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SEMITIC GUTTURALS AND DISTINCTIVE FEATURE THEORY*

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1. Introduction

An adequate theory of phonological distinctive features must meet two criteria: (a) it must be able to describe all the distinctions made by the sound systems of any of the world's languages; and (b) it must be able to characterize the so-called natural classes of sounds in all languages. (A natural class is a set of sounds that are recurrently treated as a group by different phonological rules.) In practice, the second criterion for the adequacy of a distinctive feature theory is a good deal more important — you can always make more distinctions by adding more features, but you generally cannot add nonredundant features to define more natural classes.

The Semitic languages are well-known for the diversity of sounds produced with a primary constriction in the posterior regions of the vocal tract. Traditional grammars refer to these sounds as 'gutturals'. Standard Arabic and most colloquials have retained the full set of gutturals reconstructed for proto-Semitic: laryngeal *ʔ* and *h*; pharyngeal *ħ* and *ʕ*; and uvular *χ* and *ʁ*. Other Semitic languages, as well as some languages in the larger Afro-Asiatic family and a few other unrelated languages, have similar or smaller inventories of gutturals.

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The synchronic and historical phonology of the various Semitic languages provides a wide range of evidence that the gutturals are treated as a class by phonological rules. This classification of the gutturals can be shown through independent developments in the various languages at different historical periods and in different areas of the phonology. It follows from this observation that the gutturals must constitute a natural class within any adequate distinctive feature theory.

Within phonological theory, the dominant view of distinctive features is the *SPE* feature system, originally developed by Chomsky & Halle (1968). The *SPE* system defines the features in articulatory terms — essentially, the kinds of properties one might observe on an x-ray. Much phonological research of the last two decades has been devoted to further developing the *SPE* feature system. Most recently, the result of this work is an ARTICULATOR-BASED theory of distinctive features, where each speech sound is characterized by the active articulator (like the lower lip or the tongue blade) producing it. The most comprehensive account of articulator-based feature theory appears in Sagey (1986).

By detailed examination of the acoustic and articulatory properties of the Semitic gutturals, I will show that they do not constitute a natural class within an articulator-based theory of distinctive features. Instead, I propose a feature theory based on the traditional means of classifying consonants, point of articulation. Specifically, I will argue that the natural class of gutturals is defined by their place of articulation, [pharyngeal]. The [pharyngeal] consonants are produced with a primary constriction anywhere in the entire region that encompasses the larynx through the oropharynx. I will then go on to relate this idea to a proposal by Perkell (1980) that distinctive features are OROSENSORY TARGETS, and I will suggest that the difference between [pharyngeal] and other place-of-articulation features lies in the varying distribution of sensory feedback mechanisms throughout the vocal tract. Ultimately, the proposal I am making is not unlike the earliest classification of these sounds by the Arab grammarian Sibawaihi. In his terms, the gutturals are all "throat

consonants", produced at "the back of the throat" (laryngeals), "the middle of the throat" (pharyngeals), and "the part of the throat nearest the tongue" (uvulars). It is also quite similar to Hayward & Hayward's (1989) independent argument for a feature [guttural], developed on the basis of Cushitic evidence.

The scope of this article is necessarily quite restricted. Only the gutturals, and not the closely related issue of the emphatic consonants, are treated. Furthermore, the place of the feature [pharyngeal] within an overall model of phonological representation is scarcely touched on, nor is the status of [pharyngeal] outside Semitic or Afro-Asiatic. Indeed, in this discussion many of the relevant phonological rules are inadequately formalized. These problems are treated in a complementary study, McCarthy (1989).

2. The Phonological Classification of Gutturals

Our first task is to examine the evidence that the gutturals are a natural class. To that end, I will present some of the many phonological phenomena that treat the gutturals together as a set (silently disregarding irrelevant complications). In most cases, we know that these phonological rules were developed independently by the languages exhibiting them, showing that the natural classhood of the gutturals is universal rather than inherited from proto-Semitic.

2.1 *Root Consonant Co-occurrence Restrictions on Gutturals*

Since the time of the medieval grammarians, it has been known that certain combinations of consonants in the same root are avoided, although this problem was not investigated systematically until Greenberg (1950). Since then, other studies (McCarthy 1985; Mrayati 1987) have looked at the question with different lexical material.

Greenberg notes that there is a very strong tendency to avoid roots containing two gutturals. In the Wehr (1971) dictionary, which contains a total of 2703 triliteral roots, we find that roots containing two gutturals are indeed rare. See (1) for the frequencies. (The tables are organized in column-row order. Thus, the value 3 in column ʔ,

row χ of (1a) means that there are three roots containing adjacent ʔ and χ in that order.)

(1) FREQUENCY OF ROOTS CONTAINING TWO GUTTURALS

a. Gutturals in Adjacent Positions

C_1/C_2	ʔ	h	ʕ	ħ	ʁ	χ
ʔ	0	0	0	0	0	0
h	2	0	2	0	0	0
ʕ	0	0	0	0	0	2
ħ	2	0	0	0	0	0
ʁ	0	0	0	0	0	0
χ	3	0	0	0	0	0

b. Gutturals in Nonadjacent Positions

C_1/C_2	ʔ	h	ʕ	ħ	ʁ	χ
ʔ	0	6	1	4	0	5
h	3	0	2	0	0	0
ʕ	0	7	0	0	0	8
ħ	0	0	0	0	0	0
ʁ	0	0	0	0	0	0
χ	1	0	0	0	0	0

I have deviated in one respect from the obvious: I assume that adjacent identical root consonants are actually single consonants at the appropriate level of representation. This analysis, which bears particularly on the so-called geminate roots, is justified in McCarthy (1981, 1986).

These two matrices are obviously quite sparse, with 25/30 empty cells in the adjacent case (disregarding the diagonal) and 27/36 in the nonadjacent one. In other words, with very few exceptions, roots containing two gutturals are prohibited in Arabic. The other two types of roots in Arabic, quadriliterals and biliterals, respect the same generalization. No quadriliteral roots — many of which are neologisms — contain more than one guttural, and only a single onomatopoeic biliteral root (*hʔ*, always reduplicated in *haʔhaʔ* "to laugh") violates the generalization. Combining all the evidence, then, we see that there is a robust resistance to nearly all combinations of two gutturals in an Arabic root.

The analysis of this phenomenon in McCarthy (1985) goes along the following lines, due originally to Itô & Mester (1986).[1] The generalization "roots cannot contain two gutturals" follows from the conjunction of a universal principle and a language-particular rule:

(2) a. *Obligatory Contour Principle* (OCP) (Leben 1973; Goldsmith 1976)

Adjacent identical elements are prohibited.

b. *Anti-Spreading Rule*

$$\begin{array}{c} *[\text{pharyngeal}] \\ \wedge \\ \alpha \quad \beta \end{array}$$

In this case, the OCP says that no root can contain more than one instance of the feature [pharyngeal], under the assumption that all instances of [pharyngeal] within a root are adjacent on some autosegmental tier, whether the root consonants α and β are adjacent or not. The Anti-Spreading Rule says that [pharyngeal] cannot spread, in the sense that a single instance of the feature [pharyngeal] cannot mark a distinction in more than one segment. Together, these conditions enforce an absolute prohibition on roots containing two gutturals.

Tiberian Hebrew (with four gutturals, because of the merger of the uvulars and pharyngeals) is subject to the same constraint. In this case, the data include all triliteral roots (verbs and nouns) occurring in the Bible (1057 total). The results are reported in (3):

[1] Also see Mester (1986) and Yip (1989) for discussion of similar cases in other languages.

(3) a. Gutturals in Adjacent Positions

C_1/C_2	ʔ	h	ʕ	ħ
ʔ	0	2	0	3
h	0	0	0	0
ʕ	0	0	0	0
ħ	0	0	0	0

b. Gutturals in Nonadjacent Positions

C_1/C_2	ʔ	h	ʕ	ħ
ʔ	0	1	0	3
h	0	0	0	0
ʕ	0	0	0	0
ħ	7	0	0	0

The major point of the Arabic and Hebrew data on root co-occurrence is that there is a restriction on the distribution of guttural consonants in roots — with few exceptions, no root can contain more than one guttural. I have analyzed this phenomenon by enforcing the OCP and the Anti-Spreading Rule on the feature [pharyngeal], which characterizes the set of gutturals. The proof that a single place of articulation feature must characterize the set of gutturals comes from looking at similar restrictions on co-occurrence that are enforced at other points of articulation. For example, the frequencies of co-occurrence of labial consonants in Arabic (in the Wehr (1971) dictionary) and Hebrew triliteral roots are reported in (4):

(4) a. Adjacent plus Nonadjacent Labials — Arabic

C_1/C_2	f	b	m
f	0	0	9
b	1	1	9
m	0	0	0

b. Adjacent and Nonadjacent Labials — Hebrew

C_1/C_2	p	b	m
p	0	0	4
b	0	0	4
m	0	0	0

The existence of a place feature [labial] is uncontroversial. By parity of reasoning, the essentially identical phenomenon in gutturals also requires a distinctive feature characterizing that set of consonants.

2.2 *Vowel Lowering in Guttural Context*

In Form 1 of the Arabic verb, there is an alternation between perfective and imperfective aspect in the quality of the last vowel of the stem: *katab* "wrote", *ktub* "writes". Usually, roots occur in one of five Ablaut classes according to which vowels they have in this position in the two aspects. The following chart gives an indication of the frequency of the four types, based on all Form 1 verbs (including doublets) occurring in Wehr (1971):

(5)

Ablaut Class	Example		Frequency
a/u	katab/ktub	"write"	1029
a/i	ḍarab/ḍrib	"beat"	842
i/a	šarib/šrab	"drink"	518
a/a	faʕal/fʕal	"do"	436
u/u	balud/blud	"be stupid"	191

Membership in the *u/u* class is semantically determined; all *u/u* verbs are statives. The *i/a* class is often intransitive or stative, but not invariably so. Membership in classes *a/u* or *a/i* is entirely unpredictable.

Membership in the *a/a* Ablaut class, though, is phonologically conditioned (Brame 1970). Of the 436 *a/a* verbs, 411 contain a guttural consonant in second or third position — that is, they have a guttural adjacent to the ablauting vowel. For example, we find *a/a* verbs like *faʕal/yafaʕal* "do" with the guttural preceding the ablauting vowel and *a/a* verbs like *radaʕ/yardaʕ* "nurse" with the guttural following the ablauting vowel.

The *a/a* class is derived from both *a/u* and *a/i* — that is, the vowel of the imperfective is lowered under adjacency to a guttural. The evidence for this is that the *a/u* or *a/i* Ablaut patterns never occur with guttural roots. (The only major exception to this regularity is roots containing both a guttural and a high glide.) The central regularity is that a root like */fʕl/*, with a guttural in medial (or final position), ablauts to imperfective */fʕil/* or */fʕul/*. The high vowel of the imperfective stem is then lowered to *a* under adjacency to the guttural. The generalization about the gutturals can be informally recorded by the following mirror-image rule, which specifies adjacency (%) between the affected vowel and the guttural:

(6) [+high] → [+low] % __ [pharyngeal]

This rule is additionally subject to morphological conditioning. It affects only the vowels of the *a/i* and *a/u* Ablaut classes. It does not affect the *u/u* class (73/191 of which are guttural roots), nor the *-i* perfective of the perfective passive, nor any other vowels in the language.

Tiberian Hebrew has a much more transparently phonological version of the process in (6). In Hebrew, comparison of guttural and plain roots in identical morphological patterns shows fairly systematic use of low vowels in guttural environments:

(7)	Plain Root		Guttural Root		
	mélex (/malk/)	"king"	báhaṭ	(/bahṭ/)	"costly stone"
			báʕal	(/baʕl/)	"master"
			béṭaḥ	(/baṭḥ/)	"name of city"
			bélaʕ	(/balʕ/)	"swallowing"

Discussions of this phenomenon and proposed analyses appear in Prince (1975:39, 98) and Malone (1984:60, 69, 93).

The background is that the underlying representation of *mélex* is /malk/, on the evidence of its initial stress and the 'missing vowel' in related forms like *malkī* "my king". The surface form is derived by two processes, raising of *a* to *e* and epenthesis of *e* into the final consonant cluster. Let us follow Malone's account of this. Stress is assigned to yield /málk/, epenthesis breaks up the final consonant cluster with *e* to form /málek/, and then a rule of assimilation raises stressed *a* to *e* when in an open syllable and followed by another *e* (informally, *á* → *e* / __ C*e*).

Malone's conclusion, which appears unavoidable, is that two distinct phonological rules involved in deriving the forms on the right in (7) make reference to the guttural category. Epenthesis itself inserts *e* only as a default; when a guttural precedes the insertion site, then the inserted vowel is *a*. Another rule lowers *e* to *a* before a tautosyllabic guttural. The rules are stated informally in (8a); derivations follow in (8b):

(8) a. Epenthesis

$$\emptyset \rightarrow \begin{bmatrix}\text{-high}\\ \text{-back}\\ \langle\text{+low}\rangle\end{bmatrix} \;/\; \underset{\langle\text{phar}\rangle}{\text{C}}\ \_\_\text{C\#}$$

Preguttural Lowering

$$\text{V} \rightarrow \text{a} \;/\; \_\_[\text{pharyngeal}]]_{\sigma}$$

b.			
Underlying	malk	baʕl	balʕ
Stress	málk	báʕl	bálʕ
Epenthesis	málek	báʕal	báleʕ
Raising *á* → *e*	mélek	DNA	béleʕ
Preguttural Lowering	DNA	DNA	bélaʕ

There is some independent motivation for the Preguttural Lowering rule. Preguttural Lowering is a fairly general process that applies to long and short vowels alike and that affects all vowel qualities. Long vowels lower their second mora before a guttural, as in (9):

(9)	Underlying	Surface
	mooħ	moaħ
	nooh	noah
	ruuħ	ruaħ
	šuuʕ	šuaʕ
	ṭiiħ	ṭiaħ
	sameeħ	sameaħ

The final case we will examine where a guttural induces a low vowel is provided by the analysis of Bani-Hassan Arabic, a Jordanian Bedouin dialect, in Irshied & Kenstowicz (1984:119). In this dialect, there is a fairly general process raising *a* to *i* in an open syllable; the rule is blocked when the affected vowel is adjacent to a guttural. See (10) for examples:

(10) Nonguttural Roots	Guttural Roots	
balas/blisat "he/she denounced"	saħab/sħabat	"he/she pulled"
	daʕam/dʕamat	"he/she supported"
	balaʕ/blaʕat	"he/she swallowed"
	dibaʁ/dbaʁat	"he/she dyed"

All forms are underlyingly C*a*C*a*C, the second of each pair also having the 3FS verbal suffix *-at*. The loss of the first *a* is due to a rule that is common to all Bedouin dialects; the alternation of interest is in the second *a*.

These three examples are all historically independent developments. They show that the gutturals are treated as a natural class in conditioning rules of vowel lowering.

2.3 *Epenthesis in Guttural Context*

Tiberian Hebrew has a phonological rule which, under certain conditions, inserts a vowel after a syllable-final guttural. Compare in

(11) the treatment of plain and guttural roots under identical morphological conditions:

(11) Plain Roots	Guttural Roots
yiktōb	yaħašob
	yaʕamōd
	yahapōk
	yeʔehab
qodšō	poʕolō

Discussions of this process can be found in Malone (1984:94), Prince (1975:95), McCarthy (1979), and Rappaport (1984). The basic observation is that syllable-final gutturals are made syllable-initial by inserting after them a copy of the preceding vowel. Only gutturals in unstressed syllables are so affected; in stressed syllables they remain unchanged: *šāmáʕ* "he heard", *šāláħtī* "I sent".

An informal statement of this epenthesis rule, leaving aside the harmonizing quality of the inserted vowel, appears in (12):

(12) Postguttural Epenthesis

$$\emptyset \rightarrow V \;/\; \underset{[-\text{str}]}{V}\ \ [\text{pharyngeal}]\ \_\_]_{\sigma}$$

Essentially the same process has been noted in various Bedouin Arabic dialects, where it goes by the name "the *gahwa* syndrome" (Abboud 1979, Irshied & Kenstowicz 1984, Johnstone 1967, Mitchell 1960). A recent, quite complete analysis of this phenomenon appears in Al-Mozainy (1981).

Al-Mozainy's Bedouin Hijazi Arabic dialect has retained all six of the Classical Arabic gutturals, and they all participate in a remarkable alternation. Again, compare the behavior of plain and guttural roots under identical morphological conditions:

(13)	Plain Root		Guttural Roots	
	sawda	"black"	bʁaθa	"gray"
			dhama	"dark red"
	ʔistaslam	"he surrendered"	ʔistʕazal	"he got in a hurry"
			ʔistʁafar	"he asked forgiveness"
	maktuub	"written"	mχaṣuur	"neglected"
			mʕazuum	"invited"
			mħazuum	"tied"
			mʕaðuur	"excused"
	yašrab	"he drinks"	yχadim	"he serves"
			yħakim	"he governs"

There are minor differences from the Hebrew situation. In BHA, the vowel preceding the guttural is always *a* (although I have seen no direct evidence for imposing this condition) and there is no limitation to unstressed syllables. There is also one major difference: on the surface, the BHA rule looks like metathesis rather than insertion.

This apparent difference between Hebrew and BHA is explained by the fact that BHA phonology also has the general Bedouin Arabic rule deleting *a* in an open syllable when followed by *a* in an open syllable, formulated in 14:

(14) *a* Deletion

$$a \rightarrow \emptyset \,/\, \_\_]_\sigma\,[\mathrm{Ca}]_\sigma$$

The derivation of a form like *yχadim*, then proceeds as in (15):

(15)		
	Underlying	/yaχdim/
	Post-guttural Epenthesis	yaχadim
	a Deletion	yχadim

Again, the Hebrew and Bedouin Arabic rules represent independent historical developments that treat gutturals as a class for a type of phonological rule.

2.4 *Cross-guttural Vowel Assimilation*

The Hebrew data above in 11 show that the vowel epenthesized after a syllable-final guttural normally harmonizes totally to the preceding vowel. A similar transparency effect is met with in several rules of Geʻez (Classical Ethiopic).

Geʻez retained all of the proto-Semitic gutturals except for ʁ, which merged with ʕ. Geʻez phonology includes two important processes of vowel assimilation that apply across all gutturals but no other consonants. These processes are indifferent to whether the guttural is geminate or simplex (clusters of different gutturals are generally impossible because of the action of root co-occurrence restrictions). The data in (16) contrast the vowel pattern of a nonguttural root with the result of applying vowel assimilation across a guttural:[2]

(16)		Nonguttural Root	Guttural Root
	a.	ṭabib	lɨhiq
		yɨnabbɨr	yɨlɨʔʔɨk
			yɨbɨʕʕɨl
			yɨlɨhhɨq
			yɨsɨħħɨt
			yɨʔɨχχɨz
	b.	yɨnabbɨr	yaʔammɨn
			yaʕaqqɨb
			yaħannɨṣ
			yaχabbɨr

[2] I am making certain assumptions about the Geʻez vowel system that are not self-evident. In brief, I assume the following correspondence between Lambdin's (1978) transliteration and the actual vowel phonemes:

(i) a. Transliteration			b. Phonemicization		
i	e	u	ii	ɨ	uu
ē		o	ee		oo
	a/ā			a/aa	

In other words, I am positing a system with five long vowels and only two short ones, opposed in height. Evidence of this comes from closed syllable-shortening phenomena like /kibuur+t/ → *kibirt* or /lihiiq+t/ → *lihiqt*.

The process exemplified in (16a) raises the short vowel *a* to its high counterpart *i* when followed by a high vowel across a guttural. The process in (16b) lowers the short vowel *i* to *a* when followed by *a* across a guttural. In general, then, what we have here is a single rule of regressive assimilation of the feature [high]. It applies transparently across gutturals but no other consonants. It is formulated in (17):

(17) V → [αhigh] / __ [pharyngeal] [αhigh]

This process, then, must single out the gutturals as a natural class in the context.

2.5 *Guttural Degemination*

In Tiberian Hebrew, geminate gutturals are prohibited without exception. (This is also true of Tigre (Raz 1983) and the modern pronunciation tradition for Ge‘ez.) This simple observation, however it is formulated, obviously requires that gutturals constitute a natural class. Discussions of this phenomenon appear in Prince (1975:219f.), Malone (1978, 1984:79), and Lowenstamm & Kaye (1986).

Comparison of plain and guttural roots reveals a large number of circumstances where the lack of geminate gutturals is apparent:

(18)	Plain Root	Guttural Roots
	dibbeer	meeʔeen
		biʕeer
	/yinteen/ → yitteen	/yinħat/ → yeeħat
		/ninħam/ → niħam
	dalliim	raaʕiim
		laχiim

Although the prohibition on geminate gutturals is exceptionless, the data show that lengthening of the vowel in compensation for deletion of the guttural is subject to lexical (and grammatical) variation.[3]

[3]Another issue in Hebrew guttural degemination is the absence of geminate *r*. I consider various explanations for this phenomenon in McCarthy (1989).

2.6 *Historical Mergers of Gutturals*

There is little doubt that the set of gutturals in proto-Semitic was identical to the set of gutturals in Classical Arabic: *ʔ, h, ʕ ,ħ, ʁ, χ*.[4] The South Arabian languages and Ugaritic (neither of which are especially closely related to Arabic) have also retained the original guttural system. Yet many of the daughter languages do not exhibit the full array of six gutturals. What we observe when we examine the historical changes involved is that the mergers are almost always within the guttural set. Although sound changes need not stay within a single articulatory class, if we find a consistent pattern of merger then this is clearly evidence in support of such a class. (In other words, we can argue in favor of a natural class on the basis of sound change, but we cannot argue against one on the same basis.) (19) summarizes the historical neutralizations within the class of gutturals:

(19)		
	ʁ → ʕ	Hebrew, Aramaic, Maltese
	χ → ħ	Hebrew, Aramaic, Maltese
	ħ → h	Chad Arabic, Socotri
	ʕ → ʔ	Chad, Yemenite & Anatolian Arabic, Socotri

If historical mergers are predisposed to remain within the same articulatory class, then this too is evidence in support of the feature [pharyngeal].[5]

3. The Articulatory and Acoustic Properties of Gutturals

So far, we have amassed a considerable amount of evidence that the gutturals are a natural class. We now shift gears from phonological evidence for the unity of gutturals to a description of their phonetic properties. I will refer throughout to the gutturals in Arabic because Arabic has the full set of six gutturals and because

[4]But see Ružička (1954), who (unconvincingly) disputes the proto-Semitic origin of ʁ.

[5]Moira Yip has pointed out to me that historical mergers in Chinese typically change place of articulation. One might conjecture that this is a different phenomenon, since the Chinese mergers are contextual (they are syllable-final neutralization), but the Semitic mergers are context-free.

there is a comprehensive literature on the articulatory and acoustic phonetics of Arabic gutturals. I know of no reason to think that the phonetics of the corresponding sounds in other Semitic languages differs from Arabic in any significant way.

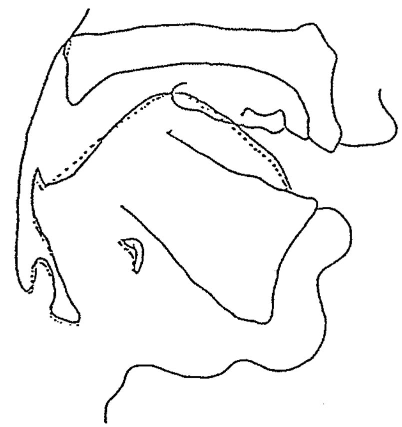
There are no articulatory data known to me that specifically deal with the production of the laryngeals *ʔ* and *h* in Arabic. Al-Ani (1970) reports that he made cineradiograms of the Arabic laryngeals but was unable to interpret them usefully. Acoustically, the laryngeals are characterized by a complete lack of formant transitions or other effects on adjacent vowels (Klatt & Stevens 1969).

Interpreting the acoustic evidence in articulatory terms, we would have to say that *ʔ* and *h*, although they involve an obvious laryngeal gesture, do not have any other constriction except for the usual coarticulatory effect of the vocalic context. In particular, there could be no pharyngeal or uvular constriction accompanying the glottal gesture. Even raising of the larynx during production of the consonant (an effect seen conspicuously with the pharyngeals) would produce a falling transition of the second formant in a following vowel as the larynx returned to its normal position.

Therefore the entire burden of producing the laryngeal consonants falls on the larynx. It may seem that this point is being belabored, but it is an important aspect of the main argument here.

Ghazeli (1977) describes in some detail the results of a cineradiographic investigation of the pharyngeals *ʕ* and *ħ*, and he includes tracings of the point of maximal constriction in one token of each (reproduced in (20)). The subject (Ghazeli) is a speaker of Tunisian Arabic, and he produces words of that dialect in his experiment. Delattre (1971) did a similar study of a Lebanese Arabic speaker, and his results do not appear to differ significantly from Ghazeli's.

(20)



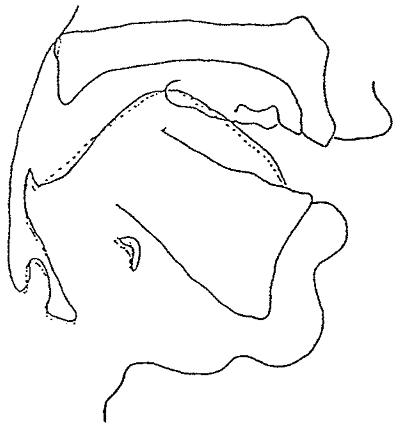
Vocal tract shape of *ʕ* (broken line) and *ħ* (solid line) in context #____*ææli*.
(From Ghazeli 1977:40.)

The main gesture in the production of the pharyngeals is an approximation of the posterior wall of the laryngopharynx and the tongue root from the epiglottis down to the pharynx. Both the posterior wall of the laryngopharynx and the tongue root are moved from their rest positions. Evidently as a mechanical consequence of these moves, the larynx itself and adjoining structures are raised considerably.

The pharyngeals have been well studied on the acoustic side, including contributions by Al-Ani (1970), Ghazeli (1977), Klatt & Stevens (1971), and Butcher & Ahmad (1987). Butcher & Ahmad present particularly detailed information about the formant transitions and effects on adjoining vowels. At the consonant/vowel boundary of *ʕ*, F_2 is relatively low, in the 1200-1400Hz range. F_1 is high — 900-1000Hz. *ħ* is roughly the same, although F_1 is not quite as high. The major effect of the pharyngeals on the steady-state portions of the adjoining vowels is significant raising of F_1 — about 100Hz relative to a neutral (glottal) environment.

Finally, we turn to the uvulars *ʁ* and *χ*. Delattre (1971) and Ghazeli (1977) presents x-ray tracings of these consonants (again similar to those in Delattre (1971)), reproduced in (21):

(21)



Vocal tract shape of ʁ (broken line) and χ (solid line) in context #__*aali*.
(From Ghazeli 1977:57)

The uvulars are produced with a much higher and slightly narrower constriction than the pharyngeals. To obtain this constriction, the dorsum of the tongue is bunched and retracted toward the posterior wall of the oropharynx. The dorsum is also raised.

Acoustically, χ is characterized by fricative noise at a very low frequency, below 1200Hz. ʁ shows formants at 500-600Hz and 1200-1300Hz — in other words, F_1 is not as high as in the pharyngeals, but F_2 is as low. The somewhat lower F_1 of the uvulars compared to the pharyngeals is consistent with the fact that they are produced quite close to the midpoint of the vocal tract. Indeed, El-Halees (1985) reports the results of a perceptual experiment which revealed that F_1 is a major cue for identifying the uvular/pharyngeal distinction within the gutturals.

Let us now sum up. On the articulatory side, the gutturals are produced by three entirely distinct gestures: a purely glottal one in the case of the laryngeals; retraction of the tongue root and epiglottis and advancement of the posterior wall of the laryngopharynx in the case of the pharyngeals; and a superior-posterior movement of the tongue dorsum in the case of the uvulars. On the acoustic side, the gutturals do share a relatively high F_1, since all are produced in the posterior

regions of the vocal tract. (This is even true of the laryngeals *ʔ* and *h*, which lack distinctive resonance properties, since F_1 is normally quite low in consonants.) We must reconcile these observations with the demonstrated phonological unity of this set of consonants.

4. Gutturals Within Distinctive Feature Theory

The basic condition for a satisfactory theory of phonological features is that it simply be capable of making all the distinctions observed in the languages of the world. Although probably no feature theory meets this requirement strictly, most generally perform quite satisfactorily in this respect. More importantly, however, the success of a theory of phonological features rests on its characterization of the natural classes observed in phonological rules. We have seen that gutturals are persistently treated as a natural class by independent phonological innovations in the various Semitic languages. Thus, any adequate feature theory must provide a single, coherent characterization of the set of guttural consonants.

The inadequacy of the feature theory in *The Sound Pattern of English* with respect to gutturals is not obvious, although it has been previously noted by Kenstowicz & Kisseberth (1979:250) and Keating (1988:7-8). The chart in (22) gives the values of the relevant features for the gutturals and for other places of articulation found in Semitic according to Chomsky & Halle (1968:307):

(22)

	anterior	coronal	high	low	back
labial	+	-	-	-	-
alveolar	+	+	-	-	-
palato-alveolar	-	+	+	-	-
velar	-	-	+	-	+
uvular	-	-	-	-	+
pharyngeal	-	-	-	+	+
laryngeal	-	-	-	+	-

From (22) it looks like the gutturals really can be singled out by featural specifications: they are [-anterior, -high]. Within that set, the features [low] and [back] distinguish the uvulars, pharyngeals, and laryngeals from one another.

The real problem is not with this chart, which gives the desired classification, but with the fact that the chart is inconsistent with the definitions of the features in *SPE* and the phonetic properties of the gutturals described above. [high], [low], and [back] refer to movements of the tongue body from its theoretical 'neutral position' (at about the location of the vowel in English *bed*). Uvulars are characterized by [-high], but we have seen that the Arabic uvulars actually raise the tongue body. Pharyngeals are [+low, +back], but the distinctive gesture in pharyngeals is with the tongue root, the epiglottis, and the posterior pharyngeal wall, not the tongue body. In fact, the tongue body is front with the Arabic pharyngeals, as we can see by the adjacent front allophone of the low vowel: compare pharyngeal *ħææl* with uvular *χaal*. Finally, the tongue body cannot be implicated in the production of the laryngeals at all; thus, the [+low] value is without support. There are further, technical problems with a feature specification like [-anterior, -high] that I will not go into here.

Recent phonological research on distinctive features (Halle 1988; Sagey 1986; McCarthy 1988) has developed a model that places very rigid restrictions on reference to 'place of articulation' in consonant systems. In this theory, the major classification of speech sounds is made on the basis of the active articulator that produces them. The fruit of this work is a set of three features that refer to the active articulator. [labial] sounds are produced by raising or protruding the lower lip (and possibly the upper one as well). Thus, the [labial] sounds include true labials, labiodentals, and, as a secondary articulation, lip-rounding. [coronal] sounds are produced by raising the tongue tip or blade. The [coronal] sounds are the dentals, alveolars, palato-alveolars, retroflexes, and, as a secondary articulation, apicalization. Finally, the [dorsal] sounds, made by moving the tongue body from its neutral position, include the vowels, the palatals, velars, and perhaps uvulars, and, as a secondary articulation, velarization.

There is an obvious (and somewhat trivial) sense in which this particular instantiation of articulator-based feature theory is unable to account for the gutturals. The [dorsal] articulator will only characterize the uvulars, since of all the gutturals only the uvulars are produced by the tongue body; the pharyngeals require a new articulator feature ([tongue root], perhaps); and the laryngeals involve gestures of the larynx that are not described by articulator features at all. But even if we add [tongue root] and some new feature [laryngeal] to the set of articulator features, the model fails to account for the fact that gutturals are a natural class. Since gutturals are produced by three entirely distinct active articulators, a natural class of gutturals is incompatible with the fundamental assumption of articulator-based feature theory.

The commitment to classifying consonants in terms of major articulator is clearly in error, at least as far as the gutturals are concerned. Because the gutturals are produced by three different articulators acting independently, they would require three different articulator features, basically giving up any hope of explaining why the gutturals are a natural class. We must therefore reject articulator-based features, at least as the overriding organizational principle, and look elsewhere for an explanation for this behavior.

5. The Alternative: Place theory

Since the gutturals do not share a single major articulator, the natural question is what they do have in common. All gutturals are produced by a constriction in the same region of the vocal tract. 'Region' here must be broadly defined, to encompass the area from the larynx inclusively to the oropharynx. Three different articulators have access to that region — the larynx, the tongue root and epiglottis, and the tongue body. The defining characteristic of the gutturals is not the major articulator, but the place of articulation.

There must, then, be at least one feature that characterizes speech sounds in terms of place of articulation rather than major articulator. I have called this feature [pharyngeal], and I define it to include the inclusive region from the oropharynx to the larynx.

The notion 'place of articulation' has usually been applied in an atomizing way, so that the distinction between, say, labials and labiodentals is no different from the distinction between labiodentals and dentals. But nothing inhibits us from drawing on the basic insight of articulator-based theory that there are just three places of articulation — [labial], [coronal], and [dorsal] — to which we add a fourth, [pharyngeal]. By calling [labial] a place rather than an articulator, we have only changed the basis of its definition, rather than the results. [labial] can now be defined by the set of places {labial, labiodental}, or even as the set of places accessible to the lower lip as articulator. Similar redefinitions can be made for [coronal] and [dorsal]. (These features should perhaps be renamed as well, but there is little sense in adding to the terminology.)

There remains a major asymmetry in this account. The three features [labial], [coronal], and [dorsal] divide up a region of the vocal tract approximately equal in length to the region subtended by the single feature [pharyngeal]. In other words, finer distinctions of place are made in the front of the vocal tract than in the back.

The explanation for this asymmetry comes from an examination of the relation between phonological features and speech production. Most theories of phonological distinctive features make some claim to a more or less close relationship with speech production. An important aspect of the articulator-based approach is that each feature can be thought of as "driving" the corresponding active articulator (Halle 1983).

This does not exhaust the options for the feature/production relation. In particular, Perkell (1980) has proposed that distinctive features are

> *orosensory* patterns corresponding to distinctive sound producing states. These 'orosensory' patterns consist of proprioceptive, tactile and more complicated air-pressure and airflow information from the entire vocal tract. As examples, the orosensory goals for the features 'high' and 'back' might consist of specific patterns of contact of the sides of the tongue body with the teeth and the pharyngeal wall. The orosensory goal for the feature 'coronal' might be contact of the sides of the tongue blade with the teeth or alveolar ridge... (Perkell 1980:338).

The vocal tract can report its state through feedback mechanisms like touch or proprioception. Distinctive features are defined as particular patterns of feedback from the vocal tract with consistent acoustic consequences.

The proposed feature [pharyngeal], then, would be defined as the orosensory pattern of constriction anywhere in the broad region of the pharynx. The corresponding "distinctive sound producing state" of [pharyngeal] is high F_1, a property that the gutturals share (but which also serves to differentiate among them).

If features are defined as orosensory goals rather than articulatory instructions, we expect that differences in the acuity of orosensation at different points in the vocal tract will be reflected in the phonological organization imposed on those regions. In particular, the large [pharyngeal] region should be rather poorly differentiated compared to the smaller [labial], [coronal], and [dorsal] regions.

There are three sources of evidence for differences in sensory acuity in the vocal tract, all of which do indeed support the model proposed here, where the wide [pharyngeal] region is treated as equivalent to the narrower [labial], [coronal], and [dorsal] regions.

First, the actual distribution of sensory neurons in the vocal tract corresponds quite well to our expectations. In a comprehensive survey of the histological literature, Grossman (1964:132) concludes that:

> This review of the reported oral sensory nerve elements reveals a progressive decrease in the frequency of sensory endings from the front to the rear of the mouth in humans...These findings are compatible with the author's initial experimental evidence which indicates that tactile discriminations are most acute in the anterior mucosal surfaces of the mouth. It is probably not coincidental that many important speech articulatory phenomena occur in the same oral region.

Second, direct measurements of sensory acuity can be obtained from experiments determining the minimal distance for two-point discrimination, in which subjects are asked to report whether they feel two points rather than one from a caliper-like device. Ringel (1970) performed such an experiment on four regions of the vocal tract at the midline and right and left sides. The results (means of 25 subjects, in millimeters, followed by standard deviations) are as follows:

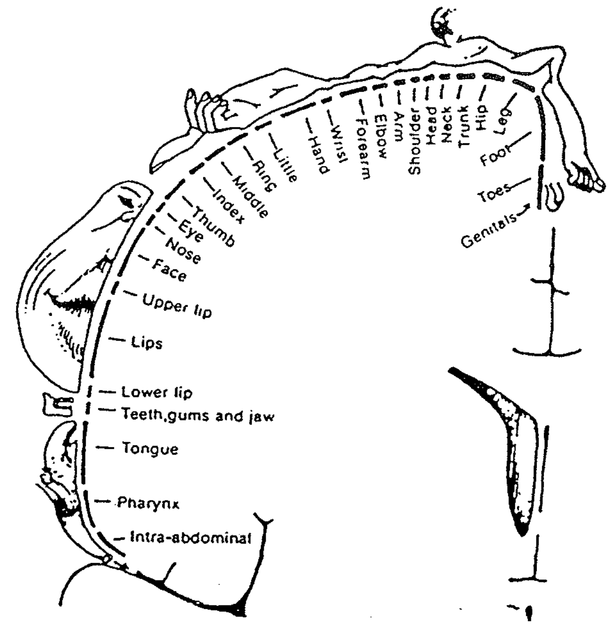
(23)

	Left	Middle	Right
Upper Lip	2.47 (.84)	2.31 (.72)	2.49 (.69)
Tongue Tip	1.82 (.41)	1.70 (.46)	1.72 (.47)
Alveolar Ridge	3.21 (1.39)	2.66 (1.09)	3.20 (1.29)
Soft Palate	2.95 (1.17)	2.64 (1.10)	3.06 (1.26)

Unfortunately, there are no measurements of two-point discrimination for the tongue-body or the pharynx. (The apparatus is rather large and would probably excite the faucal gagging reflex in these cases.) Certainly, what we do see is differences in sensory acuity among different regions of the vocal tract. Furthermore, the tongue tip, an articulator that corresponds directly to a phonological feature, is unusually sensitive.

The most interesting evidence of the relative lack of pharyngeal sensory differentiation comes from the observation that the size of the cortical projection of a body part corresponds to its sensory acuity. The following diagram scales the body according to its cortical projection, obtained by low-voltage stimulation of the cortex in conscious patients undergoing brain surgery:

(24)



The sensory homunculus (Penfield & Rasmussen 1950)

The regions noted in the diagram do not correspond precisely to the areas of interest to us: the lower lip, the tongue blade and tip, the tongue body, and the pharynx. Nevertheless, it is clear that the whole pharynx is about half the size, sensorily speaking, of the tongue, which includes two articulators. Perhaps too we can find a similar equivalence in the case of the lower lip.

6. Conclusion

I have argued first that the guttural consonants of Semitic constitute a natural class. A review of the relevant articulatory and acoustic properties of the gutturals shows that they cannot be characterized as a natural class in any major theory of distinctive features. Furthermore, I have shown that the failure of these theories is not a superficial one; it stems from fundamental assumptions about the nature of distinctive feature definitions. Instead, I have argued for a new feature, [pharyngeal], which characterizes a broad region of place of articulation. And I have claimed that this feature makes sense in the context of a theory that defines features as orosensory targets, given known differences in sensory feedback from different regions of the vocal tract.

McCarthy (1989), a longer study, deals with many related issues: how are the gutturals distinguished from one another; what is the relation between gutturals and emphatics; what is the status of gutturals in language families beside Semitic; how does [pharyngeal] fit in with current phonological work on 'feature geometry'?

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