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The Phonology and Phonetics of 'Voiceless' Vowels

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0. This paper argues that the so-called 'voiceless' vowels found in some languages have to be represented phonologically as aspirates, as has been proposed for voiceless sonorants in general by Halle and Stevens (1971), Mester and Itô (1989) and Cho (1991). For example, the Halle and Stevens system groups aspirated consonants and voiceless vowels by the same feature, [spread glottis] while voiceless, unaspirated consonants are characterized by an unrelated feature, [stiff vocal cords].¹

First, it will be demonstrated that none of the languages which have been claimed to have distinctively voiceless vowels have voiceless vowels, and that 'voiceless' vowels arise due to phonological and phonetic rules of the language in question. Second, a closer investigation of several languages known to exhibit 'voiceless' vowels supports a hitherto unrecognized distinction between aspirated vowels and devoiced vowels. It will be argued that aspirated vowels arise by aspiration assimilation in the phonological component of a grammar in such languages as Comanche and Acoma whereas phonetically devoiced vowels are produced by phonetic implementation rules which apply in a non-assimilatory and gradient fashion (as in Papago, Woleaian and Japanese).

1. Although voiceless vowels which arise from allophonic rules are not uncommon across languages, Comanche and its related Numic language Ute (and Southern Paiute) are the two well-known examples for which there has been a considerable debate as to whether the voiced/voiceless distinction should be part of the underlying representation for vowels.

Opinions differ as to the nature of the voiceless vowels in Comanche. Canonge (1957) assumes that all voiceless vowels are phonemic, whereas Jakobson, Fant and Halle (1952) question Canonge's (1957) claim that the language has underlyingly voiceless vowels, with the following remark: "either the vocal murmur is not a distinctive feature and functions merely as a border mark, or it may be a concomitant of the tense-lax opposition" (1952:26).

More recently, Miller (1973) and Armagost (1984, 1986, 1987, 1988) claimed that voiceless vowels in Comanche are phonologically predictable. My analysis of Comanche vowel devoicing is based mainly on the data and the analyses given in Armagost, although I differ from him in claiming that vowel devoicing is the result of assimilating the aspiration feature, rather than [-voice].

First, there are two distinct types of vowel devoicing in the language: one, often called 'inorganic,' the other, 'organic'. Inorganic devoicing is optional and insensitive to other phonological and morphological factors. Also, it applies only in the final vowel of a word. On the other hand, organic devoicing is

The constraint in (4) assumes only an indirect relationship between tone features and aspiration in contrast to the Halle and Stevens system in which tones and laryngeal features on vowels and consonants are characterized by the same set of features. (See Anderson 1978 for a critique of this approach).

In addition, there are several other conditions on vowel devoicing as observed in detail by Armagost. First, there is no devoicing before tautomorphemic [h]+Obstruent which corresponds to the old geminates of Shoshoni, as illustrated by a few correspondents in (5). Blocking of vowel devoicing in such clusters is exemplified in (6).

(5) Correspondences

Shoshoni	Comanche	
appy	ahpy?	'father'
kittaa	kihtaa	'hard'
iccimi	ihcumi	'close the eyes'
tukku	tuhku	'flesh'

(6) /h+C/ as non-trigger

naki-kuhpa	'inside the ear'	na-tyhka-?	'groceries'
tena-hpy?	'man' (Absolute)	woβi-hta	'wood' (Obj)

It has been reported that /h/ which triggers devoicing has to be followed either by a sonorant or a morpheme boundary. This distributional fact lends support to the claim (made by Miller but argued against by Armagost) that tautomorphemic h+stop clusters result from a rule of preaspiration which applies to geminate stops, which faithfully reflects the actual historical development. If these clusters are assumed to be underlying unaspirated geminates, there is no need to modify the rule of Vowel Aspiration; the only necessary stipulation is ordering Vowel Aspiration before Geminate Preaspiration.⁴

Second, there is a constraint on two adjacent aspirated syllables; on the surface, no two adjacent syllables contain voiceless vowels. When two potential targets occur next to each other, only the first vowel devoices, as illustrated by (7). Potential target vowels are underlined.

(7) Consecutive Syllable Constraint

/sapih-kah/	→ sap <u>h</u> ka	'at the belly'
	sym <u>t</u> si <u>h</u> wa	'tear completely'
	ekA-s <u>a</u> hpana?	'soldier'

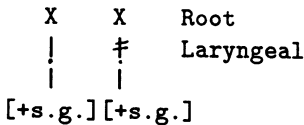
Third, there is an analogous dissimilatory effect holding among consonant triggers, as shown by (8). Vowel Aspiration fails when the two consonants flanking the potential target vowel are both aspirates.⁵ Compare the examples in (8) with a form like *haicIh-a* 'friend (obj./poss/)'.⁵

(8) Dissimilation in /h/.../h/

puhihuba 'tea' naha-hu-tu?I 'will happen'
 puhihiki 'brush arbor'

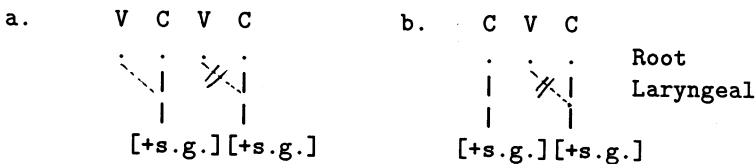
In order to account both for the vocalic and consonantal dissimilations shown in (7) and (8), we propose a single rule of delinking which is clearly motivated by the OCP, which prohibits two adjacent root nodes with the laryngeal specification.

(9) Dissimilation as Delinking



Note that the OCP on aspiration holds on two immediately adjacent root nodes, so that delinking applies between two syllables as well as between an aspirated consonant and a vowel. The interaction between Vowel Aspiration and Dissimilation is represented in (10).

(10) Interaction between two aspirated segments



In the unifying account of dissimilation as delinking the second laryngeal node, there is no difference whether or not the first syllable is devoiced due to the initial high tone since the source of aspiration is the aspirated consonant, rather than the vowel.

Fourth, vowel clusters of either identical or different vowels are never subject to devoicing. In other words, only short syllables devoice, and long vowels and sequences of glide+vowel fail to undergo the rule, as exemplified by (11).

(11) No Devoicing in Vowel Clusters

pisaa-hu-tu?I 'will apply warpaint'
 paa-rua-hu-tu?I '(water) will rise up'
 ni?maihtu?I 'will tire'

In the absence of detailed information on syllable structure, it is difficult to determine whether the right rule should be based on an intersyllabic or

intrasyllabic constraint, but relying on the description by Armagost that heterosyllabic vowel clusters are interrupted by the glottal stop, we assume that all syllables in Comanche should have an obligatory onset except for the word-initial syllable. I will assume a constraint on heavy syllables, which does not allow the aspiration specification within a branching syllable (i.e. in a bimoraic syllable).

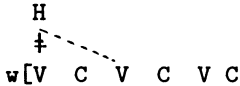
In the next section, the language-particular aspect of this constraint will be clearly demonstrated; Vowel Aspiration in Acoma freely laryngealizes long vowels in contrast to Comanche.

Finally, there is an interesting interaction between a tone shift (which is termed 'stress shift' by Armagost) and Vowel Aspiration. As mentioned earlier, in an unmarked case, the high tone is realized on the initial syllable of a word, but for certain stylistic effects which are not well understood, the tone can optionally shift one syllable to the right, as illustrated by the first two examples in (12). However, when the second syllable is devoiced, the stress shift rule is sensitive to the previous application of Vowel Aspiration, thus skipping over the adjacent syllable if it contains a voiceless vowel, as illustrated by the last example in (12).

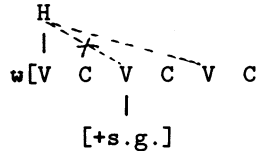
(12) Tone Shift over Aspirated Vowel

- kasábipikuhkina 'making wing noises'
- tɪh ɨjaroʔinU 'mounted up'
- muplhábiiyU 'was lying bent'

a. Tone Shift



b. Tone Shift over Aspiration



The Accent-Aspiration Constraint in (3) can handle the phenomenon of vowel skipping without further stipulation. If the tone were to shift to the following aspirated vowel, it would result in specifying a high tone in the environment of the aspiration feature, an ill-formed feature combination. Therefore, the tone shift rule is blocked from applying to an aspirated vowel, and the high tone is realized on the third syllable.

This interaction between tone shift and Vowel Aspiration constitutes another piece of evidence for treating prominence in Comanche as tonal rather than stress-related. Whereas the close relationship between tones and laryngeal features is well documented in the literature (Mock 1987), it is highly unlikely that rules of stress assignment and stress shift are sensitive to laryn-

geal specification of target vowels (except perhaps for the case of Piraha as proposed by Everett 1988).

In this section, I hope to have demonstrated that Vowel Aspiration is a true phonological rule spreading the feature [+s.g.]. As has been demonstrated, it closely interacts with other well-established phonological rules of the language such as Geminate Preaspiration, Tone Shift, and Dissimilation.⁶

In addition, the fact that voicing is not one of the features that play a role in the consonant system in Comanche seems to support the position that voicing is not relevant in the vowel system either. Note that the obstruent inventory consists of a set of unaspirated voiceless stops and /s/, /h/ and /ʔ/. Furthermore, the fact that only /s/ and /h/, to the exclusion of the unaspirated voiceless stops, constitute a set of triggering segments strongly supports that the feature involved in the vowel devoicing rule is aspiration rather than [-voice]. There are two ways of capturing /s/ and /h/ as a natural class. One is by stipulating that the trigger is [+continuant], and the other is to assume that both /s/ and /h/ are characterized by the feature [+spread glottis]. In an autosegmental approach, it makes better sense to specify the triggers by the feature(s) they propagate rather than by an unrelated feature such as [cont].

It is interesting to note that historically, vowel aspiration was restricted to vowels before /h/ (the quintessential aspirated consonant), but has become generalized to include /s/. We can speculate that the /s/ in Comanche is not the 'normal' fricative but the aspirated [s^h], which is known to occur in Burmese, Korean and Chumash.⁷

2. Assuming that /s/ in some languages is an aspirate is not without precedence. Kagaya (1974) and Kim (1971) suggested that the Korean /s/ be treated as aspirated on the basis of the fact that /s/, like the other aspirated consonants, involves a wide open glottis when the constriction of the vocal tract starts to release.⁸ Iverson (1983) reanalyzes Kagaya's data, observing that /s/ shares the glottal width of the aspirated series but has the same vocal fold tension as the lax series. He concludes that even though the ambivalent laryngeal configuration of /s/ makes it possible to align it with the aspirated or the lax series, it should belong to the lax category on phonological grounds. The same kind of argument can be given for Comanche /s/. Even though it is not an underlyingly aspirated sound, it acquires [+s.g.] before the rule of vowel devoicing applies, which makes it possible to identify /s/ and /h/ as a natural class.

3. What is often termed 'inorganic' devoicing in Comanche is radically different from the Vowel Aspiration presented in the previous section. Its phonetic characteristics are clear from its behavior. First, devoicing is optional and gradient. Second, it applies only in prepausal position, which has nothing

to do with the aspiration environment as the trigger of the rule. Third, it is not sensitive to any one of the conditions Vowel Aspiration is subject to. For instance, inorganic devoicing is unaffected by a voiceless vowel in the preceding syllable, thus creating two consecutively devoiced vowels, as illustrated by (13).

(13) Devoicing in two consecutive syllables

/sapɪh-ka/ → sapɪka ~ sapɪkA 'at the belly'
 /omɔɪsɪ/ → omɔmɪsɪ ~ omɔmɪsɪ 'still by foot'

Finally, the two processes result in two different phonetic realizations of the low vowel /a/. /a/ devoiced by inorganic devoicing is realized as a devoiced low vowel [A], whereas organic devoicing produces the unexpected high back vowel [ɪ] except when it is preceded by the glottal stop.⁹

4. Acoma, which belongs to the Keres language family, has a rule exactly parallel to Comanche Vowel Aspiration except for a few minor differences. According to Miller (1965), vowels in post-accentual position obligatorily devoice when the preceding consonant is a fricative (/h/ and /s/) or a plain stop, which is always aspirated in post-accentual position in the language.¹⁰

(14) Acoma Obligatory Devoicing (Miller 1965:17)

cʔápɪpɪcɪ 'it is spotted' sɣúhɪma 'I believed.'
 zɪyuuçEEʔe 'they took him' yuusɪ 'God'
 báaʃU 'straw'

Very much as in Comanche, Vowel Aspiration in Acoma interacts with other rules such as Tone assignment, so that it never applies to any accented vowels including preaccentual vowels which are always realized as [+high]. Not only pitch accent but also glottal accent is relevant in blocking Aspiration, again confirming the close relationship between laryngeal features and tone features whose distributional restriction can be accounted for by the same constraint as (3).

(15) No Devoicing in accented syllable

kuhâaru 'curd' kusêeʔe 'his hair'

The similarities and differences between Comanche and Acoma are summarized in (16) and (17).

(16) Similarities

- a. triggering C's: all and only the aspirated consonants
- b. Accent-Aspiration Constraint
- c. obligatory

(17) Differences

- a. directionality (right C in Comanche and left C in Acoma)
- b. triggering C's (fricatives in Comanche and all Obsts in Acoma)
- c. dissimilation ('yes' in Comanche and 'no' in Acoma)
- d. Heavy Syllable Constraint ('yes' in Comanche and 'no' in Acoma)

In addition to Vowel Aspiration, Acoma has a rule of optional devoicing: a final vowel and sonorant devoices. Sonorant devoicing can also be caused by the following devoiced vowel.

(18) Acoma Optional/Variable Devoicing

kawâayU 'horse' s^hinAnI 'skin'
 sénâa?A^hsI 'my arch' kuhâarU 'curd'

In addition, the vowel may devoice in preaccentual position when the vowel is surrounded by voiceless consonants. Note that all voiceless (even unaspirated consonant) are triggers in contrast to the aspirated triggers of Vowel Aspiration. In (19), devoiced vowels are underlined>.

(19) Acoma Optional Devoicing in preaccented position

ka^hšâiti 'summer' kh^hətsâaná 'your eye'
 k^həžâaná 'your eye' saçəkání 'when I smoked'

5. There are other languages with postlexical, phrasal vowel devoicing rules. In Woleaian (Sohn 1975), five voiceless vowels occur in final position at the ends of words, along with a series of voiced vowels. According to Sohn, a voiceless vowel is a simple vowel and a voiced vowel is a long vowel in word-final position. In word-final position, a simple vowel loses its voice and a double vowel becomes short unless it is protected by a following modifier word or a suffix, as illustrated by the examples in (20).

(20) Woleaian Vowel Devoicing (Sohn 1975)

/tto/ → ttO 'deep'
 /bboo/ → bbo 'pounding stone'
 /bboo we/ → bboo we (*bbo we) 'that pounding stone'

Similarly, Papago (Saxton, et al. 1983) has a phrasal rule which devoices sonorants including vowels. In particular, unstressed vowels devoice sentence

finally and after /h/ and glottal stop, as shown in (21).

(21) Papago Vowel Devoicing (Saxton, et al. 1983)

maI	'to learn'	miA	'near'
s-tohA	'white'	mo?O	'head'
hikIhuU	'already'	dagItoO	'to drop something'

In addition to utterance final devoicing, there is devoicing before /h/ as well as between a stop and a voiceless consonant, as illustrated by the last two examples in (21). As in Woleaian, unstressed vowels in utterance-final position are shortened in Papago, "giving the impression of single and extra-short vowels, respectively" (Saxton et al. 1983:114), even though both long and short vowels undergo devoicing. The patterning of Vowel shortening with vowel devoicing can be thought of as resulting from a single phonetic process of reduction, rather than from two unrelated phonological rules.

Japanese High Vowel Devoicing seems to be a clearer case of a phonetic implementation rule. According to Han (1961), the two high vowels of Japanese /i/ and /u/ are devoiced between voiceless consonants in an unaccented syllable, and also after a voiceless consonant and before pause. Devoicing is determined by many factors such as the effect of tempo and the effect of pitch-accent. Also, there is a close relationship between the duration of vowels and devoicing: the vowel /u/ is more readily devoiced than /i/, which correlates with the fact that /u/ is inherently shorter than /i/. In addition, although voiceless stops, affricates, and fricatives trigger voiceless vowels, there is a hierarchy: fricatives and affricates show greater effect than stops. All these factors point to the conclusion that Japanese Vowel Devoicing is a phonetic rule that is governed by many factors which cannot be reduced to standard phonological operations.

More recently, Jun and Beckman (1993) conclude that the phenomenon of vowel devoicing in Japanese and Korean cannot be attributed to the phonological rule of assimilation. Rather, they argue for treating it as an instance of overlap and blending; in other words, "the glottal opening gesture for the consonant overlaps and blends into the glottal closing gesture for the following vowel, in effect obscuring the vowel's voicing specification."

6. In conclusion, it has been argued that there are two kinds of Vowel 'Devoicing' across languages. First, when a phonological rule is involved, a vowel is aspirated rather than devoiced due to the surrounding aspirated consonants by assimilation. Secondly, a phonetic rule of devoicing is often triggered by all voiceless consonants (regardless of the presence or the absence of aspiration) and often governed by non-phonological gradient factors.

Notes

[1] In addition, they assume a direct relationship between consonants and tones by assigning the same feature to voiceless consonants and a high tone on the one hand, and voiced consonants and a low tone on the other. That particular aspect of their theory does not have a direct bearing on the present study of voiceless vowels.

[2] Voiceless vowels are represented in capital letters.

[3] Armagost deals with this restriction on preaccented syllables by further stipulating that the rule applies only when preceded by a voiced syllable. This formulation makes a prediction different from our account: when there are more than two potential targets in preaccentual position, he predicts that the second syllable should devoice since it is preceded by a voiced syllable. On the other hand, we predict no devoicing in any of the preaccented syllables, since all of them are realized as high-pitched. Although there seem to be no relevant examples in Comanche, in Acoma, all preaccented syllables which are realized as high pitched are immune to obligatory phonological devoicing.

[4] Since all true geminates always surface as h+stop clusters, there are a few cases in which reanalysis of underlying forms has taken place, which will not be discussed in this paper.

[5] Armagost proposes a stridency condition, according to which devoicing occurs only when the two consonants flanking the potential target vowel do not agree in stridency, with the following result (no Devoicing in h..h, s..s, c..s and Devoicing in h..s, s..h, c..h). However, by limiting the domain of the rule within a lexical word, thus excluding clitics such as the discourse particles, /se?/ and /ha/, there is no need to stipulate the rather unmotivated stridency condition. Instead, the dissimilation rule shown in (9) suffices. In addition, what Armagost calls a true exception to the rule, whose effect is to preserve an important distinction in narratives, disappears since the exceptional item always involves the discourse markers.

[6] An analogous analysis can be extended to Ute and the closely related Southern Paiute (Goss 1970, Sapir 1930), where vowels are described to undergo aspiration in a metrically weak position when surrounded by aspirates. For both Comanche and Ute, analyses utilizing aspiration assimilation seem to make more sense in accounting for the close relation between vowel devoicing and the aspirated environment rather than positing distinctively voiceless vowels.

[7] In Burmese all obstruents occur in plain, aspirated, and voiced series including the sibilants (Cornyn 1944). The forms involving /s/, /s^h/, /z/ are shown in sūn 'vigor', s^hūn 'rice for priest' zūn 'spoon'. Chumash has a phonetic, though not underlying, contrast between aspirated and unaspirated fricatives. Chumash has a rule that converts sequences of like consonants into an aspirate (CC → C^h, ss → s^h) (Applegate 1972). Steriade (1982) assumes that /s/ in

Attic Greek is redundantly aspirated.

[8] In particular, Kim (1970) argues for a new definition of aspiration as a function of the glottal opening at the time of release of the oral closure, rather than as a function of VOT (contrary to what Lisker and Abramson (1964) proposed.) This approach makes better sense, given the fact that there can be aspiration in final stops, where there is no VOT at all. Jun (1989) notes that /s/ and /h/ pattern together in assigning a High tone in the phonological phrase of the Chonnam dialect of Korean.

[9] We can assume a later phonetic rule delinking the low specification from the aspirated low vowel [A].

[10] Even though Miller does not specifically mention the behavior of /s/, in all the examples given, sibilants (/s, s', ʃ/) always trigger devoicing, as shown by the fourth and fifth examples of (14). In Cheyenne, all voiceless fricatives (/s, x, ʃ, h/ trigger devoicing (Leman and Rhodes 1978).

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