (1988) and Mester and Ito (1989) give no special status to coronals with respect to underspecification.

The major reason why these researchers have reached different conclusions is that they have used competing criteria in determining what is underspecified in underlying representation. For example, Avery and Rice (1989) assume that phonemic inventories (and not phonological rules) are relevant for determining what is underspecified. Thus, in their view, the Coronal Node is present in the underlying representation of any two phonemes (in an inventory) that differ only in a

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