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Typology and Universals of Vowel Systems

JOHN CROTHERS

ABSTRACT

Following previous typologies I divide vowel systems into subsystems based primarily on length and nasalization, and take the number and arrangement of vowel qualities in the short oral vowel system of a language as the main classificatory parameter. For a given number of such vowels, the types of arrangements found in the languages examined were subject to severe restrictions which can be expressed in a series of universal rules. These rules, in turn, can be largely explained by a modified version of Liljencrants and Lindblom's model of dispersion of vowels in the vowel space.

CONTENTS

1. Introduction[1]

This paper presents a new typology of vowel systems based on an areally and genetically representative sample of languages developed by the Stanford Phonology Archiving Project. The representative nature of the sample makes it possible to determine with more confidence than before which types of system are more natural and which are marginal or deviant, and to set up a number of universal or near universal rules about such systems. The rules go beyond earlier proposed universals about vowel systems (Trubetzkoy, Jacobson, Hockett, Chomsky and Halle, Sedlak) in a number of respects. Further, a detailed comparison between the typology (and universals) arrived at empirically and the theoretical typology generated by Liljencrants and Lindblom's model of dispersion of vowels in the vowel space shows that with some revisions the model predicts most universals of vowel quality systems. I consider this to be evidence in favor of a 'functional' approach to language universals.

1.1 The sample

This study is made possible by the materials collected by the Stanford Phonology Archiving Project, of which I am a member. At the time of writing the Archive contained phonetic-phonemic descriptions of 209 languages, the vowel systems of which I took as the basis of my typology.[2] The sample is areally and genetically balanced to the extent permitted by available descriptions of languages and current understanding of genetic relationships. The data on each language is drawn from one or more published descriptions. All symbols are translated into a standard set (see Appendix I for the full set of vowel symbols used). The principles of the phonemic analysis are briefly discussed in Sec. 1.4. In general the analysis of the vowel system of a language presented in this paper corresponds to the analysis in the Phonology Archive. However, in reviewing the material I have made some changes in the phonemic analyses in cases where I felt a change would bring the analyses more into line with the principles stated in Sec. 1.4. This generally involved elimination of marginal phonemes. In most cases the source grammar for each language in the Archive has been read by at least two

[1] I am very grateful to Alan Bell, Lynn Friedman and John Ohala for their comments on an earlier draft of this paper. I would also like to acknowledge the help of all the members of the Stanford Phonology Archiving Project in gathering and organizing the data on which this paper is based.

[2] See Vihman 1976 for a detailed description.

people on the staff, the second checking the analysis for consistency. I have also checked many details in preparing this paper. Doubtless, mistakes of fact and interpretation remain; still, the sample offers a large body of data that has been subjected to a fairly careful and consistent analysis.

1. 2 Vowel quality

Vowels can be defined as syllabic sounds produced without closure in the middle of the oral tract (Fant 1973:176ff). The quality of vowels with normal voicing is determined by the supraglottal resonators, and can be classified acoustically in terms of their resonant frequencies. Oral vowels, produced with closed velum, are often classified according to the center frequency of the first two resonances (formants; F_1 for first formant, F_2 for second formant, etc.). The third formant is probably of some significance for high front vowels, and also for vowels of opposite rounding and backness and the 'r-colored' vowels. One approach (Liljencrants and Lindblom 1972, Fant 1973: 186ff) is to classify vowels by F_1 and a weighted average of F_2 and F_3. Nasal vowels differ from oral vowels (in theory at least) by the addition of nasal formants, by a broadening of the bandwidth of all formants, by a reduction of their amplitude, and by an upward shift of the first oral formant. (See Ohala 1975: 294, also Wright 1975, calling the last point into question.)

It appears that there is only a partial correlation between the positions of the articulating organs and the acoustic quality of a vowel (Lehiste 1973). According to Lindblom and Sundberg, who constructed a detailed model of vowel production, the shape of the oral resonating cavity is controlled by the position of the lips, the height of the jaw, the amount of constriction of the tongue and the point at which it occurs (palatal, velar, pharyngeal), and the height of the larynx. They make the following correlations between articulators and the vowel formants. 1) Tongue constriction in the palatal or velar region gives a relatively lower F_1, while pharyngeal constriction produces a high F_1. 2) Palatal vowels have a relatively high F_2; velar vowels have a low F_2, and pharyngeal vowels fall in between. 3) Retraction of the tongue constriction raises F_1 somewhat and lowers F_2 considerably. 4) Opening the jaw raises F_1; it also lowers F_2 for a palatal vowel and raises it for a velar vowel. The traditional articulatory parameters 'open' and 'close' can be interpreted as referring to the jaw opening normally (but not necessarily) used in the production of a particular vowel. 5) Increased tongue constriction raises F_2 for a palatal vowel, decreases F_2 for a velar vowel or a pharyngeal one. 6) Lip rounding lowers all

formants, primarily F_3 for palatal vowels, F_2 for velar vowels. 7) Lowering of the larynx lowers all formants. Correlations 1-6 are illustrated in the following diagrams; Fig. 1 representing an outline of the acoustic space, Figs. 2-4 the main articulatory parameters.

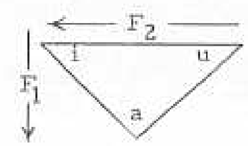


Figure 1. acoustic space

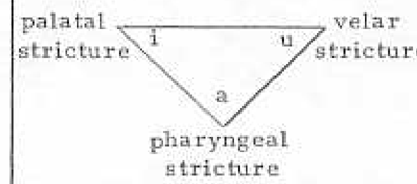


Figure 2. position of stricture

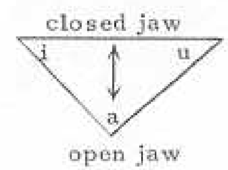


Figure 3. jaw position

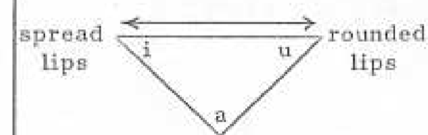


Figure 4. lip position

Descriptive linguists generally use articulatory parameters, the position of the lips and the tongue, to identify vowel quality. Since tongue position is not observable without special equipment, its specification is just a conventional label, not necessarily accurate, which linguists associate with a particular sound and the kinesthetic experience of producing that sound. The easiest way to bring outdated linguistic terminology into line with modern phonetics is to interpret the articulatory descriptions as specifying acoustic qualities. In the process of translation, however, certain articulatory labels, such as lip rounding or central tongue position, lose the independence they appear to have if interpreted literally. The vowel [a], frequently referred to as central, is so only in acoustic terms (F_2 neither high nor low). Articulatorily, the traditional term is wrong, since there is considerable retraction of the tongue, making [a] actually further 'back' than [u] in articulation. The acoustic reinterpretation of the terminology actually saves it from an error. Lip rounding, although articulatorily independent of tongue position, acoustically only modifies qualities determined by tongue position. Palatal vowels are generally unrounded because this leads to a higher F_2 and F_3, which are high for palatal vowels; velar vowels are generally rounded because this causes a lower F_2, which is already low for them. In other words, rounding reinforces the 'backness' of the velar vowels, and unrounding (spreading) reinforces the 'frontness' of the palatal vowels (cf. Fant 1973: 186ff). Rounded palatal vowels and unrounded velar vowels fall acoustically between 'front' and 'back.' It appears that rounded palatal vowels are closer to the unrounded palatals, and unrounded velar vowels closer to the rounded velars in the acoustic space. To this extent the traditional terminology 'front rounded' and 'back unrounded' can be taken as valid acoustically, but it must be remembered that both types are acoustically centralized with respect to their maximally 'front' and 'back' counterparts, and that rounding is not an independent perceptual dimension which can be separated from the front-back dimension.

The effects of an expanded pharynx, produced by lowering of the larynx and advancement of the tongue root, can also be described in terms of the first two formants, although the acoustic and articulatory facts are still not entirely clear. Lindau's in-depth study of several African languages with vowel harmony shows that for several KWA languages pharyngeal expansion (also called 'tongue root advancement,' e.g. by Stewart) is the feature distinguishing the two harmonic sets of vowels, and that the set with expanded pharynx are acoustically considerably higher (lower F_1) than the other set. (Due apparently to concomitant adjustments of the front and body of the tongue, there is no corresponding lowering of F_2.) It is not yet known whether vowels produced with expanded pharynx exhibit anything like the 'singing formant,' ('covered voice') which is also due to pharyngeal expansion (Sundberg). Lindau also found that in two NILOTIC languages with vowel harmony superficially quite similar to that found in West Africa, pharyngeal expansion did not play a role.

A traditional vowel chart, such as the IPA, can be roughly interpreted as an acoustic chart, with the articulatory terms read as acoustic ones. Thus 'high' means 'low F_1,' 'front unrounded' means 'high F_2,' etc. as shown in Fig. 5.

In determining the vowel systems of the sample languages I interpreted vowel tenseness in two different ways. When associated with a difference between long and short vowels, I subsumed it under the length feature. For example, languages which distinguish between long /i·/ and short /I/ (e.g. GERMAN, ENGLISH) have been interpreted as having a primary length distinction rather than a distinction

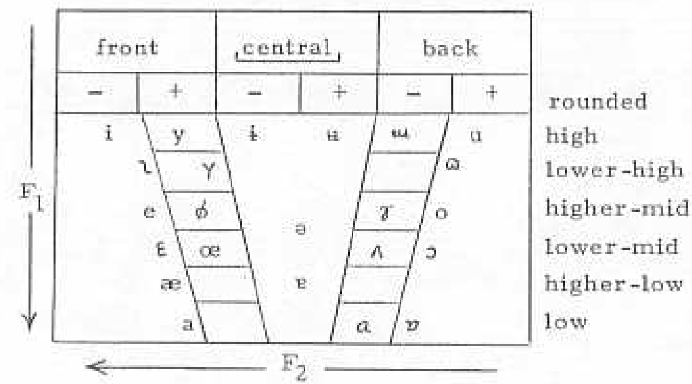


Figure 5

between two vowel qualities. On the other hand, in a language like PANJABI (Gill and Gleason 1963) there is said to be no appreciable length distinction between /i/ and /I/, so the difference is interpreted as one of vowel quality. Acoustically, lax vowels are more central than their tense counterparts. (See American ENGLISH formant data in Peterson and Barney 1952. /I/ and /U/ are both lower and more central than /i/ and /u/, in addition to being shorter, in ENGLISH.) In general one is probably justified in interpreting lax vowels as central with respect to tense counterparts. However, in the descriptive literature [I] and [U] are frequently treated as being simply lower than [i] and [u]. In the few cases in the language sample where this raised questions about the relative position of phonemically distinct vowels of the same length, I have treated /I/ and /U/ as being both lower and more central than /i/ and /u/.

I have not included retroflex ('r-colored') vowels in the present survey. The relevant acoustic parameter is lowering of F_3 and F_4 (see Lindau 1975: 21), which involves another dimension of vowel quality. Since retroflexion of vowels is not common as an independent, contrastive feature, its omission does not greatly affect the typological picture.

1.3 Types of vowel systems

The general basis for the typology of vowel systems laid down by Trubetzkoy and Hockett seems to me to be valid. In particular, different subsystems of vowels can be separated from each other on the basis of features other than the shape of the oral resonator, giving three separate subsystems: normal length oral vowels, long oral vowels (or, in a few cases, overly short vowels), and nasal vowels. Long nasal vowels may of course be found in languages with both long oral vowels and nasal vowels, but their inclusion does not seem to add much to a typological survey. Differences in voice quality may also occur, e.g. normal versus creaky or breathy voice, but when this does occur, it can often be interpreted in conjunction with the consonantal or tonal system of a language. VIETNAMESE, for example, has both creaky and breathy voice in addition to normal voicing, but both are associated with specific tonal configurations. There are a few cases of languages with vowel subsystems differing in voice quality, but they are too rare to be of typological importance. The basic vowel quality system of a language is the arrangement of qualities of normal length oral vowels. Languages may have anywhere from three to about twelve distinct vowel qualities in the basic system. The arrangement is determined to a large extent simply by the number of vowels; for a given number of vowel qualities, only one or two arrangements occur with any frequency in the world's languages. This makes it a natural basis for vowel system typology. (See Sedlak 1969, Liljencrants and Lindblom 1972. Also, Jakobson (1968) and Chomsky and Halle (1968) use number of vowels at least as a basis for discussion.)

For the purpose of further distinctions I have found it most useful to distinguish between 'peripheral' and 'interior' vowels, the former including the extreme palatal (front unrounded), the extreme velar (back rounded), and the low vowels, the latter including all acoustically more 'central' vowels, i.e. back unrounded, front rounded, and non-low central or centralized vowels. See Fig. 6.

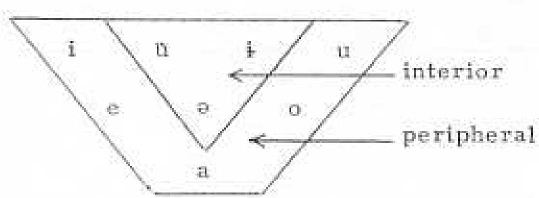


Figure 6

The number of interior vowels supplies a second typological parameter. Types of vowel systems can be identified by a pair of numbers, x:y, where 'x' is the total number of vowels and 'y' the number of interior vowels. The standard five vowel system /i e a u o/, having no interior vowels, is 5:0; the four vowel systems /i e a u/ and

/i ɨ a u/ are symbolized 4:0 and 4:1 respectively. This is sufficient to characterize all of the relatively common systems and a number of less common ones as well. Further refinements, where needed, are based on the arrangement of the peripheral or interior vowels. First, on the basis of the most common systems (e.g. 5:0), certain arrangements of peripheral vowels can be established as normal. Other arrangements, differing from these in having a gap at any position, are termed 'defective.' This is symbolized by an asterisk preceding the number of vowels in the system (*x:y). If two different defective systems are found with the same number x:y, a single asterisk is used for one, a double asterisk for the other. Thus *5:1 and **5:1 represent two different five vowel systems, each with one interior vowel, but with different gaps in the peripheral system. Since such systems are not common, there seems to be little point in incorporating into the notation the precise nature of the gap. Several differences of arrangement are found in languages with two or more interior vowels. The commonest type is a vertical arrangement, as in FRENCH, GERMAN and VIETNAMESE, with /ü ö ɜ/, /ü ö/, and /ɨ ə/ respectively, which is left unmarked in the notation: 11:3, 7:2, and 10:2 respectively for these languages. If there is a distinction between front rounded and back unrounded, as in TURKISH, with /ü ö ɨ/, this is noted by an apostrophe after the second number, x:y' (for TURKISH 8:3'). A double apostrophe indicates systems with centralized /IU/ in contrast with /i u/, as in PANJABI, 10:3". The notation is summarized in Fig. 7.

number of vowels in basic system
number of interior vowels
defective peripheral system ——— $\boxed{**}$ x : y $\boxed{''}$
{ * first type
** second type }
interior vowel system
{ vertical arrangement unmarked
' front rounded versus back unrounded
" centralized /IU/ versus peripheral /i u/ }

Figure 7

The systems of Trubetzkoy and Hockett for classifying vowel quality systems, based on the number of height and backness distinctions, are needlessly complex for typological purposes, since these parameters are roughly determined by the total number of vowels in a system. Trubetzkoy's distinction between linear, triangular, and quadrangular systems does not seem to be especially useful. Linear systems either do not exist at all, or if they do, are subject to a variety of problems of interpretation (see discussion of two vowel systems below, Sec. 2.4). The distinction between triangular and quadrangular systems is based simply on whether there is one (triangular) or two (quadrangular) low vowels. Actually, due to the shape of the vowel space, all systems are roughly triangular in phonetic terms, and the overwhelming majority are triangular by Trubetzkoy's criterion.

1.4 Phonemic analysis

The vowel system of each language in the sample is analyzed along the lines of classical phonemic method. This is not the place for a general discussion of the pros and cons of phonemic analysis. The following remarks are offered only as a general guide to my interpretation of the phoneme, and its relevance to typology. The basic principle of phonemics is contrast: two sounds are in contrast if they can occur in the same environment and are not generally in free variation. This principle, modified to allow for partial overlap of phonemes, is probably sufficient in the majority of cases to decide whether the difference between two sounds is phonemic or not. But as various critics of the phoneme have pointed out (see Chomsky 1964), this principle, if rigorously applied, may in some cases lead to the establishment of more phonemes than linguists would generally like. Criticisms of this type can be largely met, in my opinion, by adding to phonemic theory a distinction between marginal and full phonemes, the former including all phonemes with a severe distributional restriction in terms of phonological environment, or morphological or lexical function. Marginal phonemes may include phonemes in unassimilated loans, phonemes that occur in limited contexts as the result of morphophonemic fusion, sounds that generally have non-contrastive distribution but, due to a sound change or some special morphological pattern (e.g. reduplication), occur contrastively in a limited environment. In short, I think one should recognize that phonological systems, being always in a state of change, may at any time contain sound differences that are neither fully phonemic nor fully non-phonemic. I have tried to restrict the vowel systems here to the more fully phonemic vowels. In all likelihood the results would not be very different if more marginally phonemic vowels were included.

One difference between the approach used here and some other approaches to phonemic analysis is that here primary emphasis is placed on the phonetic manifestation of phonemes. Each phoneme

is characterized by a phonetic unit, its major realization (primary member). For example, if the only high front vowel in a language is phonetically [I], the phoneme is called /I/, not /i/. The rationale for this is simply that if one is interested in what sorts of phonetic means languages employ to make distinctions, it is important not to normalize the data prematurely, and thus build preconceived ideas into the results. Of course, for typological purposes considerable normalization is necessary, but I have done this at the last minute, as it were, in the assignment of particular phonemic systems to a general type. For example, all of the three vowel systems in the sample are grouped into a single type: /i a u/. The phonetic manifestations vary considerably, particularly in the case of /u/. (All these manifestations are listed in Appendix III.) However, the decision to treat the different phonetic units, [u U ɯ o], as being typologically /u/ was only made at the point when I was considering all of the three vowel systems, to determine how many basically different patterns of arrangement they exhibited. In the phoneme inventories of each language, the high back vowel is characterized phonetically.

Another point on which my type of analysis may differ from that of others is the phonemic status of neutral vowels, that is vowels (most often [ə]) which are phonetically different from the other phonemes of a language, but do not contrast with them, the neutral vowels being restricted to unstressed position. I have tried to exclude such vowels from the phoneme inventories, although it is not always easy to determine from phonological descriptions whether a symbol /ə/ represents an independent phoneme or a neutral vowel.

There are both practical and theoretical reasons for basing phonological typology on the classical phoneme, thus interpreted. On the practical level, the majority of modern language descriptions have a phonemic basis. On the theoretical level, phonemic analysis answers a basic phonological question: what phonetic features are employed distinctively in a language? The abstract systematic phonemes of generative phonology do not provide an answer to this question since they do not express phonetic features in a direct way. For example, there is no way to tell from Chomsky and Halle's systematic vowel phonemes of ENGLISH what phonetic properties are actually used to distinguish one vowel phoneme from another. Indeed, it is not possible to tell, without detailed comparison of the effects of all the complex rules on all of the vowels, which of the systematic vowel phonemes contrast with each other at the surface level.

2. Survey of Vowel Systems by Type

2.1 General

The types of basic vowel quality systems found in the sample are indicated in Table 1. (See Appendix III for a full listing of languages by type, including phonetic specification of each vowel.) Table 2 gives the approximate vowel qualities found in the more common systems. The number of vowels in the basic system of the sample languages ranges from three to twelve. The more common types, in descending order of frequency, are 5:0, 6:1, 3:0, 4:0 plus 4:1, 7:2, 7:0, 9:2 and 6:0. (See Fig. 8. The reason for grouping 4:0 and 4:1 together is explained in Sec. 2.3.) These types account for over 80% of the sample languages, and no other type represents more than 3% of the total; all these others can be regarded as marginal types, essentially deformations of the more common types. The predominance of type 5:0 is well known. A further fact which can be observed in earlier surveys (e.g. Sedlak), though it does not seem to have been commented on, is that the more frequent types cluster around the 5:0 system (Figs. 8 and 9). Well over 80% of the sample languages have from three to seven vowels, and the only relatively common system outside this range is 9:2. The 5:0 system thus represents an optimum system in a special sense, as the high point in the frequency distribution of types. It can be taken as a single, very rough norm or archetype for language in general.

Table 1. Basic vowel system types

Type	No. of languages	Type	No. of languages	Type	No. of languages
?2:0	1	6:0	7	9:2	7
3:0	23	*6:0	1	9:2''	3
4:0	13	**6:0	1	*9:2	1
4:1	9	6:1	29	9:3'	4
5:0	55	*6:2'	2	10:2	2
*5:0	1	7:0	11	10:3'	1
*5:1	5	*7:1	3	10:3''	1
**5:1	1	7:2	14	?10:3''	1
***5:1	1	8:1	2	11:3	1
*5:2	1	?8:1	2	?12:3	1
		8:2	2		
		8:3'	3		

?indicates considerable uncertainty about the analysis.

Table 2. Common vowel system types

3:0	i a u
4:0	i ɛ a u
4:1	i ɨ a u
5:0	i ɛ a u ɔ
*5:1	i ɛ ɨ a o
6:0	i e ɛ u o ɔ
6:1	i ɛ ɨ a u ɔ
7:0	i e ɛ a u o ɔ
7:2	i e ɨ ə a u o
9:2	i e ɛ ɨ ə a u o ɔ

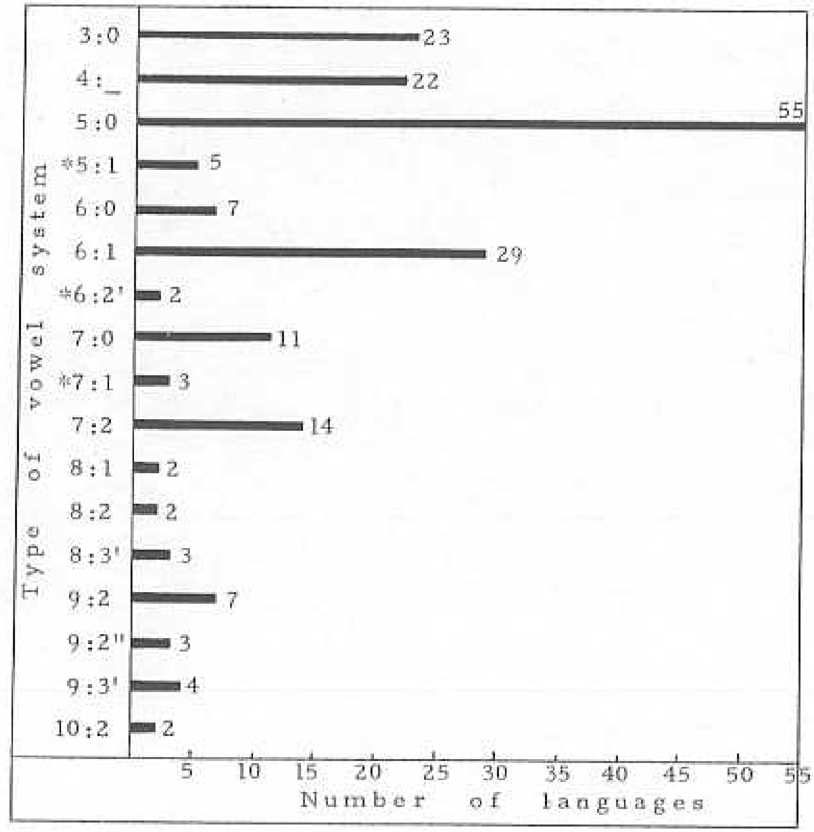


Figure 8. Frequency of vowel system types
(Types represented by only one language are omitted. Types 4:0 and 4:1 are grouped together as 4:_.)

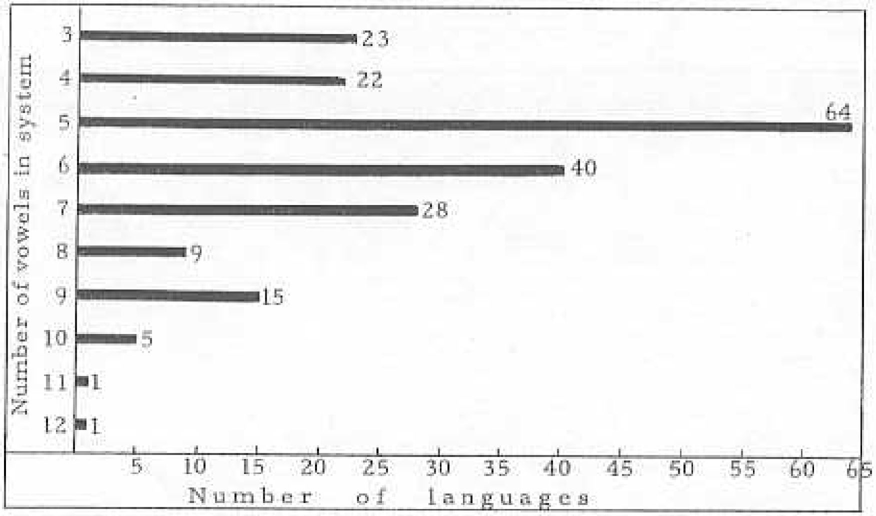


Figure 9. Frequency by size of vowel system

2.2 Peripheral vowels

The number of peripheral vowels ranges from three to eight in the sample languages (one questionable case of nine). For a given number of peripheral vowels there is only one common type of arrangement. There are 17 languages which I consider defective types, one of the common types with a vowel missing at some point (generally /e/, /u/ or /o/, never /i/). The general reason for this kind of patterning seems to be that the vowel space has 'corners,' namely /i/ and /u/, where the vowels stay relatively fixed, forcing the remaining vowels into a narrow range of positions. Fully 3/4 of the sample languages have a peripheral system with one of the 'triangular' patterns 3:0, 5:0 or 7:0 (see Table 3). The 4:0 peripheral system does not occur with any interior vowels because systems that could be interpreted this way (*5:1, *6:2) are more naturally interpreted as defective versions of the peripheral 5:0 system (see Sec. 2.4 on four vowel systems).

2.3 Interior vowels

Languages with more than one interior vowel make up only about 1/4 of the sample. As noted earlier, these have been divided into three types, those with a vertical arrangement (unmarked notation), those with front rounded and back unrounded vowels ('), and those

with centralized /ɪ ʊ/ (''). As can be seen from Table 4, only the vertical arrangement is common. Generally speaking, the interior column has back unrounded vowels, /ɨ ə/; front rounded vowels are found chiefly in Europe and north Asia (see Crothers 1975). Only two cases of three height distinctions in the interior vowels are found in the sample, FRENCH and PACOH, and the latter is uncertain.

Table 3. Peripheral vowel systems (questionable types omitted)

type of peripheral vowel system	found in basic system	no. of languages	defective peripheral system	no. of languages	total
3:0 /i a u/	3:0 4:1	23 9			32
4:0 /iɛ a u/	4:0	13			13
5:0 /i ɛ a u ɔ/	5:0 6:1 7:2 8:3	55 29 14 3	*5:1 **5:1 *6:2' *5:2	5 2 2 1	101 (+10 def.)
6:0 /i e æ u o ɒ/	6:0 8:2 9:3	7 2 4	*5:0	1	13 (+1 def.)
7:0 /i e ɛ a u o ɔ/	7:0 8:1 9:2 9:2'' 10:3' 10:3''	11 2 7 3 1 2	*6:0 *7:1	2 3	26 (+5 def.)
8:0 /i e ɛ æ a u o ɔ/	10:2 11:3	2 1	*9:2	1	3 (+1 def.)

Table 4. Interior vowel systems (questionable types included)

no. of interior vowels and type	found in basic vowel systems	no. of languages	total
0	3:0 4:0 5:0 6:0 7:0 *5:0 *6:0	23 13 55 7 11 1 2	112

(continued next page)

Table 4 cont.

no. of interior vowels and type	found in basic vowel systems	no. of languages	total
1	4:1	9	52
	*5:1	5	
	**5:1	2	
	6:1	29	
	7:1	3	
	8:1	4	
2	*5:2	1	29
	7:2	14	
	8:2	2	
	9:2	7	
	10:2	2	
	*9:2	1	
3	11:3	1	
	?12:3	1	
2'	*6:2'	2	10
3'	8:3'	3	
	9:3'	4	
	10:3'	1	
2''	9:2''	3	5
3''	10:3''	2	

2.4 Comments on types of systems

2.4.1 Two vowels The sample contains one language with a two vowel system, KABARDIAN, with /ɨ ə/. In my opinion this is not a clear case, because, according to Kuipers, there is a normal set of five long vowels of the type 5:0. He analyzes these as phonemic diphthongs of one of the two short vowels plus /y/, /w/ or /h/; phonetically, however, they are simple vowels. Further, the long vowels have about the same duration as short vowels in other (European) languages, while the two short vowels are extremely short. In fact /ɨ/ seems to be little more than a transitional sound between consonants, and is regularly lost under certain conditions. For these reasons I think it would be preferable to regard the five 'long' vowels as forming the basic vowel system of KABARDIAN, treating the two short vowels as a reduced or 'overshort' system. This is not to deny that KABARDIAN has a peculiar vowel system; the peculiarity, however, lies in the high frequency of the reduced vowels, and not in the structure of the basic vowel quality system. A similar reinterpretation can probably be made of other linear vowel systems mentioned by Trubetzkoy. In any case, this type of phenomenon has been found only in a few CAUCASIAN languages, and, though interesting as an extreme, has little bearing on the general picture of vowel system typology.

2.4.2 Three vowels I have assigned all three vowel systems in the sample to the same type, in spite of a number of differences in phonetic quality of the phonemes, because in all cases the three vowels stand in the same relative relationship and occupy the same regions of the vowel space. Of the three vowel types, /i a u/, the last ranges most widely, from [o] through [U] and [u] to [ɯ], the last being found in two languages, JAQARU and NUNGGUBUYU. Together with ALAWA (4:0) and possibly ONEIDA, these are the only languages in the sample which do not have lip rounding as a phonetic feature of the vowel system. Unfortunately, one cannot tell from the descriptions whether the 'unrounded' quality of the vowels in question is an acoustic quality or is just based on observation of the lips. This question is relevant, since, as anyone can tell for himself, it is possible to produce vowels of 'back rounded' perceptual quality with little or no lip rounding. Whatever the phonetic details, however, they will not prevent the classification of these languages to the basic 3:0 type (4:0 for ALAWA), because the general character of the phoneme oppositions remains the same: roughly high front /i/ versus roughly high back /u/ versus roughly low central /a/. These oppositions are not simply relative; they involve specific areas of the vowel space; it is just that in a three vowel system the areas are larger and more vague than in a more complex system. In other words, a hypothetical three vowel system /i ü ɛ/ does not fall within the basic 3:0 type, because although the relative position of the vowels in the system is correct (front versus back, high versus low), they are bunched up much too closely in one part of the vowel space. No such system has ever been reported.

The vowels of three vowel systems often show considerable subphonemic variation. For example, in GREENLANDIC ESKIMO, /i/ includes [i], [e] and [ə], /u/ includes [ʉ], [u], [o] and [ɔ], and /a/ includes [æ] and [ɑ] (Thalbitzer 1904).

2.4.3 Four vowels By my system of classification there are two types of four vowel systems, 4:0 (/i ɛ a u/) and 4:1 (i ɨ a u/), which probably should be regarded as subtypes of a single type, which might be characterized as /i ə a u/. The peculiarity of four vowel systems is that in addition to the vowels of the basic 3:0 system, they have a fourth vowel which may range anywhere from mid or even low front, through mid central, up to high central. The reason for this, according to my revised model of the vowel space (see Sec. 4.3), is that four vowels do not pack very efficiently into the vowel space, and this leaves room for the fourth or central vowel to move into different positions. As in three vowel systems, there is considerable variation, especially in the position of the back vowel, and the general statements made with regard to the specific phonetic character of vowels in a three vowel system apply here too. The types of vowel systems reported in the literature all fall within the range of 4:0 or 4:1, with the exception of the system /i a u o/, not found in the sample, but reported by Hockett for CEBUANO BISAYAN, and by Sedlak for KALINGA and CROW. (Note: the interpretation of the CROW vowel system remains in doubt; there is an [e] of uncertain status, and /o/ appears to be infrequent (Kaschube 1954). In KALINGA, in spite of some apparent minimal pairs for /u/ and /o/, the two vowels are mostly in free variation (Gieser 1958). In any case, this type of system, if it exists, is a very marginal one.)

2.4.4 Five vowels The system 5:0 is the only five vowel system that occurs with any frequency. The degree of deviation from the typical vowel positions is considerably smaller than that found in three and four vowel systems. The system *5:1, found in five languages in the sample, resembles the 6:1 system with one of the back vowels removed. (It might also be interpreted as a 5:0 system with /u/ fronted to /ɨ/.) Trubetzkoy reports such a system with /ü/ as the interior vowel in TABARASSAN and KYURI; all the languages in the sample have a back unrounded vowel. The peculiar system /i ɨ a u ɔ/, which looks like 6:1 with /ɛ/ removed, is found in PAPAGO. (Note: comparative evidence indicates that the system derives from a normal 5:0 with /ɛ/ becoming /ɨ/ (Voegelin, Voegelin and Hale 1962). The Voegelins' and Hale's interpretation, that the PAPAGO system represents PROTO-UTO AZTECAN, and that /ɨ/, found only in the SHOSHONEAN branch of UTO AZTECAN, developed into /ɛ/ in the AZTEC and SONORAN branches, strikes me as implausible on typological grounds, and also because /ɛ/ is the more common modern reflex.) The EVENKI system /i æ ə u ʌ/ is clearly a defective 6:1, since the long vowel system has /E·/ in addition to /æ·/. SENECA, with /i e æ a ʌ/(also in the long vowels) resembles 6:0 with /u/ missing, an isolated type.

MANDARIN CHINESE, with /i ü ë a u/ (5:2) is another isolated type. (Hockett adds a retroflex vowel /r/, which I am regarding as part of the consonant system.) This is closer to the 6:1 system than to any other common type, and it is notable that /ë/ has allophones [ɛ] and [o]. Still, by any phonemic analysis these are variants of /ë/. A similar system, with interior vowels /ɨ ə/ is reported for MANOBO, in a very brief article (Meiklejohn 1961). Sedlak has reported a 5:2' system (with /ü ɨ/) for CHACOBO, but this must be due to a mistaken transcription; the system is 4:1, without /ü/.

2.4.5 Six vowels The most frequent six vowel system in the sample is 6:1, the second most frequent of all vowel systems, while the type 6:0 is represented by seven languages. Other six vowel systems may be considered typologically unimportant. Until recently (cf. Ruhlen, to appear), the typological importance of the 6:1 system does not seem to have been recognized. The interior vowel of the system is generally a central unrounded vowel (/ɨ/ or /ə/) while the remainder of the system consists of the vowels of 5:0. One language in the sample, the WU dialect of CHINESE, has /ü/ as the interior vowel, a type mentioned by Sedlak for BASQUE, and by Trubetzkoy for UKRANIAN. TAKI-TAKI, cited by Hockett and Sedlak, has /ü/, but only rarely, and exclusively in DUTCH words (see Hall 1948 for TAKI-TAKI). Medieval GREEK is supposed to have had /ü/, but of course there is no way of knowing the actual phonetic character of this vowel.

The 6:0 system is the only type of any frequency that could be regarded as a clear representative of Trubetzkoy's quadrangular type, but it is not frequent enough to figure prominently in a typology. In addition to the languages in the sample, 6:0 has been found by Hockett in DARGWA, MENOMINI and UKRANIAN; by Sedlak in BATS, GALLA and ZAPOTEC; and by Trubetzkoy in UZBEK, without major deviations from the pattern described here.

Two languages, CHUVASH and HOPI, which can be classed as *6:2', are peculiar in having only one back rounded vowel, and in distinguishing a front rounded from a back unrounded vowel. In the interior vowel area the closest thing to this would be the 8:3', 9:3' or 10:3' systems (eight languages altogether) which have both front rounded and back unrounded. CHUVASH in particular seems to represent an extreme typological deviation in having so few peripheral vowels for the arrangement of interior vowels.

There are two defective 6:0 systems, ENGLISH (RP) with /I E æ ǣ U ɒ/ (*6:0) (Note: the long and short vowel systems are separated), which looks most like a 7:0 system with /o/ removed, and EWE, with /i ɛ a u o ɔ/(**6:0), again resembling 7:0, with /e/

removed. (Note: in fact some dialects do have /e/, but in the dialect described, it has merged with /ɛ/ (see Stahlke 1971)).

2.4.6 Seven vowels Both 7:0 and 7:2 are not uncommon systems. Liljencrants and Lindblom find 7:0 to be the most common seven vowel system in the literature, and Ruhlen (to appear) also finds 7:0 to be relatively common (by implication more common than 7:2). I find that 7:0 and 7:2 are about equally common. This is due to my grouping together two subtypes, those with front rounded and those with back unrounded interior vowels, into the 7:2 system. This grouping has been used before (e.g. by Hockett) and is well motivated acoustically.

The system *7:1 is found in three sample languages and resembles 6:1 with an extra front vowel /e/, or 8:2 with an interior vowel removed. Sedlak finds this system in TAMIL and LIFU. (He also mentions SINHALESE, with the interior vowel /ə/, interpreted in this survey as 6:0. See footnote 19.) Hockett and Trubetzkoy mention BULGARIAN dialects and VOTYAK. In any case it is not very common compared to 7:0 and 7:2.

2.4.7 Eight vowels None of the eight vowel systems is common enough to be important typologically. The 8:1 type resembles 7:1, and 8:2 resembles the more common 7:2 and 9:2. The 8:3' system is the smallest found with three interior vowels. No languages with 8:0 were found in the sample, though this type has been reported by Trubetzkoy and Hockett for POLISH dialects. Other systems reported in the literature can be classed with 8:1, 8:2 or 8:3', but there are not many beyond the nine languages in the sample.

2.4.8 Nine vowels 9:2 is the only common type with more than seven vowels, with a vertical arrangement of the two interior vowels. All seven languages in the sample with this system have back unrounded vowels. Such systems seem to be found chiefly in Central America and Southeast Asia. Another subtype with front rounded vowels is mentioned in the literature for several GERMANIC and URALIC languages (e.g. ESTONIAN, NORWEGIAN, ICELANDIC). In the present sample several similar systems are found, but not the 9:2 system.

The reasons for treating /I U/ of the 9:2" system as interior vowels are given in Sec. 1.2. The only other system that resembles it is the 10:3" system.

The *9:2 system of SOMALI is peculiar in having four front vowels and only two back (rounded) vowels. This is due to a skewed vowel harmony system of the basic African type: there are four pairs of vowels which differ roughly on a back to front axis, e/ɛ, æ/ə, ʌ̇/ɔ, Ů/U, except that for the first pair the difference is exclusively one of height, to judge from the rather explicit phonetic characterization by Armstrong. (Note: these vowels alternate in suffixes. /i/ does not occur in suffixes, but as a stem vowel short /i/ generally takes back harmonic suffix forms, and long /i·/ takes front harmonic forms.)

The 9:3' system, like 8:3', has a backness distinction in the interior vowels, and this type of arrangement bears comparison with the 9:2" system, in which /I/ and /U/ show a backness contrast. It is notable that many of the languages with this kind of contrast in the interior vowels have vowel harmony, either the African pharyngeal (or height or tenseness) type, or the palatal type of URALIC, ALTAIC and early GERMANIC. The 9:3' system, like 8:3', occurs chiefly in languages with palatal vowel harmony. All three languages in the sample with 8:3' have palatal harmony, and two of those with 9:3' do (AZERBAIJANI and OSTYAK). The third, NORWEGIAN, of course historically had a form of palatal harmony in palatal umlaut. The 9:2" and 9:2 systems form a kind of areal and typological counterpart of 8:3' and 9:3'. The latter are found in northern Eurasia, along with cases of 9:2 which have front rounded vowels (see Crothers 1975); remaining cases of 9:2 (with back unrounded vowels) are found in Southeast Asia and Central America, while 9:2" is restricted to Africa. Considering that languages with more than seven vowels altogether make up only about 15% of the sample, one might lump them all into a general type of 'large vowel system,' with different areas of the world specializing in slightly different techniques for developing the extra vowels.

2.4.9 Ten or more vowels Languages with more than nine basic vowel qualities are quite uncommon. (There are only seven in the sample, and the typological summary by Liljencrants and Lindblom has only a few.) The types found closely resemble the different types of nine vowel system in the arrangement of the interior vowels, with the exception of FRENCH (11:3), with three distinct vowel heights in the interior vowels. (PACOH (?12:3) may have such a system with back unrounded vowels, but the data is suspect.) A few cases are cited by Liljencrants and Lindblom: NORWEGIAN dialects and MARATHI. I do not regard VIETNAMESE (cited by Sedlak 1969) as a case of this type because, although it has /ɪ ɐ ʌ/, it does not have a clear /a/ which would be below /ʌ/ in the vowel space. Instead, it has a somewhat retracted /æ̇/, which seems to be opposed to /ʌ/ more as front to back. Thus /æ̇/ and

/ʌ/ seem to be functioning as the low vowels in the system, leaving only two interior vowels, /Ï ə̈/.

3. Universals of Vowel Systems

3.1 The vowel hierarchy On the basis of the observed types of vowel systems, it is possible to set up a hierarchy of vowels based on implicational statements of the form: 'if a language has a vowel phoneme of type z, it also has one of type w.' (See Greenberg et al. 1966.) This hierarchy is represented in Fig. 10. The arrows can be read with the following meaning: 'beginning with the system /i a u/ construct a larger vowel system by adding the vowel at the head of the arrow.' The vowel symbols have both a relative and an approximate absolute value. In the relative sense each symbol must be interpreted in relation to all the other symbols that precede it in the hierarchy. The symbol /e/ must be interpreted with reference to /ɛ/, which precedes it; /e/ thus means a specifically higher mid vowel in contrast with /ɛ/, whereas the latter symbol, though it typically stands for a lower mid vowel, may also stand for a mid or even higher mid vowel in a system without a higher vowel between it and /i/. The symbols also have an absolute value in the sense that they usually stand for the phonetic value indicated, and other values stand in a cluster around this point in the vowel space. A strict definition of hierarchical rank, corresponding to the notion of implicational hierarchy, is that a vowel x on the chart has a higher rank than a vowel y if y can only be reached by passing through x. Due to branches in the chart, many pairs of vowels have no rank with respect to each other, by this definition. Thus /ɨ/, even though it occurs high on the chart, has no hierarchical

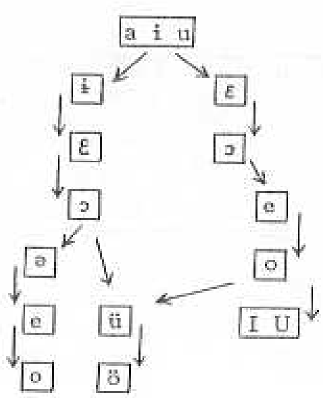


Figure 10

rank relative to /e/, which stands much lower. In other words the existence of /e/ in a language does not imply the existence of /ɨ/. However, it is possible to define a weaker sort of rank, (call it 'precedence') by which /ɨ/ 'has precedence over' /e/. We can say that x has precedence over y if x can be reached on the chart in fewer steps than y. This simply means that x may occur in smaller vowel systems than y. The implicational universals on which the chart is based are given as universals 1-7 below. (See Appendix I for a restatement of universals.)

1. All languages have /i a u/.

The closest one comes to finding counterexamples to this statement are the following cases. a) Three languages in the sample have only one back vowel, which is unrounded (JAQARU, NUNGGUBUYU, ALAWA). As noted earlier (Sec. 2.4), I take [ɯ] in these cases to be reasonably close to [u], given the range of variation found in three and four vowel systems. b) There are a number of languages in which the only back rounded vowel is [o] or lower; with 3:0, ALABAMAN and AMUESHA; with 4:0, NAVAHO, ONEIDA, HUPA, MAZATEC, CAMPA; with 4:1, ADZERA, SQUAMISH, AMAHUACA, CHACOBO; with *5:0, SENECA; with *5:1, NEZ PERCE, OCAINA. In all of these cases we find an /ɨ/ or /o/ bordering on the /u/ area; often one of these phonemes has [u] as an allophone or free variant. In the case of three and four vowel systems, it seems to me that this [o] is reasonably close to [u], given typical variation in such systems, and can be interpreted as /u/. In the case of the five vowel systems, there is clearly a gap at the /u/ position, since there is in each case a mid front vowel paired with a mid back rounded vowel, but no high back rounded vowel paired with the high front vowel. We thus have three languages which are clear exceptions to the rule (SENECA, NEZ PERCE, OCAINA), and another eleven cases that may be regarded as borderline, or, including the cases mentioned under a), a total of fourteen borderline cases (1.5% clear exceptions, 7% borderline).

The typology of vowel systems does not allow a ranking of /i a u/, there being no systems of a smaller type, so that a ranking must be established by other criteria, such as frequency or neutralization. The frequency counts by Greenberg (1966) clearly indicate a consistent pattern a > i > u, which corresponds to the hierarchy set up by Jakobson. On the typological level one might take the fact that /u/ comes closest to being an exception to the universality of /i a u/ as a reason to rank it lower than the other two.

2. All languages with four or more vowels have /ɨ/ or /ɛ/.

All of the 185 languages in the sample which are subject to this rule obey it. The system /i a u o/, not found in the sample, but cited in the literature (see Sec. 2.4), is an exception.

3. Languages with five or more vowels have /ɛ/. They generally also have /ɔ/.

Of 163 sample languages subject to this rule, one, PAPAGO, with **5:1, violates the first part. Nine languages violate the second part, the five languages with *5:1, one with *5:2, one with *5:0, and two with *6:2'. (The chart of the vowel hierarchy is constructed to reflect only the first part of this rule, i.e. it allows for the *5:1 system without /ɔ/.)

4. Languages with six or more vowels have /ɔ/ and also either /ɨ/ or /ə/, generally the former.

Of 108 languages in the sample subject to this rule, two (both languages with *6:2') are exceptions to the first part. One language, EWE (*6:0) lacks both /ɨ/ and /ə/.

5. Languages with seven or more vowels have /e/ and /o/, or /ɨ/ and /ə/ (/ʉ/ and /ɵ/ may represent the types /ɨ/ and /ə/).

Of 68 sample languages subject to this rule, there are four exceptions, the three languages with *7:1, and ALBANIAN (7:2) which has /ʉ/ and /ə/. All four have two of the six vowels mentioned in the rule, but not in the proper pairing.

6. Languages with eight or more vowels have /e/.

Of 40 sample languages subject to this rule, three, with 8:3', are exceptions.

7. Languages with nine or more vowels generally have /o/.

There are enough exceptions to this rule to make it a 'tendency' rather than a 'near universal.' Of 22 sample languages subject to it, five are exceptions, four with 9:3' and one with *9:2. In addition to the vowels mentioned in rule 5, languages with nine or more vowels may also have /I U/. The situation is summed up in Table 5.

3.2 Normal vowel system

My remaining generalizations are quantitative, concerning the number of vowel contrasts in a system or in different parts of a

Table 5

Rule	applies to — languages	no. of exceptions	% exceptions
1	204	3	1.5%
2	185	0	0%
3a*	163	1	1%
3b	163	10	8%
4a	108	2	2%
4b	108	3	3%
5	68	4	6%
6	40	3	8%
7	22	5	23%

*The letters a and b indicate the narrower and wider interpretations of the rules, respectively.

system. The dominant fact, with respect to quantity, is the general preference for the 5:0 system (Sec. 2.1) restated as follows:

8. A contrast between five basic vowel qualities is the norm for human language, and in general the most common systems are those that have close to this number of basic vowels.

3.3 Height and backness

9. The number of height distinctions in a system is typically equal to or greater than the number of backness distinctions.

(The 'backness' dimension is here understood to include both backness and rounding. For example /ʉ/ is further 'back' than /i/ (see Sec. 1.2).) The interpretation of this rule depends on whether the opposition of /a/ to /ɛ/ and /ɔ/ is taken as a height opposition. In terms of the acoustic space both height and backness are involved. I have interpreted it as a height distinction, which of course biases the data in favor of more height distinctions. Thus, the 5:0 system is interpreted as having more height than backness distinctions. Clearly, however, to regard the opposition /ɛ/-/a/-/ɔ/ as strictly a backness opposition would be even more unrealistic acoustically. It has to be understood that this rule can be interpreted only in a very rough way. There are 18 languages in the sample that are exceptions (see Table 6), although for the languages with 4:1 there is a tendency for the central /ɨ/ or the back /u/ to be mid rather than high, so that in these cases the violation is marginal (seven languages). (Note: the 4:1 system, if interpreted as having three degrees of backness and two degrees of height, violates Chomsky and Halle's rule (1968: 410, rule no. 9) to the effect that an interior vowel (front rounded or back unrounded) is more marked than a mid vowel. If interpreted as a universal implication, the marking convention thus has a number of exceptions, although it is still true as a general tendency, and in fact is just a special case of my more general rule 9.) (Note: the 6:1 system is a borderline case, since it may be interpreted as having only two degrees of height, but must be interpreted as having three degrees of backness, as illustrated:

i ɨ u

$\overline{e}\binom{a}{a}\overline{o}$

The two height interpretation is rejected here for the reason given above in connection with the role of /a/ in the 5:0 system.)

Table 6. Number of height and backness contrasts

height = backness		height > backness		height < backness	
type	no. of languages	type	no. of languages	type	no. of languages
3:0	23	5:0	55	4:1	9
4:0	13	*5:0	1	*6:2'	2
*5:1	5	6:0	7	8:3'	3
**5:1	2	*6:0	2	9:3	4
*5:2	1	7:0	11	total	18
6:1	29	7:1	3		
7:2	13	8:1	4		
10:3	3	8:2	2		
total	89	9:2	7		
		9:2''	3		
		*9:2	1		
		10:2	2		
		11:3	1		
		total	99		

Another approach to this rule is to find the average number of vowels, based on the whole sample, found on the horizontal and vertical dimensions of the vowel space. I considered the distance from /i/ to /u/, from /i/ to /a/, and from /u/ to /a/, and found the following average number of vowels: /i-u/ 2.5, /i-a/ 3.1, /u-a/ 2.9. If these figures are taken as defining a triangular 'vowel space,' it has a 'height,' a distance from /a/ to /ɨ/ of about 2.7, just a little larger than the backness dimension of 2.5.

Still another measure of the horizontal and vertical dimensions can be found in the maximum number of contrasts, four in both cases. Hockett also finds four contrasting degrees to be the maximum. Trubetzkoy says that five heights are quite rare, but finds six in GWEABO; this, however, involves the problematic feature of pharyngeal expansion. Moulton reports cases of five heights. It seems at least that four heights cannot be regarded as an absolute maximum, while there are no reported cases of languages with more than four backness distinctions. Also there are more sample languages with the maximum number of heights than with the maximum degrees of backness, 35 with four heights, 14 with four degrees of backness, so that one might say that the limit on heights comes closer to being exceeded than that on backness.

The relation between height and backness and the minimum and maximum number of distinctions in each has been commented on in typological studies and work on feature systems. Trubetzkoy (and apparently Jakobson) based the notion of the primacy of height over backness on the existence of linear vowel systems. (All languages have height distinctions, not all have backness distinctions, an implicational universal: backness implies height.) However, since linear systems and the associated universal are at best problematic, the relation between the two dimensions has to be established by other means.

There seems to be general agreement that the minimum number of height distinctions is two, and that the maximim number of distinction is four for both height and backness, with the exceptions for height mentioned above. The present results confirm this. An apparently different view is expressed in the feature systems of Jakobson, Fant and Halle (1951), and of Chomsky and Halle (1968), which allow for a maximum of three height distinctions. However, in both systems the feature of tenseness is available for further distinctions (cf. the treatment of the FRENCH e/ɛ distinction by Jakobson, Fant and Halle 1951: 37), and in principle could generate three additional vowel 'heights,' so that despite initial appearances these feature systems do not go beyond what Trubetzkoy claimed in Principles of Phonology. Still, it is notable that not many languages have more than three height distinctions, and that if one is willing to live with the classification of /ɛ a ɔ/ as equally 'low' vowels, distinguished by backness and rounding only (e.g. in the 7:0 and 9:2 systems), the three height system can be made to work for the overwhelming majority of languages. There are only four languages in the present sample for which this would not work, SOMALI (*9:2), IAI and VIETNAMESE (10:2), and FRENCH (11:3).

As for the 'backness' dimension, general agreement on the maximum of four degrees conceals some problems in the interpretation of the features of backness and rounding. Trubetzkoy realized that the two articulatory features were interrelated, and subsumed them under the notion of 'timbre,' with front unrounded and back rounded as the 'extreme' degrees of the feature; but at the same time he remained reluctant to use a single feature, and in fact made a major point of determining for particular vowel systems whether backness or rounding was a distinctive feature. It has become a kind of tradition in phonology to notice the relationship of backness and rounding, but to continue to use two features, no doubt chiefly for articulatory reasons. When this is done in a feature system, some kind of separate statement is necessary to establish the connection between the two features. Chomsky and Halle, for example, have a marking convention (1968: 405, no. XI) saying that front rounded and back unrounded are more marked than front unrounded or back rounded, though of course the convention does not express <u>why</u> this is so (see Sec. 1.2). Use of two binary features, backness and rounding, is sufficient to characterize the different degrees of backness in nearly all languages. A problem, found only in NORWEGIAN in the sample, occurs when both the interior vowels of a set of four high vowels are rounded, i.e. a set like /i ü u̇ u/. The corresponding problem in SWEDISH has been much discussed (see Fant 1973: 192-201). The general problem is that /u̇/ cannot be either back rounded or front rounded unless some other feature distinguishes it from /ü/ or /u/. While Fant's suggestion of an additional 'classificatory' feature <u>labial</u> has found approval elsewhere (see Anderson 1975: 299), Fant also adds that "perception of a vowel probably operates with a direct identification of its approximate place in a multidimensional parameter space," rather than by "a strict decomposition in terms of phonological features." The features, I might add, are made up by linguists for the sake of an ideal of classificatory neatness. In the vowel space /u̇/ is simply a central vowel, between /ü/ and /u/, and would be most simply and accurately characterized as having a third degree of backness out of the possible four. The fact that this position in the vowel space is achieved by different articulatory means than the more usual unrounding of a back vowel is of course interesting, but does not affect universals or typology.

A related problem for feature systems is the interpretation of the vowels /I U/ in the systems 9:2" and 10:3". Doubtless these would be classified by the tenseness or pharyngeal expansion feature, but the problem remains that the contrast between these vowels and /i u/ is one of vowel quality, i.e. a difference in acoustic height and backness. Surely, the relative rarity of such systems and their complementary distribution with vowel systems containing front rounded or back unrounded vowels has to be explained in terms of the place of these vowels in the vowel space. The atomistic feature approach, in separating tenseness (or pharyngeal expansion) from the general vowel quality features, fails to express a significant fact about vowel system typology.

3.4 <u>Interior vowels</u>

The relation of the interior vowels to the front and back vowels has often been commented on. Trubetzkoy says that an interior vowel column must have a high vowel. This is only trivially true in that the /ɨ/ of systems 4:1, 6:1, 7:1, etc. is often more like /ə/, mid rather than high. (Note: in languages with only /ɨ/ in the interior vowel system, it is phonetically mid in about half the instances, five languages (out of nine) with 4:1, three (of five) with *5:1, 12 (of 29) with 6:1, and two (of three) with 7:1.) Since this kind of system (or one with /ö/ but not /ü/) is the main kind of evidence one would look for to test the validity of the proposed rule, it will hardly do to reclassify these counterexamples as having an 'indeterminate' vowel /ə/, as Trubetzkoy does. Hockett states a similar rule: that there are not more backness distinctions at the lower positions than at the higher ones, but he notes that there are some exceptions. I find, in addition to these cases with one interior vowel /ə/, CHEREMIS (8:3') and KOREAN (9:3') with two mid interior vowels and only one high one.

A weaker version of these rules, stated as 10., seems to be generally valid:

10. Languages with two or more interior vowels always have a high one.

There are 31 such languages in the sample and one exception, HOPI, with /ö/ and /ë/ (type *6:2).

Another of Trubetzkoy's rules is restated here as 11.

11. The number of vowels in a column of interior vowels cannot exceed the number in the front or back columns (low vowels excluded).

There are 39 languages in the sample with a height contrast in the interior vowels; one, MANDARIN CHINESE (*5:2), with /i ü ë a u/

is an exception to the rule. MANOBO, with a similar arrangement (see Sec. 2.4 on the *5:2 system) is the only other exception cited in the literature.

The relation of interior vowels to front and back vowels can also be stated separately. Sedlak, for example, says that a front rounded vowel of a given height implies both a front unrounded vowel and a back rounded vowel at the same height. This is always true in the present sample (the rule applies to 21 languages, including two with 'central' rounded vowels). He also says that a back unrounded vowel of a given height implies a front unrounded vowel of the same height. MANDARIN CHINESE is an exception to this rule, as are the five languages with 4:1 which have /ə/ as the interior vowel. There remain 65 languages with back unrounded vowels for which the rule holds true. A corresponding rule, not stated by Sedlak, is that a non-low back unrounded vowel of a given height generally implies a back rounded vowel of the same height. (This rule, of course, cannot be generalized to the low vowels, since it would fail completely for /a/.) There are some exceptions, MANDARIN CHINESE again, six languages with 4:1 in which the /ɨ/ and /u/ differ substantially in height, and all five languages with *5:1 (a total of 11), leaving another 59 languages for which the rule holds true.

3.5 Front and back vowels

12. The number of height distinctions in front vowels is equal to or greater than the number in back vowels.

This rule presents no real interpretation problems, since /a/ can be either included in both front or back series, or excluded from both. In the 6:0 system, where /a/ contrasts with a low front vowel, I have counted it in the back series. On the other hand, in the 4:0 system, /a/ is typically lower than /ɛ/, and I have taken it to be low central, while the latter is front (lower-mid). As can be seen from Table 7, the great majority of languages (all common types except 4:0) show equal numbers of height distinctions in front and back vowels. There is thus a general tendency toward symmetry in this sense, though other factors contribute to overall symmetry. Systems with two or more interior vowels generally show symmetry there. In the vertical arrangement of interior vowels, they generally all have the same degree of backness (front rounded or back unrounded), though there are some exceptions: ALBANIAN (7:2), MANDARIN (*5:2). However, all eight languages with the _:3' interior vowel system (i.e. three interior vowels including both front rounded and back unrounded) are asymmetrical. It is

difficult to say to what degree a property of overall symmetry is to be found in vowel systems (cf. Chomsky and Halle's rule (10), 1968: 410).

Table 7. Height contrasts in front and back vowels

front = back				front > back		front < back	
type	no. of languages	type	no. of languages	type	no. of languages	type	no. of languages
3:0	23	8:3'	3	4:0	13	**5:1	1
4:1	9	9:2	7	*5:0	1	**6:0	1
5:0	55	9:2''	3	*5:1	5		
**5:1	1	9:3'	4	*6:0	1		
*5:2	1	10:2	2				
6:0	7	10:3'	1	*6:2'	2		
6:1	29	10:3''	2	*7:1	3		
7:0	11	11:3	1	*8:2	2		
7:2	14			*9:2	1		
8:1	4	total	177	total	28	total	2

3.6 Correlations between the basic vowel system and the systems of long and nasalized vowels

3.6.1 Long vowels Nearly half (45%) of the sample languages have contrasting long and short vowels. In most cases (70%) the vowels of the two systems are equal in number and arrangement, either identical in quality or showing minor differences. In another 19% the long vowel system is larger than the short vowel system, while 8% have more short than long vowels. By far the most commonly reported difference of quality between long and short vowels of corresponding positions is centralization (laxing) of the short high vowels, i.e. short /I U/ versus long /iˑ uˑ/, reported in 20% (19 languages) of the languages with long vowels. (It seems likely that the real proportion would be higher, and that this detail is simply overlooked in many phonemic descriptions.) However, in another 5% (five languages) one or both of the long high vowels is lower than the corresponding short vowel. In seven languages the short /a/ is reported to be more centralized than the long /aˑ/. Other quality differences are not common enough to make generalization worthwhile.

13. There is a tendency for high and low vowels of a short vowel system to be more central than the corresponding long vowels.

3.4.2 Nasal vowels As for the nasal vowel systems, the well known universal stated as 14. (cf. Ferguson 1966, Ruhlen 1975) is confirmed by the sample.

14. The number of vowels in a nasal vowel system is equal to or smaller than the number in the oral vowel system.

The sample has 50 languages (24%) with nasal vowel systems, which compare with the basic systems as shown in Table 8.

Table 8

	$V=\tilde{V}$	$V>\tilde{V}$	$V<\tilde{V}$
No. of languages	22	28	0

The one apparent exception to the rule, OJIBWA, is not a real one since, although the short vowel system is 3:0 and the nasal vowel system 4:0, the long vowel system is also 4:0, and the nasal vowels are actually long. (There is, in addition, a system of short nasal vowels, only marginally contrastive and not counted as part of the phonemic system, of the type 3:0.) So actually, the nasal vowel system is identical in structure, if not contrastive function, to the oral vowel system. As for the 28 languages in which the nasal system is smaller than the oral, the following tendency, in agreement with previous work (Ruhlen 1975), is found:

15. If a nasal vowel system is smaller than the corresponding basic vowel system, it is most often a mid vowel (front, back, or both) that is missing from the nasal system.

This is shown in Table 9. The numbers do not add up because some languages fall into two categories.

Table 9. Relation of nasalized systems to larger basic systems

	No. of languages
1. mid vowel missing (includes 2)	20
2. front and back mid vowels missing	(12)
3. high vowel missing (includes 5)	5
4. low vowel missing (includes 5)	5
5. high and low vowel missing	3
6. ?	1

4. Vowel Dispersion: An Explanatory Model

Vowel system typology and the associated universals can be explained, in large part, by the principle that the vowel phonemes of a language tend to disperse evenly in the available phonetic space. Using a characterization of the vowel space in terms of the first three formants, and a measure of dispersion, Liljencrants and Lindblom were able to construct theoretical vowel systems that corresponded closely to a substantial number of actual vowel systems, though there were some discrepancies, especially in the interior vowels of larger systems.

I have made some revisions in the model which lead to a better fit; in this section I present my revised model and examine the extent to which it predicts actual vowel system typology. Lindblom, in a recent paper, has incorporated several revisions into the original model which correspond roughly to the ones I have made, though mine are mathematically cruder. As far as I can see my results are similar to, but not the same as Lindblom's. Since his new model has not been presented in detail, and since my own beginning point was the original L&L model, in what follows I compare my revised model chiefly with the original.

4.1 The L&L model The vowel space is defined as a two dimensional space in which one dimension is F_1 and the second is a weighted average of F_2 and F_3. To disperse vowels in this space L&L set up a computer program to maximize the sum of the distances between all pairs of vowels in the space, with each vowel defined as a point in the space. For a given number of vowel points, the configuration giving the maximum sum of distances between vowels is the optimal arrangement. This model generates vowel systems which are close matches for the empirical systems 3:0, 4:0, 5:0 and 6:1 (i.e. over half the sample languages). For larger systems the model is defective in producing too many interior high vowels. The seven and eight vowel systems have four degrees of backness in the high vowels, with no interior mid vowels. The nine, ten, eleven and twelve vowel systems have five degrees of backness in the high vowels, and an interior mid vowel appears first in the eleven vowel system. Only a few systems in the sample approach this arrangement of interior vowels, three languages with 9:2" (interior vowels /I U/) and CHUVASH (≠6:2') with /ʉ ɨ/. The general defects of the model seem to be a tendency to push all vowel points to the perimeter of the space, and too much space between /i/ and /u/.

4.2 Optimal vowel system A further point which L& L did not try to account for is the optimal size for vowel quality systems (five vowels), which must, in some sense not yet defined, depend on a balance between the maximization of perceptual distance between vowels and maximization of the information content of the speech signal, the former favoring fewer vowels further apart, the latter more vowels. Theoretically, this optimal size should be predictable from such factors as the limits on the human ability to distinguish vowels, the average amount of noise in the speech situation, the average information content of spoken communications, the relative contribution of consonants and vowels to the total information content, and so on. Since a number of these factors seem difficult to quantify, much less to relate to each other in a principled way, we have to be content for the moment simply to observe that the preference for five vowel systems is a fact.

4.3 Revised model In my revision of the L&L model I define the vowels as (equal) circular areas rather than as points, and the optimal arrangement is that which allows the maximum diameter for a given number of vowels in the vowel space. (One can imagine that a number of vowel circles are set into the vowel space, and are allowed to grow until they bump into each other or the sides of the vowel space. Actually, I kept the vowels as circles of a constant diameter, and the vowel space was 'shrunk' around them until the smallest possible vowel space was achieved. All that is needed for this is a set of checkers and a set of graduated outlines of the vowel space. The checkers are pushed around until a smallest vowel space is found, and one generally becomes apparent quite rapidly.) If the center of each vowel circle is considered its locus in the vowel space, then each vowel can be thought of as a point which 'repels' its nearest neighbors and the perimeter of the vowel space (if it is adjacent) to an equal degree, but exerts no repulsive force on vowels further away in the system. This seemed to me to be a plausible technique for dispersing the vowels, and I thought it might reduce the number of vowels on the perimeter of the space.

The relative dimensions of the perceptual vowel space are a problem because it is not known how the acoustic signal is modified perceptually. I think there is some basis for reducing the F_2 dimension in the perceptual space (distance from /i/ to /u/) to about half the scale it has in the acoustic space, i.e. to half the scale of the F_1 dimension (distance from /a/ to /ɨ/). Flanagan has found that it takes a considerably greater change in F_2 than in F_1 to make a perceptible difference in vowel quality. (While Flanagan's figures for different vowels vary considerably, the average change in F_1 needed to get 80% judgments of a change in vowel quality was about 30 hz, while the change in F_2 needed to get similar judgments averaged about 75 hz.)

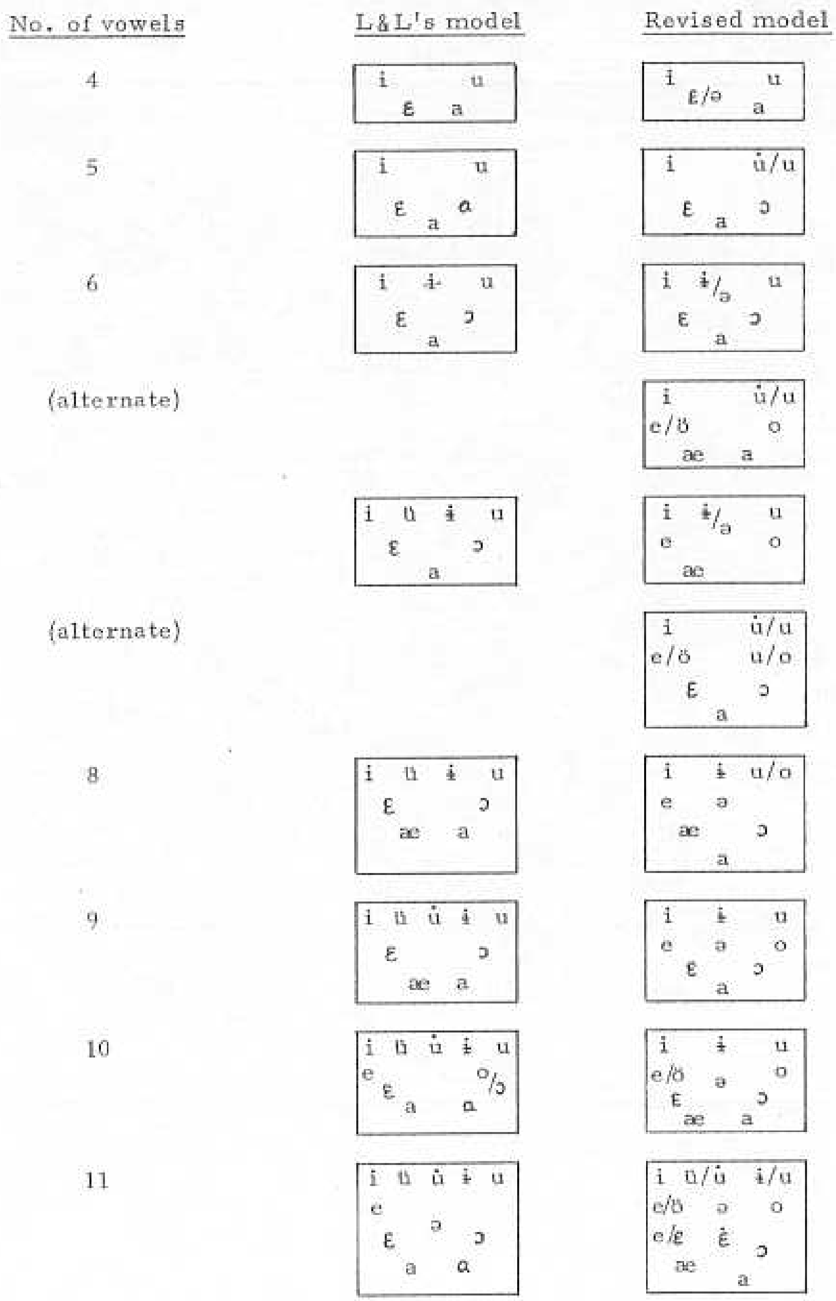
Lindblom, in coming to grips with this problem, has made a similar, though more complex, change in the model, reducing the contribution of F_2 (and higher formants) to the perceptual space in proportion to how low F_1 is. High vowels /i u/ with low F_1 suffer the greatest reduction in the theoretical perceptual salience of higher formants; i.e. the distance between /i/ and /u/ is considerably reduced. As an empirical basis for this change Lindblom cites data on DUTCH vowels, showing that confusions between vowels are correlated strongly with differences in F_1, but weakly with distance in an F_1-F_2-F_3 acoustic space.

This change of scale makes the theoretical model of the vowel space correspond much more closely than a strictly acoustic scale to the empirically determined average dimensions of vowel systems. As observed earlier (Sec. 3.2), the horizontal distance /i-u/ is empirically more or less equal to the vertical distance /a-ɨ/, whereas in the original L&L model the former is about twice the latter. It would be nice to be able to say that this change in scale is directly motivated by our understanding of vowel perception. However, as it stands we only have a few general indications, just cited, that F_1 is more important perceptually than higher formants. The proper weighting remains to be determined.

In Fig. 11 the vowel systems predicted by the revised model are compared with the predictions of the original model. An advantage of the revised model is that it allows construction of 'reasonably good' non-optimal systems, some of which are offered for comparison in Fig. 11. The general criterion I adopted for such systems was that the diameter of the vowels should be larger than in the next larger optimal system. For example, the alternate seven vowel system is better (the vowels have a larger diameter) than what one would obtain by simply removing a suitable vowel from the optimal eight vowel system.

No. of vowels	L&L's model	Revised model
3	i u a	i u a

Figure 11.
(continued next page)



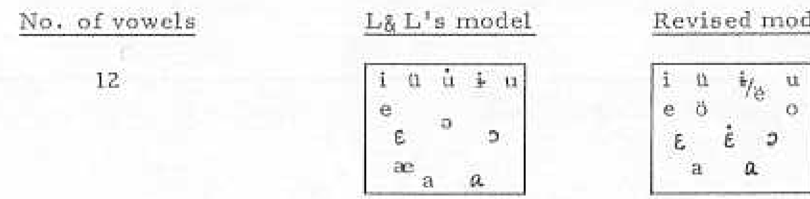


Figure 11

4.4 Comparison of predicted and actual systems

Three vowels The predictions of the two models are the same and agree with actual types.

Four vowels The revised model allows the fourth vowel to range anywhere from /ɛ/ through /ə/ to nearly /ɨ/. This allows for both the 4:0 and 4:1 systems, whereas the original model only generates 4:0. An additional contribution of the revised model is that it shows the four vowel system to be inefficient — the vowel diameter in this system is only slightly larger than in the 5:0 system, but much smaller than in the 3:0 system. To put it another way, if you remove a vowel, say /ɔ/, from the 5:0 system, it is very difficult to reposition the remaining four vowels so that they will make use of the extra space; most of it just goes to waste. This may explain why four vowel systems are less common than the 3:0 or 6:1 systems, even though they are close to the optimal number of vowels.

Five vowels Both predictions are similar, and correspond closely to the 5:0 type. The revised model shows a slight shift of /u/ toward /u̇/. Two languages in the sample show this (JAPANESE and GARO), but it is not a general trend.

Six vowels Both models predict the common 6:1 system. An alternate system is reasonably close to the less common 6:0 type.

Seven vowels Both models fail to generate either of the common seven vowel systems, 7:2 and 7:0. However, the revised model comes a good deal closer, in generating the intermediate 7:1 system (found in three languages in the sample), while L&L's model generates a relatively unnatural system with both /ü/ and /ɨ/. (ALBANIAN, with 7:2, comes closest to this.) An alternate system is fairly close to 7:0. The empirical 7:2 system can be obtained from the predicted eight vowel system by removing a low vowel.

Eight vowels There are no common eight vowel systems. The revised model seems to be reasonably close, in predicting 8:2, since 8:1, 8:2 and 8:3' are all attested. There are no cases of 8:2' with both /ʉ/ and /ɨ/, as predicted by the original model.

Nine vowels The revised model offers a good match for the common 9:2 system. The original model is badly off here in predicting three interior high vowels /ʉ u̇ ɨ/. The 9:2'' system comes closest to the original model, but is still not a good match, there being only two interior high vowels.

Ten, eleven and twelve vowels There are too few actual systems of these sizes to make detailed comparison worthwhile. The original model again predicts too many high interior vowels, while the revised model generates a more nearly vertical arrangement of the interior vowels, which is closer to the actual systems. Both actual systems 10:2 and 11:3 are predicted by the revised model.

The general success of the revised model in predicting actual vowel system types can be judged in the following table, in which I give the types and numbers of actual vowel systems which are 1) good matches for the predicted systems, 2) obtainable by removing one vowel from the optimal system of the next larger size, and 3) obtainable by removing two vowels from an optimal system. (In most cases the vowels to be removed are interior vowels, mid vowels, or low vowels; in a few cases /u/, but never /i/). For comparison the number of good matches for the original model is also given, showing that the improvement is found in the larger vowel systems.

Table 10.a Relation of predicted to actual vowel systems

good match		remove one V from predicted system		remove two V from predicted system	
type	no. of languages	type	no. of languages	type	no. of languages
3:0	23	6:0	7	*5:2	1
4:0	13	7:0	11		
4:1	9	7:2	14	*6:2'	2
5:0	55	*5:1	5	8:3'	3
6:1	29	**5:1	2	9:2''	3
7:1	3	8:1	2	9:3'	4
8:2	2	*5:0	1	10:3''	1
9:2	7	*6:0	1		
10:2	2	**6:0	1		
11:3	1	*9:2	1		
		10:3	1		
total	144 (70%)	total	46 (23%)		14 (7%)

Table 10.b L&L model related to empirical vowel systems

type	3:0	4:0	5:0	6:1	total
no. of languages giving good match	23	13	55	29	120 (58%)

4.5 Comparison with random hypothesis. While it seems obvious that in some sense the L&L model (and the revised version) predict possible vowel systems, in order to actually demonstrate this it is necessary to show that the systems predicted differ in some clear way from what would be predicted by a more random arrangement of vowels. This can be done by an example of possible random arrangements of a certain number of vowels. Let us imagine the vowel space divided into 16 compartments representing vowels qualities known to be distinct in some of the world's languages (see Fig. 12).

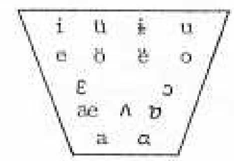
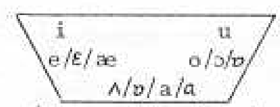
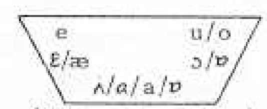


Figure 12

We then consider possible five vowel systems containing any combination of five of the 16 vowels. If the number of such systems which is reasonably close to a 5:0 system, when compared with the total number of combinations, comes anywhere near the actual percentage which the 5:0 system represents of all actual five vowel systems (86%), then obviously we can dispense with the vowel dispersion theory, and explain vowel system typology as due to random arrangements of perceptibly different vowels. Given the 16 vowels, the total possible number of five vowel systems is 16!/11! 5! = 4,368. Interpreted somewhat loosely, matches for the 5:0 system could be obtained by the following combinations:



(33 combinations)



(28 combinations)

The total of 61 vowel systems represents just 1% of all possible combinations. Another 300 or so possible combinations come reasonably close to some other attested five vowel system (*5:1, etc.), which still adds up to less than 10% of the possible random combinations. In other words, 10% of the random possibilities account for 100% of attested five vowel systems. Clearly, the random hypothesis is untenable in anything like this form.

4.6 Limits to predictability

The extent to which vowel quality systems are predictable must not be overemphasized. What we find is not absolute predictability, but clustering of types around general norms. The success of the model lies in the fact that it separates these norms (the predicted vowel systems) on a principled basis from other conceivable arrangements which are abnormal or altogether unattested. An analogy might be the kinds of predictions made by theoretical models of weather systems. It is possible for such models to simulate real weather conditions, beginning with factors such as the size of the earth, rate of rotation, amount and distribution of solar radiation at different seasons, distribution of continents and oceans, density of the atmosphere, rates of water evaporation, etc. It would be unreasonable to judge a model a failure if it failed to predict the skiing conditions in Sun Valley in January, 1980. It would probably be quite a success just to predict the average annual snowfall within a few feet. In fact, a model might be judged a success if it just showed snow falling in the right parts of the world at the right times of year.

Randomness is found in several different aspects of vowel system typology. First, the number of basic vowel qualities in languages ranges from three to about twelve. Even if we take note of the fact that the most frequently utilized vowels in any language are likely to be those that are typologically the most common, i.e. short, non-nasal /i e a u o/ (Greenberg 1966), this still represents a considerable degree of randomness in vowel system typology. Second, the exact phonetic value of the vowel phonemes of any particular type of system varies from one language to the next. For example, the theoretical model predicts /ɛ/ and /ɔ/ as the mid vowels of a 5:0 system. Of 55 actual systems, 13 are explicitly described as having 'higher mid' /e/ and /o/, rather than /ɛ/ and /ɔ/. Variability of about this degree is built into the whole classification of vowel systems I have presented, and has to be kept in mind when the predictions of the model are judged. Another instance is the assignment of /ɨ/ and /ü/ to the same general position. The model makes no distinction between these two vowels in the predicted systems 6:1, 7:1, 8:2, 9:2, 10:2 and 11:3, so this remains a random element. Third, all of the systems which can only be obtained by altering a predicted system (30% of the sample of course represent a degree of randomness for the model. Finally, it must be remembered that a set of

complicating factors has been ignored. Vowel quality may play an auxiliary role in distinguishing short oral vowels from other vowel types, such as long vowels, nasal vowels and diphthongs. Languages which have similar basic vowel quality systems may differ considerably in the employment of vowel quality in any of the other functions.

4.7 Prediction of universals

Since the dispersion model generates the major empirical vowel system types, and since universal rules are derived from typology, it obviously follows that many of the empirical universals are in fact predicted by the model. This is my justification for saying that the universals do not have any kind of independent status, but are simply instances of much more general principles, namely those built into the dispersion model. This can be seen in detail in the vowel hierarchy based on vowel systems generated by the model (see Fig. 13). This ordering of vowel types corresponds pretty closely to the empirically based orderings presented in Fig. 10.

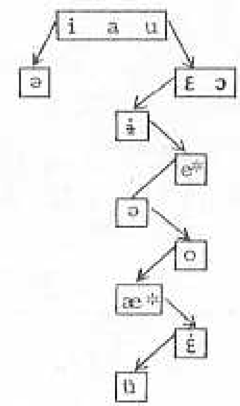


Figure 13. Vowel hierarchy predicted by model
(*These two vowels could be interchanged.)

To put it another way, most universals which concern the quality of the vowels in a system of a given size are predicted by the model, the seven vowel systems being an exception. On the other hand, universals concerning the number of vowels in a basic system are not predicted. The situation is summarized in the following table (Table 11).

Table 11. Comparison of actual universals with predictions of model

Universal*	Prediction
1. All languages have /i a u/.	-Three vowel minimum not predicted. -Predicted for languages with three or more vowels.
2. Four V include /ɨ/ or /ɛ/.	-Predicted.
3. Five V include /ɛ/, generally also /ɔ/.	-Both /ɛ/ and /ɔ/ predicted, but not ranked.
4. Six V include /ɔ/, also /ɨ/ or /e/.	-Predicted. Model prefers /ɨ/ as sixth V.
5. Seven V include /e o/ or /ɨ ə/.	-Model predicts /e ɨ/, which is wrong, but at least involves two of the correct V.
6. Eight V include /e/.	-Predicted (for seven V).
7. Nine V include /o/.	-Predicted (but note high number of actual exceptions).
8. Five V is optimal number.	-Not predicted.
9. Height distinctions equal or exceed backness distinctions.	-Not predicted. (This feature is built into the model on the basis of typological evidence. There is some experimental basis (Sec. 4.3).)
10. Interior height distinctions do not exceed front or back height distinctions.	-Predicted.
11. Two interior V include one high V.	-Predicted.
12. Height distinctions in front V equal or exceed those in back V.	-Predicted.

*See Appendix II for a restatement of universals. Those dealing with the relation of the basic vowel system to other systems are not included in this chart.

4.8 Functional nature of the universals

The model of vowel systems presented above is a functional one in the sense that it relates phonological structure to factors operating

in the ordinary use of language. Stated simply, the idea is that since the linguistic function of sounds is to distinguish different meaningful elements, one would expect the dominant types of phonological system to be those which make the most efficient use of the human sound production and perception abilities. Of course a general notion like 'efficient use' cannot be appealed to in the abstract; it has to be exemplified by close study of the production and perception of human speech sounds. The L&L model of the vowel space and the achievements of modern phonetics which stand behind it clearly show how this notion can be given a concrete meaning. The notion of 'dominant type of sound system' has to be established by collection of a sufficiently large and representative group of accurate linguistic descriptions. I have tried to show, in this paper, how a data base such as the Stanford Phonology Archive can be used for this purpose. The fact that a number of the generalizations arrived at here concerning vowel systems were known or suspected before, on the basis of other data collections, encourages me to believe that large collections of this sort of descriptive data will tend to converge on the same range of types or norms, in spite of a number of methodological and theoretical uncertainties.

The functional approach differs in several respects, two of which I discuss briefly here, from the major current phonological theory, generative phonology. First, the functional approach includes highly explicit phonetic models, in this case a model of the vowel space. In contrast generative phonologists have sought to reduce phonetic description to feature systems, with a relatively limited number of features and distinctions within each feature (only two at the 'classificatory' level). While features, when properly defined, have the virtue of characterizing the kinds of contrasts or types of rules that typically occur in languages, the justification for a particular system of features and the system of relations between features (marking conventions, etc.) is not readily apparent in the features themselves. For example, the features [high, low, back, round], interpreted as binary features, are obviously largely sufficient for characterizing the kinds of vowel contrasts that occur in the world's languages; similarly, the marking convention to the effect that mid vowels are less complex than front rounded or back unrounded vowels reflects a well established typological fact. But the generative model, in stopping with the mere statement of these facts, however elegantly expressed, fails to explain why these features or this marking convention, rather than different features or an opposite marking convention, should be the ones which are actually true or appropriate for human language. It is only by moving on to an explicit phonetic model that we can justify either. In this sense a functional model achieves a type of explanation which lies beyond the range of the formal descriptive devices of generative phonology.

A second difference concerns the character and assumed basis of phonological universals. Most phonologists would agree that phonetics plays a prominent role in phonological universals. The careful attention given by Chomsky and Halle to the phonetic basis of distinctive features gives evidence of this. However, in the generative literature, primary emphasis in the search for phonological universals has been given to definition of the right classificatory feature system and development of the proper formal devices for description of phonological processes. The assumption behind this appears to be that the organization of phonological information in the human mind is highly formal, that the phonological structure of a language constitutes a highly complex formal organization imposed on the raw phonetic materials. If this assumption is true, then of course special attention must be given to this formal level, and the phonologist can expect to learn something important about phonological universals simply by investigating the interaction of formal devices in linguistic descriptions. The functionalist approach, in contrast, emphasizes the centrality of phonetics and the single functional principle of perceptual contrast. From this point of view, what is important in the phonological organization of individual languages is just that this organization constitutes a set of limitations on the contrastive role of the phonetic materials. To put it another way, the generativist assumes complex, innate phonological structure <u>in addition to</u> innate phonetic capacities, while the functionalist does not. Which of these viewpoints will prove most revealing in accounting for the entirety of phonological universals remains to be seen. However, in the limited area of vowel systems, a functional model is quite successful, and this confirms, for this area, the assumption that explicit phonetic models and the concept of perceptual contrast give a sufficient basis for explaining phonological systems.

APPENDIX I
Universals restated

1. All languages have /i a u/.
2. All languages with four or more vowels have /ɨ/ or /ɛ/.
3. Languages with five or more vowels have /ɛ/. They generally also have /ɔ/.
4. Languages with six or more vowels have /ɔ/ and also either /ɨ/ or /e/, generally the former.

5. Languages with seven or more vowels have /e o/ or /ɨ ə/. (The types /ɨ ə/ may be represented by /ü ö/.)
6. Languages with eight or more vowels have /e/.
7. Languages with nine or more vowels generally have /o/.
8. A contrast between five basic vowel qualities is the norm for human language, and in general, the most common systems are those with close to this number of basic vowels.
9. The number of height distinctions in a system is typically equal to or greater than the number of backness distinctions.
10. Languages with two or more interior vowels always have a high one.
11. The number of vowels in a column of interior vowels cannot exceed the number in the front or back columns.
12. The number of height distinctions in front vowels is equal to or greater than the number in back vowels.
13. There is a tendency for high and low vowels of a short vowel system to be more central than the corresponding long vowels.
14. The number of vowels in a nasal vowel system is equal to or less than the number in the corresponding oral vowel system.
15. If a nasal vowel system is smaller than the corresponding basic vowel system, it is most often a mid vowel that is missing from the nasal system.

APPENDIX II
Vowel categories used by Stanford Phonology Archive

Front		Central		Back		
i	ü	ɨ	u̇	ɯ	u	High
I	Ü	ɪ̵	U̇	Ɪ̆	U	Lower-high
e	ö	ė	ȯ	ë	o	Higher-mid
E	Ö	ə	Ȯ	Ë	O	Mid
ɛ	ɔ̈	ɛ̇		ʌ	ɔ	Lower-mid
æ		æ̇			ɒ	Higher-low
ä		a	ȧ	ɑ	ɒ	Low

unrounded rounded

Length is indicated in Appendix III by a raised dot (˙), nasalization by a tilde (˜). The symbol (>) for 'retraction' is used in <u>ad hoc</u> ways explained in the notes. It should be remembered that <u>this</u> chart merely represents a convenient set of categories for labelling the kinds of things that descriptive linguists say about vowels, and is not meant to present a phonetic or phonological theory of vowels.

APPENDIX III

List of sample languages by basic vowel system type

(Notes at the end of the list)

? 2:0	KABARDIAN[1]	ɨ ɛ̇ // i· E· a· u· O·
3:0	ALABAMAN	I a o// e· a· o·
	ALASKAN ESKIMO	i a u// i· a· u·
	ALEUT	i a u
	AMUESHA	e a o// e· a· o·
	DIEGUEÑO[2]	I a U//e· a· o·
	GADSUP	i ɛ̇ u// e· ä· o·
	GREENLANDIC ESKIMO	i a u// I· a· U·
	HAIDA[3]	i a U
	JAQARU	i a ɯ// i· a·ɯ·
	KAROK	i a U// i· e· a· U· o·
	LAK[4]	i a u// i· a· u·
	MANTJILTJARA	i a u// i· a· u·
	MOROCCAN ARABIC	i æ u
	NUNGGUBUYU	I æ̇ ɯ // a·
	NYANGUMATA	I a U// i· a· u·
	OJIBWA[5]	I a U// i· ɛ· a· o· //ĩ· ɛ̃· ã· õ·
	PUGET SOUND SALISH	I a U
	QUECHUA[6]	I a U
	SHILHA	i a u
	TAGALOG[7]	I ə U (e o)// i· a· u· (e· o·)
	TELEFOL	I ɛ̇ U// i· ɛ· a· u· o·
	TOTONAC	i a u// i· a· u·
	WESTERN DESERT LANGUAGE	i a U// i· a· u·
4:0	ALAWA[8]	i E a ɯ
	CAMPA	i e a o
	CAYAPA	i ɛ U ɑ
	CHAMORRO[9]	i æ u ɑ
	HUPA	I E a O// E· a· O·
	MALAGASY	i E a U
	MAZATEC	i ɛ a o// ĩ ɛ̃ ã õ
	MOXO	i ɛ a u
	NAVAHO	I ɛ a ɔ// i· ɛ· a· o·// ĩ ɛ̃ ã ɔ̃
	NOOTKA	I ɛ ə U// i· æ· a· u· ɔ·
	ONEIDA	i E a O// i· E· a· O·//ə̃ ũ
	PAEZ	i ɛ a u// ĩ ɛ̃ ã ũ
	WICHITA	i ɛ u ɑ// e· ɛ· o· ɑ·

4:1	ADZERA	i a ɯ o// i· a· o·
	AMAHUACA	I a ɯ o// ĩ ã ɯ̃ õ
	CHACOBO	i a ɨ O
	JIVARO	i a ɯ u// ĩ ã ɯ̃ ũ
	KWAKIUTL	i a ə u // i· a· u·
	MARGI	i a ə u
	PASHTO	i a ə u// E· O· a·
	SQUAMISH	e a ʌ o
	WAPISHANA	i a ɨ u// i· a· ɨ· u·// ĩ ã ɨ̃ ũ
5:0	AWIYA[10]	i E a u O
	ATAYAL	i ɛ a u ɔ// i· u·
	AROSI	i ɛ a u ɔ// i· ɛ· a· u· ɔ·
	ASMAT[11]	i e a u ɔ
	AUYANA	i e ə u O
	AINU	i ɛ a u ɔ
	BATAK	i ɛ a u o
	BASQUE	I E a u O
	BULGARIAN[12]	i ɛ u ɔ ɑ
	BURUSHASKI	i E a u O// i· E· a· u· O·
	CANTONESE (TAISHAN)[13]	i æ a u ɔ
	DAKOTA	i e a u o// ĩ ã ũ
	DIDO[14]	i E u o ɑ //E· ɑ·
	EGYPTIAN ARABIC[15]	I E ä U O (ɑ)// i· E· ä· u· O· (ɑ·)
	FULANI	I e æ̇ U o// i· ɛ· a· u· ɔ·
	GBARI	i e a u o
	GEORGIAN	I E ä U O
	GARO	i E a u̇ o
	HAKKA	i ɛ a u ɔ
	HAUSA	I E ə U O// i· E· a· u· O·
	HAWAIIAN	i E a u O// i· E· a· u· O·
	JAPANESE	i ɛ a u̇ o // i· ɛ· a· u· ɔ·
	KUNIMAIPA	i e a u U
	KUNJEN	I ɛ a U O
	KALIAI	i E a u O// i· E· a· u· O·
	KHASI[16]	I ɛ a U ɔ// i· ɛ· a· u· ɔ·
	KHARIA	i e a u o// ĩ ɛ̃ ã ũ õ
	KOTA	i E a u O
	LAKKIA	i ɛ a u ɔ// ĩ ɛ̃ ã ũ ɔ̃
	LUVALE	i e a u o// i· e· a· u· o·
	LUISEÑO	I E a U O// I· E· a· U· o
	MIXTEC	i e a u o// ĩ ã ũ õ
	MAUNG	i ɛ a u o
	MAORI	i ɛ u ɔ ɑ // i· E· u· o· a·

5:0	MUNDARI	I E a U O
	MALTESE ARABIC	i E a u O//i· E· a· u· O·
	BEEMBE	i ɛ a u ɔ//i· ɛ· a· u· ɔ·//ĩ ɛ̃ ã ũ ɔ̃
	NAMA[17]	i e ä u o //ĩ ã ũ õ
	NASIOI	i ɛ a u o //i· ɛ· a· u· o·
	NUBIAN	i E a u O//i· E· a· u· O·
	POMO	I ɛ a U ɔ//I· ɛ· a· U· ɔ·
	RUSSIAN	i ɛ ä u O
	RYUKYUAN	i E a u O//i· E· a· u· O·
	SPANISH	i E a u O
	SWAHILI	i E a u O
	TELUGU	I e ə U o//i· e· æ· a· u· o·
	TEWA[18]	i E ɑ u O//i· e· ä· u· o·//ĩ ɛ̃ ɑ̃ ũ
	TZELTAL	I E a U O
	WIK MUNKAN	i ɛ a U ʌ//i· ɛ· a· U· ʌ·
	WALAMO	i E a u O // i· E· a· u· o·
	WOLIO	i e a u o//?i· e· a· u· o·
	ZAN	i E a u O
	ZOQUE	i ɛ a u O//Ẽ
	ZULU	i ɛ å u ɔ //i· ɛ· å· u· ɔ·
	ZUNI	i ɛ a u ɔ // i· ɛ· a· u· ɔ·
*5:0	SENECA	i e æ a O//i· e· æ· a· O·//ɛ̃ ɔ̃
*5:1	ISLAND CARIB	i E a Ë u//ĩ Ẽ ã Ë̃ ũ
	MARANUNGKU	i æ a ə U
	NEZ PERCE	I æ a Ï ɔ//i· æ· a· ɯ· ɔ·
	OCAINA	i ɛ a ɯ O//ĩ ã ɯ̃ Õ
	TOLOWA	i E a ə u//i· E· a· u·//ĩ ã ũ
**5:1	EVENKI	i æ ə u O//i· E· æ· ə u· O·
***5:1	PAPAGO	i a ɨ u o// i· a· ɨ· u· o·
*5:2	MANDARIN	i ü a ë u
6:0	CHIPEWYAN	i e ɛ a u o//i· ɛ· a· u·//ĩ ɛ̃ ã ũ
	LITHUANIAN	i ɛ æ U ɔ ɑ //i· e· æ· u· ɔ· ɑ·
	PERSIAN	i e ä u o ɑ
	SELEPET	i ɛ a u o ʌ
	SINHALESE[19]	I E ä a U O//i· e· æ· a· u· o·
	SONGHAI[20]	i e ɛ a u o//i· E· a· u· o·
	YUCHI	i e æ u o ʌ//ĩ Ẽ ã Ũ Õ
*6:0	ENGLISH (RP)	I E æ æ̇ U ɑ//i· ə· u· O· ɑ·

**6:0	EWE[21]	i ɛ a u o ɔ//i· ɛ· a· u· o· ɔ· (e·)//ĩ ɛ̃ ã ũ õ ɔ̃
6:1	ANGAS	e ɛ I̵ a u o//i· ɨ· a·
	ARAUCANIAN	i ɛ a ɯ u ɔ
	BARASANO	i ɛ a ɨ u o//ĩ ɛ̃ ã ɨ̃ ũ õ
	BODO	i E a ə u ɔ
	CARIB	i E æ̇ ɯ u O//i· E· æ̇· ɯ· u· O·
	CHONTAL	i E a ɔ u O
	CHUKCHI	i E a ɔ u O
	DAGBANI[22]	i ɛ a ə u ɔ//i· e· a· u· o·
	DELAWARE[23]	i ɛ a ə u ɔ//i· æ· a· u· ɔ·//ĩ· æ̃· ã· ə̃· ũ· ɔ̃·
	GILYAK[24]	i E a ɨ u O
	GOAJIRO[25]	i ɛ a ə u ɔ//i· ɛ· a· ə· u· ɔ·//ĩ ɛ̃ ã ũ ə̃ ɔ̃
	GUARANI	i E a ɨ u O//ĩ Ẽ ã ɨ̃ ũ Õ
	IRAQW	i ɛ a ə U ɔ//i· e· u· o· ɑ·
	ITONAMA	i e a ɨ u o
	KANURI	i E ä ɨ u O
	KET[26]	i ɛ ä ɨ u ɔ//i· ɛ· ä· i· u· ɔ·
	KURUX	i E a ə u O//i· E· a· ə· u· O·//ĩ Ẽ ã ũ Õ
	MAIDU	i E a ɨ u O
	MALAY	i e a ə u o
	MALAYALAM	I e a ɨ U ɔ//i· e· a· u· o·
	PICURIS	i e ə u o ɑ//ĩ ẽ ə̃ ũ õ ɑ̃
	POLISH	i ɛ ɨ u ɔ ɑ// ɛ̃ ɔ̃
	SA'BAN	i ɛ a ɨ u ɔ
	SIRIONO[27]	i e a i̵ u o//ĩ ẽ ã ĩ̵ ũ õ
	TARASCAN[28]	i ɛ a ɨ u o
	TICUNA	i E a ɨ u O//ĩ ã ɨ̃ ũ Õ
	WU	i E ü a u O//ĩ æ̃ Õ
	YUKAGHIR[29]	I ɛ ä ə u O//?i· a· u· o·
	YURAK[30]	i E Ë u O ɑ//?a·
*6:2'	HOPI	i ɛ ö a ë o//i· ä· ö· a· ë· o·
	CHUVASH	i E ü ɯ u ɑ
7:0	BENGALI	i E æ a u o ɔ//ĩ Ẽ æ̃ ã ũ õ
	BURMESE[31]	i e ɛ a u o ɔ//ĩ æ̃ Ũ
	GA	i e ɛ ä u o ɔ//ẽ ɛ̃ ä̃ ũ ɔ̃
	GBEYA[32]	i e ɛ a u o ɔ// ĩ æ̃ ã ũ ɔ̃
	ITALIAN	i e ɛ a u o ɔ
	KPELLE	i I ɛ a u U ɔ//i· I· ɛ· a· u· U· ɔ·//ĩ ẽ ɛ̃ ã ũ õ ɔ̃
	NENGONE	i e ɛ a u o ɔ//i· e· ɛ· a· u· o· ɔ·
	PORTUGUESE	i e ɛ a u o ɔ//ĩ ẽ ɛ̃ ũ õ
	SEDANG[33]	i e æ a u o ɔ// ĩ ã õ ɔ̃

(7:0)	TUNICA	i e ɛ a u o ɔ
	YAO	i e æ a u o ɔ//a·
*7:1	SENTANI	i e ɛ ä ə u ɔ
	WASHKUK	i e ɛ a ɨ u O
	WOLOF[34]	i e ɛ a ə u ɔ//i· e· ɛ· u· o· ɔ· a·
7:2	ALBANIAN	i E ü ə u O a
	AMHARIC	i e a ɨ ə u o
	BRETON[35]	i E ä ü Ö u O//i· ɛ· ü· ö· u· o· ɑ·//ɑ̃·
	DAFLA	i ɛ ɯ ʌ u ɔ a//i· ɛ· ɯ· ʌ· u· ɔ· a·
	GERMAN[36]	I ɛ Ü ɜ æ U ɔ//i· e· ü· ö· a· u· o·
	HUNGARIAN	i ɛ ü ö u o ɑ//i· e· ü· ö· a· u· o·
	KOHO[37]	i ɛ a ɯ ɤ u ɑ//i· e· ɛ· a· ɯ· ɤ· u· o· ɑ·
	KOMI	i E a ɨ ə u O
	MONGOLIAN	i e ü Ö U ɔ a //I· e· ü· Ö· ɔ· a·
	NAGA	i E a ɯ ə u O
	RAWANG	i E a ɨ ə u O//i· E· a· ɨ· ə· u· O·
	SUNDANESE[38]	i ɛ a ɨ ə u o
	RUMANIAN	i e a ɨ ə u o
	YAY[39]	i ɛ a ɯ ə u O//a·
8:1	EWONDO	i e ɛ a ė u o ɔ//i· e· ɛ· a· ė· u· o· ɔ·
	JAVANESE	i e ɛ a ɔ u o ɔ
?8:1	APINAYE[40]	i e ɛ a ɯ u o ɔ//ĩ ɛ̃ ã ɯ̃ ũ õ
	MIANKA	i e ɛ a ö u o ɔ//ĩ ẽ ã ö̃ ũ õ
8:2	ICELANDIC	i e ɛ ö ɜ u o ɑ
	TIBETAN	i ɛ æ ü ö a u o//i· ɛ· æ· ü· ö· a· u· ɔ·// ?ĩ· ɛ̃· ã· ũ· ü̃· ö̃·
8:3'	CHEREMIS	i ɛ ü Ö ə ʌ u ɔ
	KIRGHIZ	I ɛ ü ö a ɨ U o//I· ɛ· ü· ö· ɨ· U· o·
	TURKISH	i ɛ ü ɜ a ɯ u O
9:2	CHAM	i e ɛ a ɨ ə u o ɔ
	KAREN	i e ɛ a ɨ Ė u o ɔ
	LAHU	i e E a ɨ e u o ɔ
	LAO	i e ɛ a ɯ Ë u ɔ ɑ//i· e· ɛ· a· ɯ· Ë· u· O· ɔ· ɑ·
	MAZAHUA	i e ɛ a ə ʌ u o ɔ //ĩ ẽ ã ə̃ ũ õ
	NUNG	i e ɛ É ɨ ė u o ɔ//æ· a· ɑ·
	OTOMI	i e æ a ɨ ə u o ɔ//ĩ æ̃ ã ũ
9:2"	AKAN[41]	i I e ɛ a u U o ɔ//ĩ Ĩ ã Ũ ũ
	GREBO[42]	i e e˞ ɛ a u o o˞ ɔ//ĩ ẽ ɛ̃ ã ũ õ ɔ̃
	LUO[43]	i I E ɛ a u U O ɔ

*9:2	SOMALI	I e ɛ æ Ú Ó ə U ɔ//I· e· ɛ· æ· Ú· Ó· a· U· ɔ·
9:3'	AZERBAIJANI	i ɛ ä ü ö ɯ U o ɑ
	KOREAN	i e æ ö a ɯ ɤ u o//i· e· æ· ɯ· ɤ· u· o·
	NORWEGIAN	I E æ Ü ɜ a ů u ɑ//i· e· æ· ü· Ö· a· ů· u· O·
	OSTYAK	i E ä ü Ö ɯ u O ɑ
10:2	IAI	i e ɛ æ ü ɜ a u o ɔ//i· e· ɛ· æ· ü· ɜ· a· u· o· ɔ·
	VIETNAMESE	I e ɛ æ Ï ë ʌ U o ɔ//ä·
10:3'	AKHA	i e ɛ ö a ɯ ə u o ɔ
10:3"	PANJABI	i I E æ a ə u U O ɑ//ĩ Ĩ Ẽ æ̃ ã ə̃ ũ Ũ Õ ɑ̃
?10:3"	LOGBARA	i I e ɛ a ɛ́ u U o ɔ// i· I· e· ɛ· a· ɛ́· u· U· o· ɔ·
11:3	FRENCH	i e ɛ ä ü ö ɜ u o ɔ ɑ //æ̃ ɜ̃ õ ɑ̃
?12:3	PACOH	i e˄ e ɛ ɨ ə˄ ə a u o˄ o ɔ// i· e˄· e· ɛ· ɨ· ə˄· ə· a· u· o˄· o· ɔ·

Notes:

1 The short vowels of KABARDIAN seem to form a reduced system. See Sec. 2.4 on two vowel systems.

2 I have analyzed DIEGUEÑO /ə/ as a neutral vowel.

3 The HAIDA vowel system presented here is not certain.

4 LAK has three 'guttural' (gortanye) vowels. Possibly they are pharyngealized (cf. DIDO (5:0)). Depending on the details, this could be a six vowel system.

5 OJIBWA long nasal vowels occur as independent phonemes word finally. Short nasalized vowels are the result of loss of /n/ before /s/.

6 /E O/ occur in SPANISH loans.

7 TAGALOG /e o/ occur in ENGLISH and SPANISH loans. Apparently, there is still some instability.

8 ALAWA probably derives from a 3:0 system, but has developed a new contrast, /ɛ/, though it is not an especially common vowel.

9 CHAMORRO /e o/ have been set aside as SPANISH loans. /æ/ has a somewhat marginal status; it is chiefly derived from /a/ after /i/ in a preceding syllable, but there is a certain amount of contrast.

10 AWIYA has a /ə/, but it seems to be a transitional sound in consonant clusters.

11 The grammar says that /ə/ is an independent phoneme, but I can find it only in unaccented position in the examples given.

12 A neutral vowel /ə/ occurs unstressed in BULGARIAN.

13 Other CANTONESE dialects have quite different vowel systems.

14 DIDO has a full set (5) of pharyngealized vowels. There seems to be a question as to whether they can be interpreted as allophonic variants adjacent to pharyngealized consonants. If not, this is a ten vowel system.

15 According to the grammar, there is a marginal contrast between /ä/ and /ɑ/, which are chiefly in complementary distribution. This is difficult to evaluate.

16 The grammar treats /i/, which contrasts with /I/ as /ii/, though, apparently, it is not as long as the other long vowels. I treat /i/ as long. Phonemic status of long vowels uncertain.

17 NAMA has an [ə] which seems to be in complementary distribution with [i].

18 TEWA also has /æ/, which is at best marginal (three instances reported).

19 SINHALESE has a /ə/ that may be marginally contrastive.

20 The contrast of /e/ and /ɛ/ is hard to evaluate. They may contrast only finally.

21 Stahlke (1971) calls /ɛ/ and /ɔ/ 'retracted.'

22 DAGBANI /ə/ does not occur in open syllables and is partially in complementary distribution with /i/, but there seems to be a certain amount of contrast.

23 It is not clear that DELAWARE /ə/ is phonemic.

24 GILYAK has four unstable long vowels deriving from vowel followed by velar spirant before consonant.

25 While /ə̃/ is rare, /ə̃i/ is very common.

26 The grammar gives a ten vowel system for KET. But /e o/ seem clearly to be initial allophones of /ɛ ɔ/. The three central unrounded vowels given in the grammar as distinct phonemes are very hard to judge. I have tentatively grouped them into a single phoneme /ɨ/, though there is no clear evidence for this.

27 The symbol /i / represents "a voiced, high, close, front unrounded vowel with friction and back tongue rounding or grooving ...not the same as the back unrounded vocoid found in other TUPI-GUARANI languages."

28 The vowel /ɨ/ is described as 'retroflexed,' and occurs only after sibilants, sometimes being replaced by a long sibilant. The distribution seems suspicious, but there are minimal pairs with most of the other vowels. The situation is difficult to evaluate; in any case the system borders on being 5:0.

29 The /ə/ of YUKAGHIR is described as slightly retracted from the position of /ɛ/ and weakly labialized. Only four long vowels are exemplified.

30 The grammar lists both /i/ and /ɯ/, but from the discussion it appears that they must be in complementary distribution, with /i/ after palatalized consonants, /ɯ/ elsewhere.

31 BURMESE has, in addition, four nasalized diphthongs.

32 /ɛ ɔ/ are harmonic pairs of /e o/, probably 'retracted.'

33 According to the grammar, all the oral vowels of SEDANG have creaky voiced counterparts which are distinctive. There are supposed to be six nasal vowels, but only four are exemplified.

34 WOLOF /ə/ has also been described as /ö/.

35 BRETON /ə/ seems to be a neutral vowel.

36 In some types of GERMAN, /ɛ·/ is marginally distinctive.

37 The long vowels always have falling pitch. /ë/ and /ɑ/ merge in one dialect.

38 Nasal consonants cause extensive nasalization of vowels, which can be considered nondistinctive, except for one very marginal environment.

39 YAY /ə/ is rare in closed syllables.

40 The grammar gives three back unrounded vowels, /ɯ ë ʌ/, but the examples do not establish a contrast.

41 The vowels /I ɛ a U ɔ/ form a harmonically 'retracted' set.

42 GREBO /e˒ o˒/ are 'retracted' or 'muffled.'

43 LUO has extensive vowel harmony. The vowels can be divided into tense and lax, or advanced and retracted sets.

APPENDIX IV
Language references

Abbreviated references are given here for all languages in the sample. Most can be found in their full form in the Bibliography to Working Papers on Language Universals (Fahrenholz 1976). References for all other languages referred to in this paper can also be found there. References not to be found there are marked a code letter, (R) indicating that the full reference is in Ruhlen 1975a; (B) indicating that it is given below under "Bibliography." A complete bibliography for the sample languages can also be obtained on request from the Stanford Phonology Archiving Project, Department of Linguistics, Stanford University, Stanford, California 94305.

ADZERA Holzknecht 1973
AINU Simeon 1969 (R)
AKAN (FANTI) Welmers 1946 (R)
AKHA Katsura 1973
ALABAMAN Rand 1968
ALASKAN ESKIMO Mattina 1970 (R)
ALAWA Sharpe 1972
ALBANIAN Newmark 1957
ALEUT Menovshchikov 1968 (R)
AMAHUACA Osborn 1948
AMHARIC Leslau 1968
AMUESHA Fast 1953

ANGAS Burquest 1971
APINAYE Burgess and Ham 1968
ARAUCANIAN Echeverria and Contreras 1965
AROSI Capell 1971
ASMAT Voorhoeve 1965
ATAYAL Egerod 1966 (R)
AUYANA (USARUFA) Bee 1965
AWIYA (AGAW) Hetzron 1969 (B)
AZERBAIJANI Householder 1965
BARASANO Stolte and Stolte 1971
BASQUE N'diaye 1970
BATAK (TOBA BATAK) Tuuk 1971
BEEMBE (BEMBA) Jacquot 1962
BENGALI Ferguson and Chowdhury 1960
BODO (BORO) Bhat 1968 (B)
BRETON Ternes 1970
BULGARIAN Aronson 1968 (R), Klagstad 1958 (B)
BURMESE Okell 1969
BURUSHASKI Morgenstierne 1945
CAMPA Dirks 1953
CANTONESE (TAISHAN) Cheng 1973 (R)
CARIB Peasgood 1972 (R), Hoff 1968
CAYAPA Lindskoog and Brend 1962
CHACOBO Prost 1967
CHAM Blood 1967
CHAMORRO Topping 1973
CHEREMIS Ristinen 1960
CHINESE Chao 1968; Cheng 1973 (B); Dow 1972 (B)
CHIPEWYAN Li 1946
CHONTAL Keller 1959
CHUKCHI Skorik 1968 (R)
CHUVASH Andreev 1966 (R)
DAFLA Ray 1967 (R)
DAGBANI Wilson and Bendor-Samuel 1969 (R)
DAKOTA Boas and Deloria 1939 (B)
DELAWARE Voegelin 1946
DIDO Bokarev 1967 (R)
DIEGUEÑO Langdon 1970
EGYPTIAN ARABIC Mitchell 1962
ENGLISH O'Connor 1973 (R)
EVENKI Konstantinova 1968 (R)
EWE Berry 1951, Stahlke 1971
EWONDO Abega 1970 (R)
FRENCH Sten 1963
FULANI Stennes 1967
GÃ Berry (no date)
GADSUP Frantz 1966
GARO Burling 1961
GBARI (GWARI) Hyman and Magaji 1970
GBEYA Samarin 1966
GEORGIAN Robins and Waterson 1952; Vogt 1938, 1958, 1971
GERMAN Moulton 1962
GILYAK Panfilov 1968
GOAJIRO Holmer 1949
GREBO Innes 1966
GREENLANDIC Rischel 1974 (B); Thalbitzer 1904
GUARANI Gregores and Suarez 1967; Lunt 1973; Uldall 1956
HAIDA Sapir 1923
HAKKA (CHINESE) Hashimoto 1973
HAUSA Greenberg 1941; Kraft and Kraft 1973 (R)
HAWAIIAN Pukui and Elbert 1965 (B)
HOPI Whorf 1946
HUNGARIAN Hall 1944 (B)
HUPA Golla 1970 (B); Woodward 1964
IAI Tryon 1968
ICELANDIC Malone 1952
IRAQW Whiteley 1958
ISLAND CARIB Taylor 1955
ITALIAN Agard and DiPietro 1969
ITONAMA Liccardi and Grimes 1968
JAPANESE Bloch 1950; Jorden 1963
JAQARU Hardman 1966

JAVANESE Horne 1961
JIVARO Beasley and Pike 1957 (R)
KABARDIAN Kuipers 1960
KALIAI Counts 1969 (R)
KANURI Lukas 1937
KAREN Jones 1961
KAROK Bright 1957
KET Krejnovich 1968 (R)
KHARIA Biligiri 1965
KHASI Rabel 1961
KIRGHIZ Hebert and Poppe 1963
KOHO (SRE) Manley 1972
KOMI Lytkin 1966
KOREAN Cho 1967; Martin 1951
KOTA Emeneau 1944
KPELLE Welmers 1962
KUNIMAIPA Pence 1966
KUNJEN Sommer 1969
KURUX Pfeiffer 1972 (R)
KWAKIUTL Boas 1947
LAHU Matisoff 1973 (R)
LAK Murkelinskij 1967 (R)
LAKKIA Haudricourt 1967 (R)
LAO Roffe 1946 (R)
LITHUANIAN Ambrazas 1966 (R)
LOGBARA Crazzolara 1960
LUISEÑO Bright 1965; Kroeber and Grace 1960; Malecot 1963
LUO Gregersen and Alstrup 1961
LUVALE Horton 1949
MAIDU Shipley 1956, 1964
MALAGASY Dahl 1952 (R)
MALAY Verguin 1967
MALAYALAM Sreedhar 1972 (B)
MALTESE ARABIC Borg 1973
MANTJILTJARA Marsh 1969
MAORI Biggs 1961
MARANUNGKU Tryon 1970
MARGI Hoffman 1963
MAUNG Capell and Hinch 1970 (R)
MAZAHUA Spotts 1953
MAZATEC Pike and Pike 1947
MIANKA Prost 1964 (B)
MIXTEC Hunter and Pike 1969
MONGOLIAN Hangin 1968
MOROCCAN ARABIC Abdel-Massin 1973 (B); Harrell 1962, 1965
MOXO (IGNACIANO) Ott and Ott 1967
MUNDARI Gumperz 1957
NAGA Bhat 1969 (R)
NAMA (HOTTENTOT) Beach 1938
NASIOI Hurd 1966 (R)
NAVAHO Sapir and Hoijer 1967
NENGONE Tryon 1967
NEZ PERCE Aoki 1966, 1970
NOOTKA Sapir and Swadesh 1955 (R)
NORWEGIAN Vanvik 1972
NUBIAN Bell 1971
NUNG Freiberger 1964 (R)
NUNGGUBUYU Hughes and Leeding 1971 (R)
NYANGUMATA O'Grady 1964
OCAINA Agnew and Pike 1957
OJIBWA Bloomfield 1956
ONEIDA Lounsbury 1953
OSTYAK Gulya 1966
OTOMI Blight and Pike 1976 (R)
PACOH Watson 1964
PAEZ Gerdel 1973
PANJABI Gill and Gleason 1963
PAPAGO Hale 1959 (B); Saxton 1963
PASHTO Shafeev 1964
PERSIAN Obolensky, Panah and Nouri 1963
PICURIS Trager 1971
POLISH Wierzchowska 1965
POMO Moshinsky 1974 (B)
PORTUGUESE Head 1964 (R)
PUGET SOUND SALISH Snyder 1968 (R)
QUECHUA Bills 1969; Lastra 1968
RAWANG Morse 1963
RUMANIAN Agard 1958
RUSSIAN Jones and Ward 1969
RYUKYUAN Martin 1970 (R)

SA'BAN Clayre 1973
SEDANG Smith 1968
SELEPET McElhanon 1970
SENECA Chafe 1967
SENTANI Cowan 1965
SHILHA Applegate 1958
SINHALESE Coates and de Silva 1960
SIRIONO Priest 1968
SOMALI Armstrong 1964
SONGHAI Prost 1956 (B)
SPANISH Navarro 1961
SQUAMISH Kuipers 1967
SUNDANESE Anderson 1972; Robins 1953, 1957; Van Syoc 1959
SWAHILI Polome 1967
TAGALOG Schachter and Otanes 1972
TARASCAN Foster 1969 (R)
TELEFOL Healy 1964
TELUGU Lisker 1963
TEWA Hoijer and Dozier 1949
TIBETAN Chang and Shefts 1964 Roerich and Dhuntshok 1957 (B)
TICUNA Anderson 1959 (B)
TOLOWA Bright 1964
TOTONAC Aschmann 1946
TUNICA Haas 1940
TURKISH Lees 1961; Swift 1963
TZELTAL Kaufman 1971
VIETNAMESE Thompson 1965
WALAMO Tucker and Bryan 1966 (R)
WAPISHANA Tracy 1972
WASHKUK Kooyers, Kooyers and Bee 1971 (R)
WESTERN DESERT Douglas 1955 (B)
WICHITA Garvin 1950
WIK MUNKAN Sayers and Godfrey 1964 (B)
WOLIO Anceaux 1952
WOLOF Manessy and Sauvageot 1963; Sauvageot 1965; Ward 1939 (B)
WU (CHINESE) Chao 1970 (R)
YAO Purnell 1965
YAY Gedney 1965
YUCHI Ballard 1975 (B); Crawford 1973
YUKAGHIR Krejnovich 1968 (R)
YURAK Decsy 1966
ZAN Kizirin 1967 (R)
ZOQUE Wonderly 1951
ZULU Doke 1961
ZUNI Newman 1965

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Syllabic Consonants

ALAN BELL

ABSTRACT

Some synchronic and diachronic generalizations about syllabic consonants are presented, based on a comparison of 85 languages. The main process of their formation, which is loss of a vowel and concomitant shift of syllabicity to an adjacent consonant, occurs fairly commonly in favored environments. It apparently does not generalize easily to wider contexts, however, so that in most languages the syllabicity of consonants is predictable at a relatively low phonological level. A wide variety of consonants, both resonants and obstruents, may function as syllable peaks. Resonants are preferred to obstruents as syllabics, although in some languages the only syllabic consonants are obstruents. Contrary to predictions by most scales of sonority, nasal syllabics are preferred to liquid ones. Detailed diachronic examination of nasal syllabics shows that m and ŋ are dominant, although the synchronic pattern of occurrence of nasal syllabics is not conclusive in this regard. The preference largely derives from the diachronic generalization that when syllabic nasals are formed, mu, um, ŋu, and uŋ are the first nasal-vowel combinations to be affected. Among obstruents, fricatives dominate stops as syllabics; six languages possessing syllabi stops were found, all possessing syllabic fricatives also.

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