The Story of [w]: An Exercise in the Phonetic Explanation for Sound Patterns

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Impressionistically-based, pre-theoretical taxonomies, such as many developing scientific disciplines use, are a mixed blessing. On the one hand they serve the essential, useful function of helping to organize what would otherwise be an unwieldy mass of unrelated data but on the other hand they tend to petrify the thinking of those using the taxonomies, making it difficult for them to deal with the data except insofar as they fit into the pigeonholes which have been set up. For example, many laymen, who assume a basic dichotomy between living and non-living matter, have difficulty accomodating viruses into their conceptual framework since they can exhibit properties of both of these supposedly mutually exclusive categories.

Phonology, which is still a developing science, is also plagued by this problem of unwarranted taxonomic constraints. This applies not only to traditional structural phonology but also to taxonomic generative phonology -- as has been noted before and as we will demonstrate below. This problem is dramatically evident in the treatment of [w] and other speech sounds with simultaneous and nearly equal constrictions in both the labial and velar places of articulation, e.g., [ʍ, u, kp, gb] etc., henceforth, 'labiovelars.' Simply stated, the difficulty is that many phonologists are unwilling to allow labiovelars to be classified in their phonological descriptions as both labial and velar even though their phonetic manifestation clearly has both components. For example, in most of the consonant charts accompanying descriptions of languages, [w] is placed either in the labial or velar column, not both.[1] Similarly, Chomsky and Halle (1968) argue that all labiovelars must either be primarily velars with secondary labialization or primarily labials with secondary velarization or, in their terms, must be either [+anterior] or [-anterior]. Which of the places of articulation is primary is determined by phonological evidence, not phonetic evidence. Kaisse (1975) and Anderson (1976) in more recent papers argue the same point.

Anderson, for example, reviewing the consonant inventories of some West African languages described by Ladefoged (1964) insists that doubly-articulated stops /kp/ and /gb/ have to be analyzed as labials or velars based on how they pattern in the language.[2] He suggests that since the languages Temne, Limba[3], and Sherbro have paired voiced and voiceless stops at every place of articulation except velar, where they have /k/ but not /g/, the segment /gb/ which they have must belong to the otherwise empty pigeonhole reserved for voiced velar stops. Similarly he argues that since Effutu, Kyerepong, and Nzema lack /p/, their /kp/ must fit into the

voiceless labial slot. Late, Nkonya,[4] Krachi, Itsekiri, Urhobo, Idoma, and Kutep are cited as languages which have one or more labialized velar stops, /kʷ/, in contrast with plain velar stops, /k/, thus forcing the assignment of their double stops, /kp/, to the labial pigeonhole. Anderson further suggests that the /kp/ sound in Anum and Efik must be phonologically labial for the same reason and also because these languages lack /p/. He notes that additional evidence on the phonological identity of such double stops may be gained by observing how they pattern in phonological rules, e.g., the labiovelar stops in Kpelle and Yoruba must be velars since preceding nasals assimilating to their place of articulation show up as [ŋ] not [m].[5] In languages where labiovelars pattern as both labials and velars, e.g., the /w/ in Fula, he proposes that there must be two /w/'s, one phonologically labial and one velar.

Central to the taxonomic generative position is the not-always-clearly-defined distinction between the phonetic and phonological (or "underlying") character of speech sounds. We will comment on this in more detail below.

We will show that the question of whether labiovelars are primarily labial or velar is a pseudo-problem necessitated by the largely taxonomic approach taken by phonologists. We will do this in two ways. First, by demonstrating that the 'pigeonhole-filling' approach does not yield convincing results and, second, by showing that the kind of behavior or patterning labiovelars exhibit in phonological rules--at least those which have been cited in the literature so far--can, in general, be explained by reference to their phonetic character. It is unnecessary to posit that the phonetic character of a segment differs from its phonological or "underlying" character unless the latter terms are defined in fairly innocuous ways. Since the patterns that labiovelars exhibit are phonetically-caused, we can also show that they are universal patterns and can be found in unrelated languages throughout the world.[6] Finally, we can show that there is no contradiction in finding a single labiovelar in a given language patterning like a labial in some cases but a velar in others.

Although we will focus primarily upon the labiovelar glide [w], most of our remarks will apply with equal validity to other labiovelars, [u, kp, gb, kw, gw] etc., and we will when appropriate cite data concerning these other segments as well as data involving [w] in support of our generalizations.

The data we cite are a mixture of phonetic statements, descriptions of sound change, allophonic variation, and morphophonemic variation. These are, in fact, ultimately the same thing as far as manifestation of phonetic tendencies is concerned: today's phonetic variation is tomorrow's sound change which in turn contributes to morphophonemic variation.

The "Pigeonhole-Filling" Criteria.

Anderson allows that the pigeonhole-filling criteria for deciding whether labiovelars are labial or velar may not decide the

issue by itself but still has 'evidential value.' However, this is probably still an overestimation of the value of this procedure.

The implication of this technique is that there is somehow a meaningful correlation between the gap in the "normal" consonant system and the extra labiovelar stop. But consonant systems lacking /p/ and /g/ are not at all uncommon even in languages outside West Africa and in languages that do not have any obvious 'leftover' segments ready to plug the holes (Sherman 1975). Furthermore, the presence of labialized velar stops /k^w/ and /g^w/ in addition to plain velar stops is also common enough in the languages of the world (see below) to be of uncertain value in helping decide the categorization of languages which happen in addition to have /kp/ and /gb/. Moreover, there are many West African languages which have /kp/ and/or /gb/ but no obvious gaps in the regular stop inventory that they could fit into.

If there is a correlation between such events, e.g., the absence of /p/ and presence of /kp/, there should be more languages showing the pattern that would be predicted by the product of the independent probabilities of the separate events. For example, the probability that a coin shows heads on any given toss is 1/2 = 0.5 and that a die show '6' on any given toss is 1/6 = 0.167. Thus the probability that a paired toss of a coin and a die yields heads and '6' will be 0.5 x 0.167 = 0.083. One thousand such paired tosses should yield about 83 cases of heads and '6.' Significantly more or less than that would lead us to suspect that either the coin or die (or both) were 'fixed.' In the case of segment interactions we can apply the statistical tests of significance to see whether or not the actual incidence of the combined events was disproportionately more than would be predicted by chance.

Limiting ourselves, for the sake of argument, just to the sample of 55 West African languages surveyed by Ladefoged (1964),[7] we have computed the independent probabilities of the various events of interest and give them in Table 1. From these probabilities we can predict the probabilities of combinations of these events if the combinations were due to chance. From this latter figure we can also predict how many of the 55 languages should show the combination. If the assumptions of the taxonomic phonologist are correct, there should be more languages actually showing the combined event than the results of these latter calculations would predict. As a kind of "test" of this procedure we have also computed the probability that a language from this sample will have both /kp/ and /gb/. Considering the test case first, we see that, reassuringly, there are more languages having both /kp/ and /gb/ than would be expected by chance and the difference is highly significant ($p < 0.001$ by one-tailed Chi-square). In the other cases the observed frequency is either below that predicted by chance or in one case is only insignificantly more than the predicted frequency. Thus, although there may be some interaction between certain segments, e.g., /kp/ and /gb/, the evidence does not support the notion that 'gaps' in the normal stop inventory are associated with the presence of 'leftover' double-articulated stops; nor that the

Table 1. Independent probabilities of incidence of various phonological events in sample of 55 West African languages' consonant inventories (as reported by Ladefoged 1964).

Event	No. of occurrences (out of 55)	Probability of occurrence
no /p/	11	0.20
no /g/	13	0.24
/kp/	38	0.69
no /kp/	17	0.31
/gb/	29	0.53
/k^w/	19*	0.33

*includes one case of /k^f/.

Table 2. Comparison of predicted and observed incidence of various combinations of events listed in Table 1.

Combined event	Probability of occurrence due to chance	No. of languages out of 55 expected to show combined event	No. of languages actually observed	Significance if observed expected
/kp/,/gb/	0.364	20.04	26	0.001
/kp/, no /p/	0.138	7.59	3	
/gb/, no /g/, no /kp/	0.039	2.12	3	*
/kp/,/k^w/	0.230	12.67	9	
/kp/,/k^w/, no /p/	0.046	2.53	2	

*too little data to perform test of significance.

Table 3. Incidence of labialized consonants according to place of articulation (from 706 languages catalogued by Ruhlen 1976). (Each column shows the number of languages having one or more labialized consonants at the given place of articulation.)

labial	dental	alveolar	palatal	velar	uvular	pharyngeal/ glottal
48	26	16	43	318	107	26

presence of contrasts of the sort /k/ vs. /k^{w}/ implies any disproportionate incidence of double stops. Moreover, the pigeonhole-filling criteria may give evidence which conflicts with the evidence from phonological rules. Thus Anderson would put the Efik /kp/ in the labial slot because it lacks /p/ and already has labialized velar /k^{w}/. (Actually, according to Welmers (1973) /kp/ has allophones [kp] and [p] which a taxonomist might also use as evidence of its labiality!) Nevertheless Cook (1969) reports the nasal assimilating to /kp/ sometimes appears as [ŋ].8

The problems disappear if labiovelar consonants are recognized and classified as both labial and velar and are not required to fill a single slot in the segment inventory.

Phonetic Explanations for Universal Patterns of [w].

The first universal tendency we will discuss is (A) and its corollary (A').

(A) [w] comes from both labials and velars.9

(A') labial or velar offglides, both phonemic and allophonic, are most often found on labial and velar consonants, less often on dentals and palatals.

These are fairly common patterns; evidence for (A) and (A') is given in (1)-(4):

(1) Morphophonemic alternations between /w/ and either labial or velar obstruents (or both) appear in: Nguna (Schütz 1969), Berber (Nicolas 1953), Mende (Aginsky 1935, Crosby and Ward 1944), Chichewa (Watkins 1937), Vai (Heydorn 1971b), Loma (Heydorn 1971a), Fulani (Stennes 1967), Zuni (Bunzel 1933-38), Hausa (Newman 1970), Nunggubuyu (Heath 1976), Esako (Laver 1967), Fula (Anderson 1976), Chamarro (Topping 1969). Other examples are given by Ultan (1970).

(2) There is evidence that historically labial or velar obstruents developed labial offglides or changed to /w/ in: Indo-European (Poultney 1963), Solomon Islands Melanesian (Ivens 1928, 1931).

(3) Labial offglides are predictable after the labial and velar consonants /k, g, b, w, f/ in Berber (Beni Iznassen dialect, Renisio 1932).

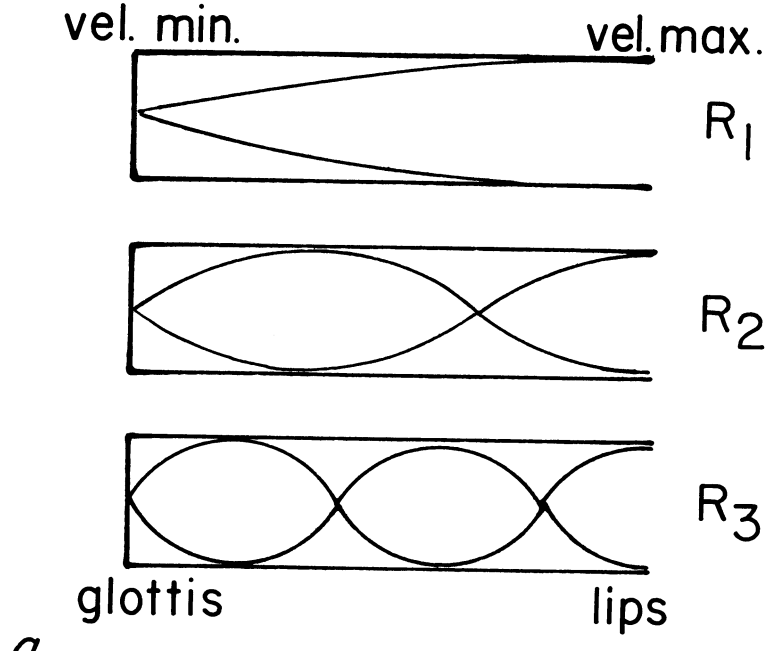
(4) A survey of the incidence of distinctively labialized obstruents in the segment inventories of 706 languages as catalogued by Ruhlen (1976) reveals that they occur most often on velar, uvular, and labial consonants, less often on dental, alveolar, and palatal consonants; see Table 3.

The reason for this pattern can be explained first by noting that back velars, labials, and labiovelars have an important acoustic feature in common, namely, a low second formant (Lehiste and Peterson 1961, Lehiste 1964). This, of course, was the motivation for the Jakobsonian acoustic feature 'grave,' defined as 'having predominately low frequency energy,' which was applied to both lab-

ials and velars (Jakobson, Fant, and Halle 1952). Back velars and labials may be heard as labiovelar glides since their formant transitions resemble those of [w] (cf. also Liberman, Delattre, Gerstman, and Cooper 1956). The role of the acoustic similarity of these sounds in sound change has been discussed by Durand (1956) and Herbert (1975).

But why do labials and back velars produce similar acoustic effects? The reasons are known but have not received much (any?) attention in the phonological literature in spite of their clear relevance to many phonological issues. The explanation requires reference to the standing wave patterns of the resonant frequencies of the vocal tract. (We omit many details which are covered more systematically in Chiba and Kajiyama 1958, Fant 1960, Small 1973, Heinz 1974, Fidelholtz 1975.) Figure 1a represents schematically the standing wave patterns of the lowest three resonant frequencies (i.e., "formants"), R1, R2, and R3, in a uniform cylinder closed at one end and open at the other, that is, a tube resembling the vocal tract. The superimposed sine waves in the tubes represent the range of velocities of the air particles due to the standing wave patterns of the resonant frequencies. It can be seen that for all resonant frequencies there will be a velocity minimum at the glottis and a velocity maximum at the lips since the air is most constrained in its movement at the glottis but is most free to move at the lips. Additional velocity maxima and minima may be located at other places in the vocal tract for the second and higher resonances. In the case of the second resonance, which is the perceptually most salient resonance for the determination of place of articulation, it can be seen that an additional velocity minimum is located in the palatal region and an additional velocity maximum in the velar-uvular region. These are the locations of the velocity maxima and minima in a tube (vocal tract) having uniform cross-dimensional area from one end to the other. With the addition of a labial constriction, the position of the inner velocity maximum shifts forward a bit to the velar region. The locations of the velocity maxima and minima in the vocal tract under these circumstances are shown in Figure 1b. The resonant frequencies in a non-uniform tube, i.e., with one or more constrictions, can be predicted by noting whether the constriction(s) coincide with or are very near these velocity maxima and minima. The rule is: a constriction at a velocity minimum raises the resonant frequency from what it would be for a uniform tube; a constriction at a velocity maximum lowers the resonant frequency from what it would be for a uniform tube.[10]

This rule correctly predicts, for example, the high second resonance and low first resonance of the palatal vowel [i] and the high first resonance and slightly low second resonance of the pharyngeal vowel [a]. More to the point, it explains why a constriction in either the labial or back velar position will have the similar acoustic effect of lowering the second formant and why simultaneous constrictions at both labial and velar regions will lower it even more. This also explains why, of all speech



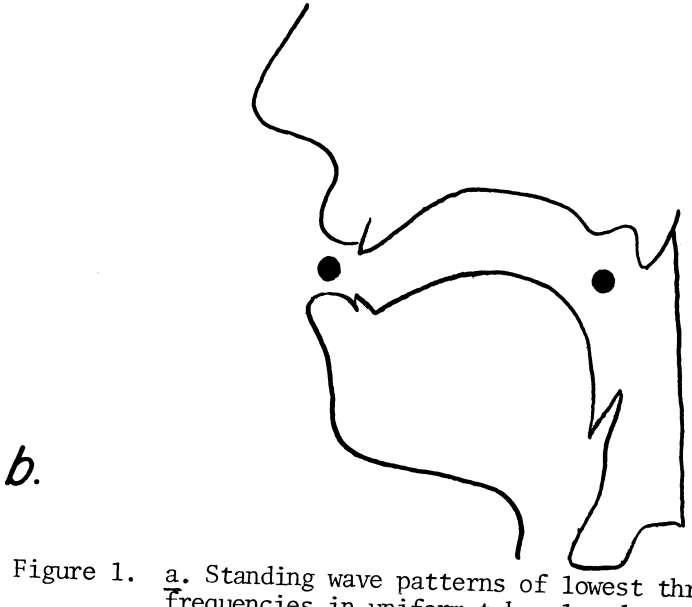


Figure 1. a. Standing wave patterns of lowest three resonant frequencies in uniform tube closed at one end and open at the other. b. Approximate location in the vocal tract of the two velocity maxima in the standing wave pattern of the second resonance.

sounds having two more or less equal places of articulation, labiovelars are so popular: they push the second formant towards an extreme low value and thus produce sounds which are auditorily very distinct from other speech segments. No other two simultaneous places of articulation (e.g., labio-palatal, palatal-velar, velar-pharyngeal, etc.) can do the same. The two simultaneous constrictions which would push the second formant to a maximally high value would be one in the palatal region and one in the pharynx immediately above the glottis. We don't find this, however, because pharyngeal constrictions are difficult and, unlike the situation with labio-velars, the two articulators, tongue tip and tongue root, are not completely independent in their movements (Lindblom, Pauli and Sundberg 1975, Lindblom 1975).

The remaining generalizations we will discuss are of particular interest since they show how [w], although both labial and velar, can, for perfectly straightforward phonetic reasons, show itself as a labial in some cases and a velar in other cases.

The second generalization regarding [w] is:

(B) When becoming a nasal or determining the place of articulation of adjacent nasals by assimilation, [w] shows itself as a velar, rarely as a labial.

Evidence for generalization (B) is found in (5) through (10) below:

(5) Nasals assimilate to [ŋ] before /w/, /kp/, and/or /gb/. For example, in Tswana (Cole 1955) m, n + w → ŋw, e.g.,
-roma "send" + wa → -roŋwa
-fena "conquer" + wa → -feŋŋwa.
Similar nasal assimilation data can be found in the following languages: Hausa (Kraft and Kraft 1973), Picuris (Trager 1971), Orizaba Nahuatal (Goller, Goller, and Waterhouse 1974), Tenango Otomi (Blight and Pike 1976), Hupa (Woodward 1964), Kpelle (Welmers 1962), Efik (Cook 1969), Ébrié (Dumestre 1970), Walapai (Redden 1966), Sierra Popoluca (Elson 1967), Maidu (Dixon 1911), Northeastern Maidu (Shipley 1956 -- but not in Shipley 1964). Also in limited environments in: Spanish (Harris 1968), Berber -- Beni Iznassen dialect -- (Renisio 1932), Mbembe (Jacquot 1962), Adioukrou (Herault 1969).

(6) Various morphophonemic, allophonic, and dialectal ŋ/w alternations. For example, in Kpelle (Welmers 1962) /w/ patterns with velars in morphophonemic alternations; e.g.:

Indefinite	Definite	
ɓɔ́ɔ	ˋmɔ́ɔi	"wax"
lúu	ˋnúui	"fog, mist"
ɣɪ̂la	ˋŋilaɪ̃	"dog"
wɛ́ɛ	ˋŋwɛ́ɛi	"white clay"

Similar data can be found in the following languages:

Iraqw languages (Tucker and Bryan 1966), Yaqui (Fraenkel 1959), Yucatec (Bowman 1959), Sinhalese (Coates and De Silva 1960), Hueyapan (Campbell 1976), Chichewa (Watkins 1937), Ngwe (Dunstan 1964), Adzera (Holzknecht 1973), Rawang (Morse 1963), Yay (Gedney 1965), Bini and Edo (Ladefoged 1964 and Westcott 1962), Mbe (Bamgbose 1967), Akan (Schachter and Fromkin 1968), Southern Paiute (Sapir 1930, Harms 1966), Yoruba (Bamgbose 1966), Kuwaa (Belleh) (Thompson 1976), Baoulé (Vogler 1968), Thonga (Passy 1914), Zoque (Wonderly 1951), Berber (Renisio 1932), Mbembe (Jacquot 1962), Mende (Crosby and Ward 1944).

Cases of historical change involving [ŋ] developing from interaction with [w] are found in (7)-(9):

(7) Ivens (1928, 1931) presents evidence from Melanesian languages that /m/ ~ /mw/ ~ /ŋg/, e.g., Ulawa /nima/; Common Melanesian /limwa/; Fiji /liŋga/ "hand."

(8) In Uto-Aztecan there is evidence of the change /w/ → /ŋ/, especially before /a/ (Munro 1973). (There is good evidence that low vowels such as /a/ are more susceptible to nasalization than higher vowels; Ohala 1975.)

(9) Additional evidence may be found in Numic (Plateau Shoshonean) (Davis 1966).

(10) The phoneme inventories of 706 languages (Ruhlen 1976) reveal the incidence of /$ŋ^w$/ outnumbering /m^w/ and /n^w/ (/$ŋ^w$/ 21 cases, /m^w/ 11 cases -- 9 of these from the Austro-Tai language family --, /n^w/ 1 case).

The explanation for (B) requires reference to the factors which create resonances and anti-resonances in the vocal tract. (Again, we simplify; for details see Fant 1960, Fujimura 1962, House 1957, Ohala 1975, Heinz 1974.) Resonances are determined by the dimensions of those airways in the vocal tract that represent a direct route from the sound source (glottis) to the point where the sound radiates to the atmosphere. Anti-resonances are determined by any airways that are cul-de-sacs branching off from this main airway. In the case of nasal consonants (see Figure 2) the direct path from the sound source (the glottis) to the radiation point (the nostrils) is via the pharyngeal and nasal airways and is substantially the same for all nasal consonants. This path is marked by filled circles in the figure where the schematic vocal tract shapes of the consonants [m], [n], [ŋ], and [w̃] are given. The main features which distinguish nasal consonants from one another, then, are differences in the oral cavity,which is a cul-de-sac branching off of the main (pharyngeal-nasal) airway and which creates anti-resonances whose frequencies depend on the dimensions of the cavity, in particular its effective length. The 'effective length,' of course, will be that length measured from the pharyngeal airway to the point of constriction in the oral cavity. In the case of multiple constrictions in the oral cavity, as in [w], it will be the back-most con-

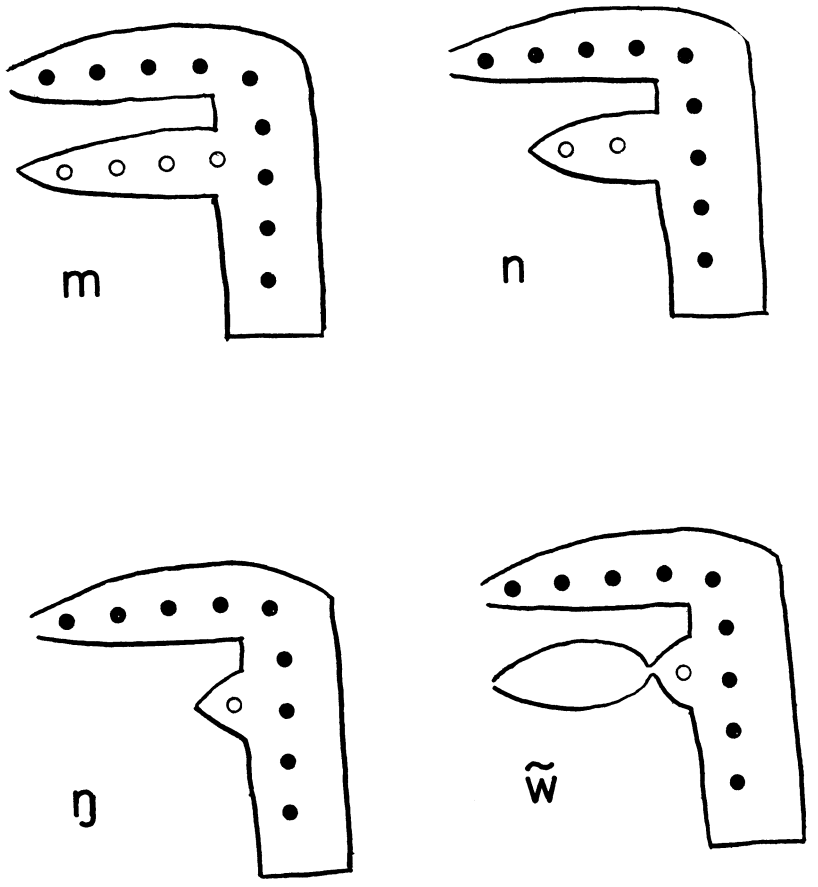


Figure 2. Schematic representation of the vocal tract shapes for the sounds [m], [n], [ŋ], and [w̃]. Filled circles indicate airways contibuting resonances of the sounds; open circles indicate airways contributing anti-resonances.

striction, provided it is small enough, which will mark the boundary of the cavity. The cavity lengths contributing the anti-resonances in the vocal tract shapes in Figure 2 are marked by open circles. [w̃], then, will be most like [ŋ] rather than [m].

For similar reasons [mʲ] or the sequence [mi] is disposed to change into [n] or [ni] as happened in some Bohemian Slavic dialects (Andersen 1973), Chinese (Chen 1973), and Herero (Homburger 1949). In this case there are constrictions at both the labial and palatal regions but the effective length of the oral side cavity is determined more by the palatal constriction than by the labial constriction. This phenomenon has been well noted in acoustic phonetics (Fant 1960, Fujimura 1962) and in perceptual studies (Malécot 1956, House 1957, Gay 1970). (Of course, the consonant transitions also contribute to the auditory similarity of [mi] and [ni] and thus the sound change [pʲ] → [t] is also not uncommon; cf. Andersen 1973.)

The third generalization we offer on [w] is:

(C) When becoming a fricative or determining the place of articulation of adjacent fricatives by assimilation, [w] shows itself primarily as a labial, less often as a velar.

Evidence for generalization (C) is as follows:

(11) In Rawang (Morse 1963) [w] occurs finally and post-consonantally while [v] occurs in initial position.

(12) In Sentani (Cowan 1965) /h/ is optionally realized as [f] or [Φ] before /w/.

(13) Similar evidence can be found in the following languages: Javanese (Horne 1961), Kirghiz (Herbert and Poppe 1963), Telegu (Lisker 1963), Selepet (McElhanon 1970), Warao (Osborn 1966), Oneida (Lounsbury 1953), Carib (Peasgood 1972), Georgian (Robins and Waterson 1952), Cashinahua-Pano (Kensinger 1963), Jeh (Gradin 1966), Chalchihuitan Tzotzil (Hopkins 1967), Cham (Blood 1967), Hungarian (Kálmán 1972), Toba Batik (Van der Tuuk 1971), Indo-European (Meillet 1964), Tenango Otomi (Blight and Pike 1976), Yolax Chinantec (Rensch 1968), Slave (Howard 1963).

(14) Pike (1943) notes that in order to make the labiovelar fricatives [ɣβ] or [xΦ],

> "the velar stricture has to be of a close variety or else its sound will be masked out and made inaudible by the vibration at the lips." [132];

cf., also Heffner (1964),

> "The fricative noises produced by the articulation of [French] [w] are slight, but such as they are, they come rather from the labial than from the velar constriction." [160]

Possible exceptions to (C) are those in (15):

(15) In Araucanian (Echeverria and Contreras 1965) [u], [w], and [γ^{w}] are in free variation. In Danish there is dialectal variation of [u] ~ [u̯u̯] ~ [ux] ~ [uk] (Andersen 1972).

With a fricativized labiovelar we are dealing with two simultaneous sources of noise produced by turbulent airflow through the labial and velar constrictions. What we must determine is why the noise produced at the labial constriction dominates. We can identify at least four reasons. The first three probably contribute to this effect but are far less essential than the fourth.

1. We have assumed thet the labial and velar constrictions in [w] were equal but there is evidence from various x-ray studies of [u], a close cousin of [w], that the labial constriction may have a slightly smaller cross-dimensional area than the velar constriction (e.g., Fant 1960). This could make the labial noise more salient than the velar noise.
2. According to Fant (1960: 274) the shape of the constriction also matters in fricative noise production. A circular constriction, which the lips can produce, is a more efficient noise generator than a slit or elliptical constriction such as would be more likely to occur at the velar region -- even if both have equal cross-dimensional areas.
3. A third factor which contributes not necessarily to making the labial noise dominant but to making the velar noise acoustically similar to the labial noise, is the fact that the air space the velar noise has to pass through, i.e., the oral cavity, shapes the noise in a way that lowers its resonant frequency towards the low center frequency of the labial noise.
4. Perhaps the most important factor is that the intensity of any sound is a function both of its inherent intensity and of the way the resonating cavities the sound passes through modify the intensity at various frequencies. The acoustic impedance seen by the velar noise source is considerably greater than that seen by the labial noise source due, in part, to the fact that the velar noise source has to pass through the narrow labial constriction whereas the labial constriction has no such constriction to attenuate its intensity.

Again we have glossed over many details, but for the reasons given the velar noise will be acoustically similar to that produced at the labial constriction and will moreover be masked by the more intense labial noise.

Central to our discussion of these last three generalizations is the assumption that if speech sounds are acoustically similar to each other, this provides the possibility of one of the sounds

changing into the other diachronically. This would happen since a listener hearing one of these auditorily ambiguous speech sounds would not know exactly how it was articulated and so when speaking himself may articulate it in a different way. This is called sound change via "acoustic imitation" by Sweet (1891) and has been further discussed by Durand (1956) and Ohala (1974a, 1974b, 1975).

A corollary of (C) is (C').

(C') Labiovelar obstruents will most likely change to labial not velar obstruents.

Evidence for (C') is the following:

(16) Indo-European k^w or kw became p regularly in Greek (with definite exceptions), in Osco-Umbrian, and in some Celtic (dialects), sporadically in Germanic (Meillet 1967, Passy 1890), e.g., Latin equus, Greek hippos. Similar data can be found in the following languages: Proto-Zapotec (Suarez 1973), Songkhla (Henderson 1975), Proto-Yuman (Haas 1963). (Cf. also Campbell 1974 who lists additional examples and one counterexample.)

The fourth generalization is (D):

(D) When assimilating to adjacent vowels, it is [w]'s labial place of articulation that remains unchanged; the place of the lingual constriction may shift under the influence of the vowel's lingual configuration.

Evidence for (D) is given in (17)-(18):

(17) /w/ is realized as [w] before back, especially back rounded, vowels, but as [v], [β], or, less frequently, [ɥ], before front vowels in: Cayapa (Lindskoog and Brend 1962). Amahuaca (Osborn 1948), Jivaro (Beasley and Pike 1957), Malayalam (Sreedhar 1972), Chontal (Keller 1959), Chinese (Dow 1972), Chipaya (Olson 1967), Hawaiian (Pukui 1965), Hueyapan (Campbell 1976), Moxo (Ignaciano) (Ott and Ott 1967), Kunimaipa (Pence 1966), Gadsup (Frantz 1966), Azerbaijani (Householder 1965), Zan (Kirizia 1967), Telefol (Healey 1964), Suena (Wilson 1969b), Binandere (Wilson 1969a), Kuman and Pawaian (Trefry 1969), Mbembe (Jacquot 1962), Island Carib (Taylor 1955), Wolof (Ward 1939), Ga (Berry 1951), Quiopetec Chinantec (Robbins 1961), Kaiwa (Guarani) (Bridgeman 1961), Yareba (Weimar 1972), Piro-Arawakan (Matteson 1965), Dogon (Calame-Griaule 1965), Proto-Takanan (Girard 1971), Ulu Muar Malay (Hendon 1966), Old Irish (Cowgill 1967), Pashto (Morgenstierne and Lloyd-James 1928), Akan (Fanti) (Welmers 1946), Gã (Kropp 1968). Cf. also Tucker and Bryan (1966: 142).

(18) There is evidence in Lɔma (Heydorn 1971a) that p, b → v / a, ɛ, e, i, but → w / ɔ, o, u.

This is easily explained in articulatory terms. Of the two constrictions of [w], the labial and the lingual, only the lingual constriction is free to (partially) assimilate its place of articulation to that of adjacent vowels. The shift of the lingual constriction of [w] in such cases is exactly comparable to its shift in other velar consonants, [k, g, ŋ, x] etc. whose place of articulation -- as is well known -- is also influenced by neighboring vowels. The labial constriction, for obvious anatomical reasons, is not likely to assimilate to the lingual constriction of adjacent vowels.

Now we need to introduce a few qualifications regarding our data. First, the operation of (D) could lead to (i.e., trigger) the development of the pattern described in (C). If so, (C) would appear for reasons quite different from those given for it, although this would in no way lessen its purely descriptive value. Fortunately, at least some of the patterns cited in support of (C) clearly did not come about due to the action of (D).

The second qualification is to admit that some cases of the manifestation of tendencies (B) and (C) may have arisen indirectly due to the action of (A). In this case they also would not, strictly speaking, have happened for the acoustic reasons we gave above. For example, an earlier [g] would naturally cause nasals assimilating to it in place of articulation to turn up as the velar nasal [ŋ]. If this [g] later changed to [w] we would now have nasals appearing as [ŋ] before [w] but for entirely different reasons from those we gave. This sequence of events is summarized in (19).

(19) *Ng → ŋg → ŋw

Fortunately, we have included some evidence which shows that the velar nasal appears due to the physical character of [w] itself, not its velar ancestor. Likewise some apparent counterexamples to (B), that is, nasals assimilating to [w] or alternating with [w] showing up as [m], are not in fact counterexamples since the [w] is known to come from an earlier labial. Such is the case for some /w/'s in Fula (Anderson 1976), Fulani (Stennes 1967), and Hausa (Newman 1970). Thus there were different causes -- but still phonetic ones --, operating at an earlier stage in the language which determined the place of articulation of the nasal.

In (20) through (23) we give examples of languages where [w] patterns as both a labial and a velar -- the situation that supposedly could not happen if languages were constrained in the way taxonomic phonologists imagine they should be. We do not include here cases like those of Fula, Fulani, and Hausa where /w/ patterns like a labial and a velar because it derives historically from earlier labials and velars.

(20) In Tenango Otomi /h/ → [Φ] / __ w, whereas /n/ → [ŋ] / __ k, g, h, w, ʔw, ʔV (Blight and Pike 1976).

(21) In Hueyapan /w/ is realized as [v] intervocalically after unround vowels; [v] alternates with [ŋ] finally (Campbell 1976).

(22) Spanish /w/ is realized generally in syllable initial position as [ɣ^{w}], less frequently as [ɣ], but in allegretto speech /n/ → [ŋ] across word boundaries before /w/ (Navarro Tomas 1961, Harris 1969).

(23) Kuwaa (Belleh) word initial /w/ is occasionally realized as [ŋ^{w}] but also becomes [v] before unrounded vowels (with some exceptions) (Thompson 1976).

(24) In some dialects of Yoruba /ã/ merges with /ɔ̃/ after the labial consonants /w, kp, gb, b, f, m/; nevertheless, nasal consonants assimilating to the place of articulation of following /w/ appear as the velar [ŋ] (Ward 1952).

Conclusion.

What are the implications of the above data for the issue of whether a phonetic labio-velar is to be regarded as phonologically or "underlyingly" a labial or a velar? To answer this we must first determine what is meant by the terms 'phonologically' or 'underlyingly' in such contexts. If they simply mean that it is descriptively convenient to treat the labio-velar as a velar or a labial, that is, if the terms just have taxonomic relevance and there are no necessary empirical implications of the labelling, then we have little to argue with, except to point out that there may occasionally be instances where it would be more 'convenient' to give such sounds two labels (cf. 20-24) and that there should be no prohibition against this.

If such terms only mean that the segment was historically a velar or a labial, we also have little to quibble about except to point out that the universal physical phonetic factors we have described may override the influence of the fossilized remnants of the segment's earlier state in determining its present-day behavior (cf. 7-8).

Moreover there are many /w/'s which emerged from /u/'s which cannot themselves be identified as either labial or velar. Thus is 'underlying' means 'is derived historically from' there will be cases where the statement '/w/ is underlyingly labial (or velar)' will be meaningless or irrelevant.

If we are to interpret such statements to mean segments are psychologically velar or labial, then we seriously dispute such claims. First of all, we have shown that the behavior of /w/ (as is true of all speech sounds) is heavily influenced by physical factors. Speakers do not have to "know" the laws of physics in order for their speech to be subject to them. Second, we dispute the general operating assumption of the taxonomic generative phonologists that it is possible to discover the psychological representation of speech sounds or of grammars in general just by examining the surface sound patterns in language. Such naive psy-

chologizing has no place in a field that has aspirations of becoming a serious scientific discipline. We do not deny that there might be a psychological representation of speech sounds different in some respects from the physical phonetic realization of the the sound. But if there is, it will take some clever psychological techniques to discover it, not the application of simplistic taxonomic methods. Attempts are currently underway to develop techniques which can reveal the psychological categorization speakers apply to speech sounds (Jaeger, forthcoming). In any case, as a research strategy, we would urge that all possible phonetic explanations for sound patterns -- particularly those which are apparently universal -- be attempted before entertaining psychological explanations. We hope to have demonstrated the usefulness of this approach.

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Footnotes.

1. The traditional consonant chart of the International Phonetic Association is an exception to this generalization.
2. In this, Anderson follows Ladefoged's lead.
3. However, Ladefoged states 'k occurs word initial and after ŋ; g or ɣ occur elsewhere.' It is thus possible that in some environments [g] and [gb] would contrast and remove the motivation to put /gb/ in the voiced velar slot.
4. However, Reineke (1972) reports that it is not clear that [k^w] represents a separate phoneme in Nkonya distinct from /k/ since it sometimes alternates with [ko]. In any event, she also reports that n, m → ŋ/ __kp, w.
5. We have been unable to verify this statement. All the sources we have consulted, Welmers (1962) for Kpelle and Ward (1952), Bamgbose (1966), Stevick and Aremu (1963) for Yoruba, report that the nasal before the labio-velar stops in these languages is [ŋm] not [ŋ] as claimed by Anderson.
6. And therefore that the patterns are not due to language-specific factors.
7. We have also accepted the consonant inventories as presente by Ladefoged and have made no attempt to correct probable errors. For example, Ladefoged does not list a /g/ for Mende but two other sources, Aginsky (1935) and Crosby and Ward (1944), do.

8. Cf. also note 4.
9. There are, of course, other sources of [w], e.g., back rounded vowels [u] and [o], [ɫ] (velarized lateral), and the vocalic transitions between such vowel sequences as /oe/.
10. See Fant (1960: 86-7) for the physical reasons motivating this rule.

References.

Abbreviations Used.

A&U	Afrika und Ubersee.
AL	Anthropological Linguistics.
AUA	Annales de l'Universite d'Abidjan. Serie H.
BSO(A)S	Bulletin of the School of Oriental (and African) Studies, London.
IJAL	International Journal of American Linguistics.
JAL	Journal of African Languages.
JASA	Journal of the Acoustical Society of America.
JWAL	Journal of West African Languages.
Lg	Language.
PL	Pacific Linguistics.
SIL	Summer Institute of Linguistics.
UCPL	University of California Publications in Linguistics.
WPLU	Working Papers in Language Universals, Stanford.

Aginsky, E.G. 1935. A grammar of the Mende Language. Lg. Diss. 20.

Andersen, H. 1972. Diphthongization. Lg. 48. 11-50.

_____. 1973. Abductive and deductive change. Lg. 49. 765-793.

Anderson, S.R. 1976. On the description of multiply-articulated consonants. J. of Phonetics. 4. 17-27.

Bamgbose, A. 1966. A grammar of Yoruba. Cambridge Univ. Press.

_____. 1967. Notes on the phonology of Mbe. JWAL. 4. 5-11.

Beasley, D. and K.L. Pike. 1957. Notes on Huambisa phonemics. Lingua Posnaniensis. 6. 1-8.

Berry, J. 1951 The pronunciation of Ga. Cambridge: Heffer.

Blight, R.C. and E.V. Pike. 1976. The phonology of Tenango Otomi. IJAL. 42. 51-7.

Blood, D.L. 1967. Phonological units in Cham. AL. 9.8. 15-32.

Bowman, E. 1959. An attempt at an analysis of Modern Yucatec from a small corpus of recorded speech. AL. 1.4. 43-86.

Bridgeman, L.I. 1961. Kaiwa (Guarani) phonology. IJAL. 27. 329-34.

Bunzel, R.L. 1933-38. Zuni. In: F. Boas (ed.). Handbook of American Indian Lnaguages, Part 3. Columbia Univ. Press. 396-515.

Calame-Grianle, G. 1965. Ethnologie et langage. La parole chez lez Dogon. Gallimard.

Campbell, L. 1974. Phonological features: problems and proposals. Lg. 50. 121-36.

Campbell, R. Joc. 1976. Underlying /ŋ^{w}/ in Hueyapan Nahuatal. IJAL. 42.1. 46-50.

Chen, M. 1973. Nasals and nasalization in the history of Chinese. Doc. diss., Univ. of California, Berkeley.
Chiba, T. and M. Kajiyama. 1958. The vowel: its nature and structure. Tokyo: Kaiseikan.
Coates, W.A. and M.W.S. de Silva. 1960. The segmental phonemes of Sinhalese. Univ. of Ceylon Review. 18. 163-75.
Cole, D.T. 1955. An introduction to Tswana grammar. London: Longmans, Green, & Co.
Cook, T.L. 1969. The pronunciation of Efik for speakers of English. Bloomington: African Studies Program.
Cowan, H.K.J. 1965. Grammar of the Sentani language. The Hague: Martinus Nijhoff.
Cowgill, W. 1967. On the fate of *w in Old Irish. Lg. 43. 129-38.
Crosby, K.H. and I.C. Ward. 1944. An introduction to the study of Mende. Cambridge: Heffer.
Davis, I. 1966. Numic consonantal correspondences. IJAL. 32.2. 124-40.
Dixon, R.B. 1911. Maidu. In: F. Boas (ed.). Handbook of American Indian Languages, Part 1. Govt. Printing Office. 679-734.
Dow, F.D.M. 1972. An outline of Mandarin phonetics. (Oriental Monograph Series, 10) Canberra: Australian National University, Faculty of Asian Studies.
Dumestre, G. 1970. Contribution a l'étude phonologique de l'ébrié (Basse Cote-d'Ivoire). AUA. 3. 19-29.
Dunstan, E. 1964. Towards a phonology of Ngwe. JWAL. 1. 39-42.
Durand, M. 1956. Du rôle de l'auditeur dans la formation des sons du langage. J. Psych. Norm. et Path. 52. 347-55.
Echeverría, M.S. and H. Contreras. 1965. Araucanian phonemics. IJAL. 31. 132-5.
Elson, B.F. 1967. Sierra Popoluca. In: McQuown, N. (ed.). Linguistics. [Vol. 5 of Handbook of Middle American Indians.] Austin: U. Texas Press. 269-90.
Fant, G. 1960. Acoustic theory of speech production. The Hague: Mouton.
Fidelholtz, J.L. 1975. An introduction to acoustics for linguistics. Ms.
Fraenkel, G. 1959. Yaqui phonemics. AL. 1.5. 7-18.
Frantz, C.I. and M.E. Frantz. 1966. Gadsup phoneme and toneme units. PL. 7. 1-11.
Fujimura, O. 1962. Analysis of nasal consonants. JASA. 34. 1865-75.
Gay, T. 1970. Effect of filtering and vowel environment on consonant perception. JASA. 48. 993-8.
Gedney, W.J. 1965. Yay, a Northern Tai language in North Vietnam. Lingua. 14. 180-93.
Girard, V. 1971. Proto-Takanan phonology. UCPL 70.
Goller, T.R., P.L. Goller, and V.G. Waterhouse. 1974. The phonemes of Orizaba Nahuatal. IJAL. 40. 126-31.
Gradin, D. 1966. Consonantal tone in Jeh phonemics. Linguistic Circle of Saigon Publications. 3. 41-53.

Harms, R.T. 1966. Stress, voice, and length in Southern Paiute. IJAL. 32.3. 228-35.
Harris, J.W. 1969. Spanish phonology. Cambridge, Mass.: MIT Press.
Healey, A. 1964. Telefol phonology. PL. 3.
Heath, J. 1976. Linguistic diffusion in Arnhem Land. Australian Institute of Aboriginal Studies.
Heffner, R-M.S. 1964. General phonetics. Madison: Univ. Wisconsin Press.
Heinz, J.M. 1974. Speech acoustics. In: T.A. Sebeok (ed.). Current trends in linguistics, Vol. 12: Linguistics and adjacent arts and sciences, Part 10: Phonetics. The Hague: Mouton. 2241-80.
Henderson, E.J.A. 1975. Feature shuffling in Southeast Asian languages: or how big is a segment? Paper presented at the Sino-Tibetan Conference, Berkeley.
Hendon, R.S. 1966. The phonology and morphology of Ulu Muar Malay. Yale Univ. Pub. in Anthropology. 70.
Herault, G. 1969. Étude phonétique et phonologique de l'adioukrou. AUA. 2.
Herbert, R.K. 1975. Reanalyzing prenasalized consonants. Studies in African Linguistics. 6. 105-23.
Herbert, R.J. and N. Poppe. 1963. Kirghiz manual. Indiana Univ. Publications, Uralic and Altaic Series, Vol. 33. Bloomington: Indiana Univ.
Heydorn, R.W. 1971a. Grammar of the Lɔma language with some Kɔnɔ words in the vocabulary. AU. 54. 77-99.
_____. 1971b. The Vai language in Liberia. AU. 54. 149-205.
Holzknecht, K.G. 1973. The phonemes of the Adzera language. PL. 38. 1-11.
Homburger, L. 1949. The Negro-African languages. London: Routledge & Kegan Paul.
Hopkins, N.A. 1967. A short sketch of Chalchihuitan Tzotzil. AL. 9.4. 9-25.
Horne, E.C. 1961. Beginning Javanese. New Haven: Yale Univ. Press.
House, A.S. 1957. Analog studies of nasal consonants. J. Speech & Hearing Disorders. 22. 190-204.
Householder, Fred W. 1965. Basic course in Azerbaijani. The Hague: Mouton.
Howard, P.G. 1963. A preliminary presentation of Slave phonemes. Studies in the Athapaskan languages, by Harry Hoijer and others. UCPL 29. 42-7.
Ivens, W.G. 1928. A grammar of the Lau language, North East Coast of Big Mala, Solomon Islands. BSOS. 5. 323-43.
_____. 1931. A grammar of the language of Kwara 'Ae, North Mala, Solomon Islands. BSOS. 6. 679-700.
Jacquot, A. 1962. Notes sur la phonologique du beembe (Congo). JAL. 1. 232-42.
Jaeger, J.J. Forthcoming. The psychological reality of phonemes revisited.

Jakobson, R., C.G.M. Fant, and M. Halle. 1952. Preliminaries to speech analysis. Cambridge, Mass.: MIT Press.
Kaisse, E. 1975. Segments with internal structure -- the Greek labiovelars. Papers from the Annual Meeting of the Northeast Linguistics Society. 5. 144-52.
Kálmán, B. 1972. Hungarian historical phonology. In: L. Benko and S. Imre (eds.). The Hungarian language. The Hague: Mouton. 49-83.
Keller, K.C. 1959. The phonemes of Chontal (Mayan). IJAL. 25. 44-53.
Kensinger, K.M. 1963. The phonological hierarchy of Cashinahua (Pano). Studies in Peruvian Indian Linguistics: I. Norman: SIL. 9. 207-17.
Kiziria, A.I. 1967. Zanskij jazyk Jazyki narodov SSSR, Vol. 4. 62-76.
Kraft, C.H. and M.G. Kraft. 1973. Introductory Hausa. Berkeley: Univ. of California Press.
Kropp, M.E. 1968. An analysis of the consonant system of Gã. JWAL. 5.1. 59-61.
Ladefoged, P. 1964. A phonetic study of West African languages. Cambridge Univ. Press.
Laver, J. 1967. A preliminary phonology of the Ayele dialect of Esako. JWAL. 4.2. 53-6.
Lehiste, I. 1964. Acoustical characteristics of selected English consonants. IJAL. Publication 34.
Lehiste, I. and G.E. Peterson. 1961. Transitions, glides, and diphthongs. JASA. 33. 268-77.
Liberman, A.M., P.C. Delattre, L.J. Gerstman, and F.S. Cooper. 1956. Tempo of frequency change as a cue for distinguishing classes of speech sounds. J. Experimental Psychology. 52. 127-37.
Lindblom, B. 1975. Experiments in sound structure. Plenary address 8th Int'l. Congress of Phonetic Sciences, Leeds, 17-23 August 1975.
Lindblom, B.E.F., S. Pauli, and J. Sundberg. 1975. Modelling co-articulation in apical stops. In: G. Fant (ed.). Speech communication. Proceedings of the Speech Communication Seminar, Stockholm, 1-3 August 1974. Vol. 2: Speech production and synthesis by rule. Stockholm: Almqvist and Wiksell. 87-94.
Lindskoog, J.N. and R.M. Brend. 1962. Cayapa phonemics. Studies in Ecuadorian Indian Languages: I. B. Elson (ed.). Norman: SIL. 7. 31-44.
Lisker, L. 1963. Introduction to spoken Telegu. New York: American Council of Learned Societies.
Lounsbury, F.G. 1953. Oneida verb morphology. New Haven: Yale Univ. Press. Yale Univ. Publications in Anthropology. 48.
Malécot, A. 1956. Acoustic cues for nasal consonants: an experimental study involving a tape-splicing technique. Lg. 32. 274-84.
Matteson, E. 1965. The Piro (Arawakan) language. Berkeley: Univ. of California Press. UCPL. 42.
McElhanon, K.A. 1970. Selepet phonology. PL. 14.

Meillet, A. 1964. Introduction a l'étude comparative des langues indo-europeennes. Univ. of Alabama Press.
_____. 1967. The comparative method in historical linguistics. Paris: Librairie Honore Champion, Editeur.
Morgenstierne, G. and A. Lloyd-James. 1928. Notes on the pronunciation of Pashto. BSOS. 5. 53-62.
Morse, R.H. 1963. Phonology of Rawang. AL. 5.5. 17-41.
Munro, P. 1973. Proto-Uto-Aztecan *w -- one source for Luiseño ŋ. IJAL. 39. 135-6.
Navarro Tomas, T. 1961. Manual de pronunciacion Española. Publicaciones de la revista de filologia Española. Num. 3. Madrid.
Newman, P. 1970. Historical sound laws in Hausa and in Dera (Kanakuru). JWAL. 7. 39-51.
Nicolas, F. 1953. La langue berbère de Mauritanie. Mémoires de l'Institut Francais d'Afrique Noire, Dakar. 33.
Ohala, J.J. 1974a. Phonetic explanation in phonology. Papers from the Natural Phonology Parasession. Chicago Linguistics Society. 251-74.
_____. 1974b. Experimental historical phonology. Historical Linguistics II. Theory and description in phonology. Amsterdam: North Holland. 353-89.
_____. 1975. Phonetic explanation for nasal sound patterns. In: C.A. Ferguson, L.M. Hyman, and J.J. Ohala (eds.). Nasalfest, Papers from a Symposium on Nasals and Nasalization. Stanford: Language Universals Project. 289-316.
Olson, R.D. 1967. The syllable in Chipaya. IJAL. 33. 300-4.
Osborn, H. 1948. Amahuaca phonemes. IJAL. 14. 188-90.
Osborn, H.A. Jr. 1966. Warao I: phonology and morphophonemics. IJAL. 32.2. 108-23.
Ott, W.G. and R.H. Ott. 1967. Phonemes of the Ignaciano language. Linguistics. 35. 56-60.
Passy, P. 1890. Étude sur les changements phonétiques. Paris: Librairie Firmin-Didot.
_____. 1914. La langue thonga. Miscellanea Phonetica. 1. 27-32.
Peasgood, E.T. 1972. Carib phonology. Languages of the Guianas. J.E. Grimes (ed.). Norman: SIL. 35. 35-41.
Pence, Alan. 1966. Kunimaipa phonology: hierarchical levels. PL. 7. 49-67.
Pike, K.L. 1943. Phonetics. Univ. of Michigan Press.
Poultney, J.W. 1963. Evidence for Indo-European alternation of initial /g^w/ and /w/. Lg. 39. 398-408.
Pukui, Mary K. and S.H. Elbert. 1965. Hawaiian-English dictionary. Honolulu: Univ. of Hawaii Press.
Redden, J.E. 1966. Walapai I: phonology. IJAL. 32. 1-16.
Reinecke, B. 1972. The structure of the Nkonya language. Leipzig: VEB Verlag Enzyklopädie.
Renisio, A. 1932. Étude sur les dialectes berbères. Paris: Editions Ernest Leroux.

Rensch, C.R. 1968. Proto Chinantec phonology. Papeles de la Chinantla. 6.
Robbins, F.E. 1961. Quiotepec Chinantec syllable patterning. IJAL. 27. 237-50.
Robins, R.H. and N. Waterson. 1952. Notes on the phonetics of the Georgian word. BSOS. XIV. 1. 55-72.
Ruhlen, M. 1976. A guide to the languages of the world. Stanford.
Sapir, E. 1930. Southern Paiute, a Shoshonean language. Proc. Am. Acad. of Arts and Sci. 65.1.
Schachter, P. and V. Fromkin. 1968. A phonology of Akan: Akuapen, Asante, and Fante. Working Papers in Phonetics (UCLA) 9.
Schütz, A.J. 1968. A pattern of morphophonemic alternation in Nguna New Hebrides. PL. 15. 41-7.
Sherman, D. 1975. Stops and fricative systems: a discussion of paradigmatic gaps and the question of language sampling. Working Papers on Language Universals (Stanford) 17. 1-31.
Shipley, W. 1956. The phonemes of Northeastern Maidu. IJAL. 22. 233-7.
Small, A.M. 1973. Acoustics. In: F.D. Minifie, T.J. Hixon, and F. Williams (eds.). Normal aspects of speech, hearing, and language. Englewood Cliffs: Prentice-Hall. 11-72.
Sreedhar, M.V. 1972. Phonology of the Cochin dialect of Malayalam. Int'l. J. of Dravidian Linguistics. 1. 100-25.
Stennes, L.H. 1967. A reference grammar of Adamawa Fulani. African Languages Monograph. Mich. State Univ. 8.
Stevick, E.W. and O. Aremu. 1963. Yoruba basic course. Washington, D.C.: Foreign Service Inst.
Suarez, J.A. 1973. On Proto-Zapotec phonology. IJAL. 39. 236-49.
Sweet, H. 1891. A new English grammar. Oxford: Clarendon Press.
Taylor, D. 1955. Phonemes of the Hopkins (British Honduras) dialect of Island Carib. IJAL. 21. 233-41.
Thompson, R.B. 1976. A phonology of Kuwaa (Belleh). M.A. thesis. San Jose State Univ.
Topping, D.M. 1969. A restatement of Chamorro phonology. AL. 11.2. 62-78.
Trager, F.H. 1971. The phonology of Picuris. IJAL. 37. 29-33.
Trefry, D. 1969. A comparative study of Kuman and Pawaian. PL. Monograph 13.
Tucker, A.N. and M. Bryan. 1966. Linguistic analyses of the non-Bantu languages of North-Eastern Africa. Oxford Univ. Press.
Tuuk, H.N. Van der. 1971. A grammar of Toba Batak. The Hague: Martinus Nijhoff.
Ultan, R. 1970. Some sources of consonant gradation. Working Papers on Lnaguage Universals (Stanford) 2. C1-C30.
Vogler, P. 1968. Esquisse d'une phonologie du baoulé. AUA. 1. 5-1
Ward, I.C. 1939. A short phonetic study of Wolof (Jolof) as spoken in Senegal. Africa. 12. 320-34.
_____. 1952. An introduction to the Yoruba language. Cambridg
Heffer.

Watkins, M.H. 1937. A grammar of Chichewa. Lg. Diss. 24.
Weimer, H. and N. Weimer. 1972. Yareba phonemes. Te Reo. 15. 52-7.
Welmers, W.E. 1946. A descriptive grammar of Fanti. Lg. Diss. 39.
_____. 1962. The phonology of Kpelle. JAL. 1. 69-93.
_____. 1973. African language structures. Berkeley: Univ. of California Press.
Westcott, R.W. 1962. A Bini grammar. Part I: phonology. African Languages and Area Center. Mich. State Univ.
Wilson, D. 1969a. The Binandere language family. PL. 18. 65-86.
_____. 1969b. Suena phonology. PL. 18. 87-93.
Wonderly, W.L. 1951. Zoque II: phonemes and morphophonemics. IJAL. 17. 105-23.
Woodward, M.F. 1964. Hupa phonemics. Studies in California Linguistics. William Bright (ed.). Berkeley: Univ. of California Press. UCPL. 34. 199-216.