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PHONOLOGY AT THE INTERFACE OF PHONETICS AND MORPHOLOGY: ROOT-FINAL LARYNGEALS IN CHONG, KOREAN, AND SANSKRIT*

Root-final laryngealized stops in the Mon-Khmer language of Chong are realized with the laryngeal gesture preceding the oral closure, implemented as a creak on the latter portion of the tautosyllabic vowel. This realization is phonologically sub-optimal, as the aerodynamic, articulatory, acoustic, and auditory properties of pre-glottalized stops do not culminate in a maximally salient percept. In contrast, those timing relations which evoke a stronger response at the level of the peripheral auditory system are optimal since a more robust neural response is likely to be more perceptually salient. The non-suffixing nature of Chong, in combination with the non-release of word-final plosives, conspire to account for this cross-linguistically marked pattern. Laryngealization in Chong may thus be viewed as the exception which proves the rule. By contrast, root-final laryngeals in Korean and Sanskrit, both of which allow for suffixation, are indeed implemented in canonical fashion – with the laryngeal gesture realized around the release interval of the oral occlusion – in those lexical environments where suffixation and root-final release are present.

0. Introduction

The Mon-Khmer language of Chong (Thonkum (1987), (1991), (n.d.)) possesses both breathy and creaky vowels. But while breathy vowels enjoy a relatively free distribution with respect to other elements of the root syllable, creaky vowels may be present *only* when a supralaryngeally articulated coda consonant is present as well. Moreover, while creakiness overlaps with post-vocalic sonorants, it is purely vocalic in the context of a post-vocalic stop; vowel laryngealization here may be viewed, in effect, as the realization of a glottalized stop. I explain this unusual distribution by considering language-particular syllabic and morphological constraints, in conjunction with the aerodynamic, acoustic, and auditory consequences of implementing laryngeal contrasts with three landmark regions of a stop consonant – its onset, its closure, and its offset. Following Kingston (1985, 1990), M. Huffman (1990), as well as my own work in this area (Silverman (1994a, 1994b, 1995a, 1995b)), I argue that laryngeal contrasts are optimally realized in positions which maximize their acoustic and auditory salience. In stops, this optimal position is at the interval of oral release. However, when optimal positions are unavailable, dispreferred positions may be employed in order to avoid laryngeal neutralization. In Chong, obligatory unrelease of root-final stops, combined with its non-suffixing nature, explain the peculiar patterning of its root-final laryngealized stops.

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Yet when otherwise disallowed root-final stop release is made available through suffixation, laryngeal contrasts may indeed be canonically realized. I show that Korean and Sanskrit implement two variations of this general pattern.

I conclude that morphological patterning can and does exert an influence on the realization of contrastive information.

In section 1 I provide background information upon which subsequent discussion is based. This includes a brief discussion of notational devices, as well as presenting the gross aspects of acoustic and auditory phonetics which are critical to my arguments. In section 2 I present the language data, considering the breathy vowels in Chong, as well as the distributional evidence supporting my claim that contrastive vowel creakiness here is intimately tied to stop unrelease. I additionally consider the role that Chong morphology plays in the realization of laryngealized coda consonants. Finally, I compare the Chong patterning of root-final laryngeals to that in Korean and Sanskrit.

1. Theoretic Background

In this section, I briefly discuss notational devices (1.1) and offer some rudimentary discussion of acoustics and aerodynamics (1.2) and of the peripheral auditory system (1.3), which is necessary in order to understand the relevant patterns.

1.1. *Notation*

Given the critical role of timing and stricture here, the data under investigation do not readily lend themselves to standard segmental notational devices. Consequently, all following discussion is presented in a version of Browman and Goldstein's theory of Articulatory Phonology (1986, 1989, 1990, 1992). In this theory, phonological primitives consist of temporally arranged gestures, where a gesture is an autonomous and abstract structure consisting of the onset, target, and offset of a constriction at a particular location and of a particular degree. As Bowman and Goldstein point out, ". . . the gestures for a given utterance, together with their temporal patterning, perform a dual function. They characterise the actual observed articulator movements (thus obviating the need for any additional implementation rules), and they also function as units of contrasts (and more generally capture aspects of phonological patterning)" (1989, 210).[1]

Departing from an orthodox implementation of Browman and Goldstein's theory, I assume that gestures and their timing (or "phasing") with respect to one another are simply means to achieve *auditory* ends (Silverman (1995a) and Flemming (1995) explore auditory phonology in rather more detail). I thus take a more concrete approach to articulatory gestures, describing their pre-theoretical *physical* articulatory characteristics. I enrich the gestural notation by indicating the relative auditory salience of a given gesture within a given gestural configuration. Throughout, optimally salient gestures are indicated with black ("█"), less-salient gestures are indicated with dark gray ("▓"), and gestures which are articulatorily implemented, though acoustically unencoded, are indicated with light gray ("▒").

(1) optimally salient gesture: █
less-salient gesture: ▓
acoustically unencoded gesture: ▒

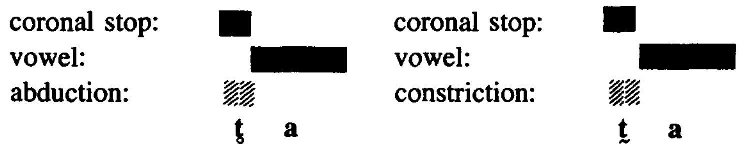
As argued in this paper, a laryngeal gesture is coordinated with the period around a voiceless stop release because this timing relationship optimizes the salience of the contrastive information. The resulting temporal stability of oral-closure-then-laryngeal-abduction is a consequence of this optimal coordination of gestures. Extending this notion to its logical extreme, the segment, which has long remained an unquestioned building block of most phonological theories, is here considered to potentially be an epiphenomenon. That is, speaker (and linguist) intuitions about segmentation may be a mere consequence of the location and temporal stability of particular auditory cues and do not in and of themselves necessarily possess any linguistic significance. Thus, characterizing laryngeal gestures as being phonologically consonantal or vocalic in affiliation is herein for expository expedience only, as it is the acoustic cues associated with particular gestural phasing patterns which are of primary phonological significance.

For further discussion of Articulatory Phonology, especially in comparison to a(n auto-) segmental model, see Browman and Goldstein (1986, 1989, 1992), Steriade (1990), Clements (1992), Kingston and Cohen (1992), Zsiga (1993), Byrd (1994), and Silverman (1995a).

1.2. *Relevant Acoustic and Aerodynamic Rudiments*

Kingston (1985) argues that laryngeal articulations are better encoded at stop releases than at stop onsets. For example, a full supralaryngeal occlusion that is unaccompanied by vocal fold approximation (voicing) possesses negligible acoustic energy. Consequently, a laryngeal abduction or laryngeal constriction which is implemented strictly simultaneously with supralaryngeal closure will not be reliably encoded in the speech signal.

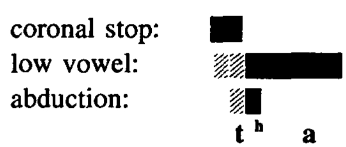
(2)



In (2), despite the implementation of a laryngeal abduction or laryngeal constriction during oral closure, these will have few if any acoustic consequences. However, a laryngeal abduction or constriction that is implemented during closure and continues beyond the stop release is realized in an especially salient fashion. This transition interval, then, is especially suited to encode laryngeal contrasts.

Unlike a voiceless stop closure, the transition interval from a voiceless stop into a following vowel is an acoustically salient event which involves the pressurized expulsion of air that has been trapped behind the oral occlusion. This pressurized expulsion of air results in a high level of acoustic energy which is especially well-suited to bear contrastive information. A laryngeal abduction implemented with a downstream closure fills the oral cavity to capacity quite quickly. Now, around the interval of oral release, the glottal abduction is maintained and may increase in magnitude around the transition from stop to vowel (Hirose, Lee, and Ushijima (1974), Löqvist (1980), Löfqvist and Yoshioka (1980), Yoshioka, Löfqvist, and Hirose (1981)). The pressure build-up behind the oral closure is thus released with a sudden force. Moreover – and this is especially important – phasing the maximal laryngeal abduction with the transition from stop closure to vowel results in maximal airflow during this critical interval, resulting in energy broadly distributed across the sound spectrum. Consequently, a laryngeal abduction coordinated with this interval is saliently encoded in the speech signal.

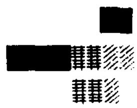
(3)



Because of its salience, the stop release interval is a preferred site for the realization of linguistically significant articulatory events. Laryngeal articulations are implemented at this site so that they may be realized with maximal acoustic salience.

Pre-aspirated stops, that is, stops with laryngeal contrasts timed to precede oral closure, do not enjoy these aerodynamic and acoustic benefits. As the laryngeal abduction here is not timed to follow the stop closure, there is no build-up of intra-oral pressure, no plosion upon release, and no sudden increase in airflow. Consequently, pre-aspirates are less salient than post-aspirates, and, not coincidentally, are less common in the world's languages.

(4) coronal stop:
low vowel:
abduction:



a ḁ t

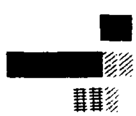
Now consider ejectives. An ejective stop involves a glottal closure as well as a supralaryngeal closure, during which transglottal flow ceases. As there is no transglottal flow, the volume of air within the sealed supraglottal cavity remains constant. Larynx raising, supraglottal wall hardening, and supraglottal cavity constriction may all combine here in order to achieve the increase in intraoral pressure necessary for an ejective's characteristic "pop" at release (Kingston (1985), MacEachern (in prep.)).

(5) coronal stop:
low vowel:
constriction, etc.:

t ’ a

Pre-glottalized stops, however, possess quite different articulatory and acoustic properties from their post-glottalized counterparts. Here, the laryngeal gesture is realized around stop onset, that is, at the transition from the preceding vowel into the stop. Given the absence of stop release, larynx raising and supraglottal configurations involving cavity constriction and wall hardening would afford little aereodynamic – hence acoustic – payoff. Consequently, the laryngeal constriction is implemented as a creak on the preceding vowel. As pre-glottals do not possess the aerodynamic qualities necessary for a salient pop, they are not as acoustically robust as their post-glottalized counterparts. Consequently, this timing pattern is cross-linguistically dispreferred.

(6) coronal stop:
low vowel:
constriction:



a a̰ t

This pattern is present in Chong, discussed in section 2.

Nasals, possessing a greater amount of acoustic energy, typically *partially* accommodate contrastive laryngeal gestures. Were the nasal voiceless or creaked throughout, place of articulation would not be encoded in the acoustic signal, as acoustic energy is sufficiently reduced during this interval as to preclude the possibility of encoding the relevant articulatory information (Dantsuji (1984, 1986, 1987), Silverman (1995a), Ladefoged and Maddieson (1996)).

(7) *nasals and contrastive laryngeal gestures:*

coronal stop:		coronal stop:	
nasal:		nasal:	
abduction:		constriction:	
	N̥ n		N̰ n

Finally, due to there minimal stricture, vowels possess the highest amount of acoustic energy of any class; they may readily accommodate the simultaneity of contrastive laryngeal gestures. Thus, in breathy and creaky vowels, the laryngeal articulation is readily recoverable.

(8) *vowels and contrastive laryngeal gestures:*

vowel:		vowel:	
abduction:		constriction:	
	a̤		a̰

The creaky nasals and breathy vowels of Chong are considered in section 2.

In summary, the relative salience of a given gesture is apparently greatly dependent on the involved degree of stricture, as well as its timing with respect to a neighboring gesture. Strict timing relations between particular gestures may guarantee specific aerodynamic properties and consequent acoustic cues.

1.3. *Relevant Rudiments of Auditory Phonetics*

In addition to aerodynamic considerations, there are interacting *auditory* reasons why laryngeal abductions are preferably realized around stop release, as opposed to stop onset. Bladon (1986) proposes some of the major principles of auditory phonetics. For present purposes, his principles **(3)**, **(4)**, and **(5)** are most relevant. These are quoted in full in (9) (1986, 5).

(9) **(3)** *On/off response asymmetry:* spectral changes whose response in the auditory nerve is predominantly an onset of firing are much more perceptually salient than those producing an offset (Tyler, Summerfield, Wood, and Fernandez 1982).

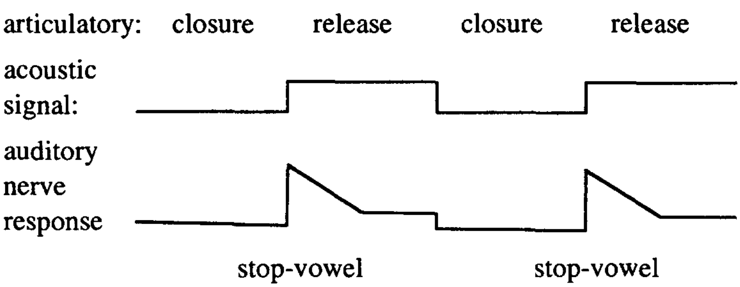
(4) *Short-term adaptation:* after a rapid onset of auditory nerve discharge at a particular frequency, there is a decay to a moderate level of discharge, even thought the same speech sound is continuing to be produced (Delgutte 1982).

(5) *Neural recovery:* silent intervals in speech sounds give rise to a rapid, high-amplitude discharge when interrupted (Delgutte 1982).

Summarizing, at any given moment in time, the level of auditory nerve response is not solely a function of the current level of the acoustic signal but also reflects recent changes, particularly increases, in the level of that signal. Consequently, the same gesture may evoke a greater neural response, that is, be more auditorily salient, when in one gestural environment than when in another. For example, stop releases involve a sudden increase in acoustic energy and hence trigger a sharp increase in auditory nerve firing rate, which decays to a moderate level through the following vowel. Given the heightened auditory response at stop release (Principle 3, Principle 5) and the rapid decay of response across the steady state of a following vowel (Principle 4), it should not be viewed as coincidental that CV transitions (and, by necessary extension, CV sequences) are especially valued.

The schematic in (10) displays in gross terms the distorting effect that the auditory nerve imparts on the incoming acoustic signal in the context of plain stop-vowel sequences.

(10) *gross schematic of articulatory, acoustic, and auditory characteristics of stop-vowel sequences:*



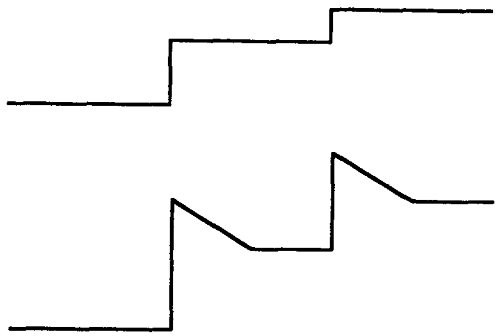
Now, consider a stop consonant that is modified by a laryngeal contrast, say, a laryngeal abduction. After the period of silence which auditorily characterizes the stop closure, spectral activity is reintroduced into the signal. If aspiration is sequenced to *follow* a stop closure, the sound spectrum changes abruptly from silence to burst and random noise. Consequently, neural activation is heightened due to the re-implementation of the stimulus (Principle 5). Consequently, the aspiration of post-aspirated stops is auditorily salient.

(11) *gross schematic of articulatory, acoustic, and auditory characteristics of post-aspirated stop:*

articulatory:
supralaryngeal: stop vowel
laryngeal: abduction

acoustic signal:

auditory nerve response:



percept: t ʰ a

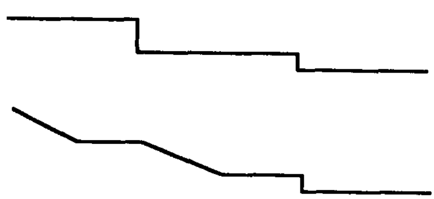
Now compare post-aspirated stops with pre-aspirated stops. Here, Bladon notes that aspiration is realized as devoicing on the latter portion of the previous vowel; a *reduction* in energy ensues between modal voicing and devoicing, and there is little spectral shift in the transition from the modal vowel to its devoiced counterpart. Consequently, the auditory nerve undergoes short-term adaptation (Principle **4**): neural discharge decays throughout the vowel-**h** sequence. Consequently, the likelihood of recovery here is relatively quite low.

(12) *gross schematic of articulatory, acoustic, and auditory characteristics of pre-aspirated stop:*

articulatory:
supralaryngeal: stop vowel
laryngeal: abduction

acoustic signal:

auditory nerve response:



percept: a ḁ t

Compare auditory nerve response in the context of a pre-aspirate with that of a plain stop in (10); as Bladon concludes, ". . . given that preaspiration suffers from an accumulation of auditory handicaps, it would not be a risky prediction that languages would rarely make use of this auditory-phonetic dinosaur" (p. 7).

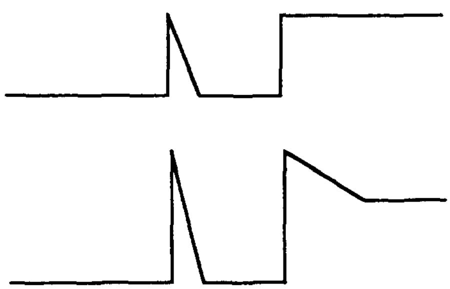
Now consider stops followed by laryngeal constrictions, that is, ejectives. If a laryngeal constriction, combined with enhancing concomitants, is sequenced to *follow* a stop closure, the sound pattern changes abruptly from silence to a sudden pop, followed by silence, then the onset of voicing. Thus, after the period of silence which auditorily characterizes the stop closure, spectral activity is reintroduced into the signal. Thus neural activation is heightened due to the reimplementation of the stimulus (Principle 5). Consequently, the glottalization of post-glottalized stops is auditorily salient.

(13) *gross schematic of articulatory, acoustic, and auditory characteristics of ejective stop:*

articulatory:
supralaryngeal: stop release vowel
laryngeal: glottal closure glottal release

acoustic signal:

auditory nerve response:

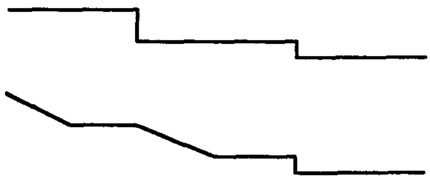


percept: t ' a

Now compare post-glottalized stops with pre-glottalized stops. Recall that since supraglottal wall hardening, pharyngeal constriction, and larynx raising would offer negligible acoustic payoff in this context, glottalization here is realized as a mere creaking of the latter portion of the previous vowel. Thus there must less spectral shift in the transition from modal vowel to voicelessness; the onset of creakiness on the vowel affords far less change in spectral activity; neural response, hence auditory salience, suffers as a consequence.

(14) *gross schematic of articulatory, acoustic, and auditory characteristics of pre-glottalized stop:*

articulatory:
  supralaryngeal: vowel stop
  laryngeal: creak
acoustic signal:
auditory nerve response:



percept: a a̰ t

To summarize, abrupt rises in amplitude result in maximal auditory nerve response. Moreover, amplitude plateaus result in the rapid decay of auditory nerve response. Assuming that a more salient speech signal is a better speech signal, phasing patterns are better to the extent that amplitude increases abruptly and frequently. Indeed, the observed cross-linguistic preference for articulatory configurations which maximize auditory nerve response offers compelling (if indirect) support for this assumption.

2. Language Data

Now that I have provided a skeletal theoretical foundation, I turn to the relevant patterns in Chong, briefly considering similar patterns in Korean and Sanskrit as well.

2.1. *Laryngeals in Chong*

Chong is a Mon-Khmer language spoken by approximately 8000 people in Cambodia and Thailand (Grimes (1988)). All forms in this section are culled from Thonkum (n.d.), who reports on the Krathing dialect. (15) shows the Krathing Chong segment inventory.

(15) *Chong segment inventory:*

p	**t**	**c**	**k**	**i(ː)**	**ɯ(ː)**	**u(ː)**
pʰ	**tʰ**	**cʰ**	**kʰ**	**e(ː)**	**ɤ(ː)**	**o(ː)**
b	**d**			**ɛ(ː)**	**ə**	**ɔ(ː)**
s					**a(ː)**	
m	**n**	**ɲ**	**ŋ**			
	l,r					
w		**j**				
h,ʔ						

Thonkum reports that Chong contains four contrastive "registers." I follow Thonkum in listing register separately from the main inventory of contrasts. In this fashion, I hope to call attention to its non-segmental nature and reinforce the idea that timing here (and, by hypothesis, among all contrastive configurations) is a means of achieving particular auditory goals. The Chong registers are presented in (16).

(16) *Chong registers:*

R(egister) **1:**	clear voice, high pitch, relatively higher F1
R2:	clear-creaky voice, high-falling pitch, relatively higher F1
R3:	breathy voice, lower pitch, relatively lower F1
R4:	breathy-creaky voice, low-falling pitch, relatively lower F1

I depart from Henderson's (1952) original usage of the term "register" to account for these particular contrasts, in that I do not view register *per se* as a phonological primitive but instead as a cover term for a number of co-occurring phonetic properties that may or may not be phonological primitives in and of themselves. Indeed, in related Mon-Khmer languages, the primary feature of so-called register may be pitch-based (i.e., tone), as Thonkum reports for the Chamkhlo' dialect of Chong, or tongue-root based, as discussed at length by Gregerson (1976). According to Thonkum's instrumental analyses, the most stable feature of register in Krathing Chong is phonation, that is, vowel breathiness and/or creakiness which resides on the latter portion of the vowel and on any post-vocalic sonorant. This not to say, of course, that Chong listeners might not exploit any and all existing cues to so-called register contrasts but simply that both the phonetic stability of phonation, as well as its explanatory power in accounting for the various co-occurrence restrictions to be discussed, point to breathiness and/or creakiness as the primary phonetic features of register here. Examples of each register are in (17).[2]

(17) *examples of Chong registers:*

R1:	c^{h}ih^{1}	**c^{h}ih**	to dry in the sun
	puk^{1}	**puk**	rotten smell
	sii^{1}	**si:**	head louse
	p^{h}oʔ^{1}	**p^{h}oʔ**	to dream
R2:	kəsut^{2}	**kəsuṵt**	to come off
	t^{h}am^{2}	**t^{h}aa̰m̰**	crab
	kəp^{h}aŋ^{2}	**kəp^{h}aa̰ŋ̰**	scraps, chips
	kəpɯt^{2}	**kəpɯɯ̰t**	to wear (skirt, tousers)

R3:	puut^3	**pṳːt**	to speak
	kəlaa^3	**kəla̤ː**	ear
	pɔh^3	**pɔ̤h**	ashes
	kəcaai^3	**kəca̤ːj**	nine
R4:	luuc^4	**lṳːṵc**	soft
	kəlaai^4	**kəla̤ːa̰j**	loose
	cam^4	**ca̤a̰m̰**	bruised
	krɤt^4	**krɤ̤ɤ̰t**	to leak

Possible codas are presented in (18), along with an example of each.

(18) *Chong codas:*

stops:	**p**	kəkɛɛp^1	**kəkɛːp**	to cut (with scissors)
	t	peet^3	**pe̤ːt**	plague
	c	kənooc^2	**kənoːo̰c**	nipple
	k	lɛɛk^1	**lɛːk**	chicken
nasals:	**m**	cum^4	**cṳṵm̰**	vine, climber
	n	kʰiin^2	**kʰiːḭn̰**	guard
	ɲ	(no examples given)		
	ŋ	kəlɛɛŋ^2	**kəlɛːɛ̰ŋ**	floor
glides:	**j**	luj^4	**lṳṵj̰**	earthworm
	w	ŋɛw^2	**ŋɛɛ̰w̰**	curved
laryngeals:	**ʔ**	rəkoʔ^1	**rəkoʔ**	tips (of climbers and creepers)
	h	pah^3	**pa̤h**	dry

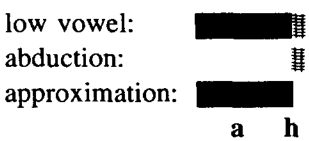
(18) shows that all plain stops, as well as the nasals, the glides, and the laryngeals, may close the syllable in Chong.

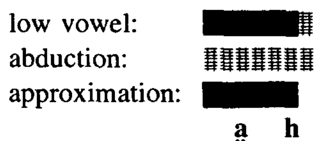
Plain breathy vowels (**R3**) are free to occur with any syllable type. However, one notable exception to this otherwise free distribution involves the set of prevocalic obstruents that possess a pronounced laryngeal abduction. This set includes all aspirated plosives, as well as the fricative **s**, in addition to plain **h**. Thus, like all languages which possess both aspirates and breathy vowels, the two do not contrastively co-occur: aspirates and breathy vowels are sufficiently distinct from each other to function contrastively, but no language contrasts aspirated breathy vowels (**tʰa̤**) with unaspirated breathy vowels (**ta̤**), as their acoustic distinction is insufficient to function in this way.

The distribution of creaky registers is far more limited, however: forms may contrast for creaky register only when a coda is present. Moreover this coda consonant must be supralaryngeally articulated. Finally, only the latter portion of the vowel is creaked; the initial portion may be either plain or breathy.

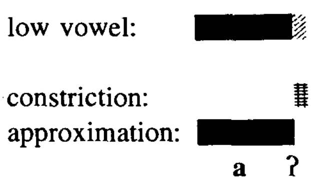
Thus, post-vocalic ʔ and **h** never occur with creaky registers though they are free to occur with so-called breathy registers; since creaky registers, in which creakiness is present only on the latter portion of the vowel, and plain glottal stop codas are so similar in their articulatory and acoustic characteristics, the two cannot contrast. Indeed, as pointed out by an anonymous JEAL reviewer, post-vocalic glottal checking may actually induce creak on the latter portion of the vowel, thus potentially neutralizing any possibility of a contrast between the two. Thus, plain root-final glottal stop may be viewed as the realization of creaky register in otherwise open roots.[3] Post-vocalic **h** and creaky register cannot co-occur either, as such configurations would require simultaneous vocal fold abduction and constriction. However, a laryngeal abduction timed fully simultaneously with the vowel may freely occur with either post-vocalic **h** or ʔ. Such forms involve either a plain or a breathy vowel, followed by a laryngeal abduction or laryngeal constriction, as shown in (19).

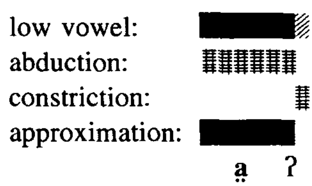
(19) *h and ʔ codas:*





examples:	kəpɔh^1	**kəpɔh**	thread
	ʔih^1	**ʔih**	not
	pɔh^3	**pɔ̤h**	ashes
	kɔh^3	**kɔ̤h**	to knock

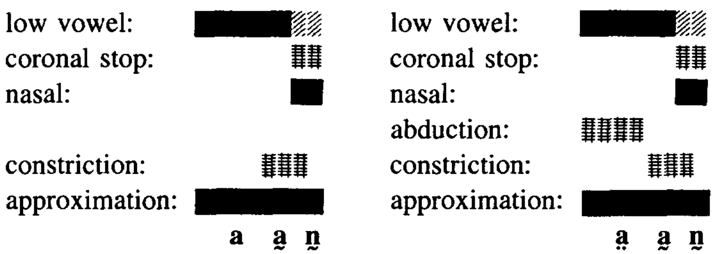




examples:	kəloʔ^1	**kəloʔ**	skin
	leʔ^1	**leʔ**	kind of hat
	klɔʔ^3	**klɔ̤ʔ**	to vomit
	peʔ^3	**pe̤ʔ**	delicious

Laryngealization may, however, be timed with the latter portion of the vowel and into sonorant codas. These supralaryngeal gestures possess sufficient acoustic energy to encode all of the relevant contrasts. Although Thonkum does not emphasize this, she briefly mentions that creaky registers trail away toward the end of sonorant codas and assumes that the concomitant pitch fall here helps to encode the contrast. Indeed, as mentioned in section 1, this partially modal realization of creaked nasals allows place of articulation to be more saliently encoded and is thus the cross-linguistic norm (Henderson (1985), Ladefoged and Maddieson (1995), Silverman (1995a)).

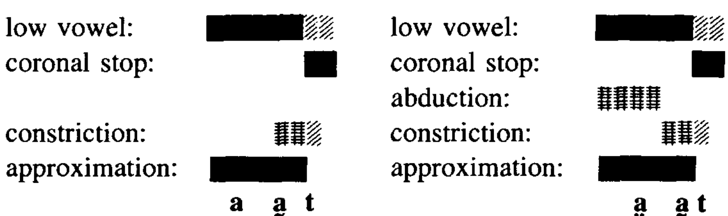
(20) *laryngealization with sonorant codas:*



examples:	ɲɯɯj^{2}	ɲɯːɯ̰j̰	kind of mushroom
	cum^{4}	cṳṵm̰	vine, climber

Most importantly for present purposes, those forms with creaky registers and post-vocalic stops manifest their creakiness exclusively on the latter portion of the vowel. That is, when a laryngeal constriction is accompanied by a supralaryngeal closure, creakiness is timed to precede the closure, realized co-extensively with the final portion of the vowel. Translated into segmental terms, we might consider such gestural configurations to be pre-laryngealized stops. And as no alternations exist in the forms with root-final laryngealized closures, there is no evidence that the configuration should be lexically classified in any way distinct from its surface realization. Thus, whether characterized in segmental terms or gestural terms, pre-laryngealized stops are always simply that: stops preceded by a laryngeal creak.

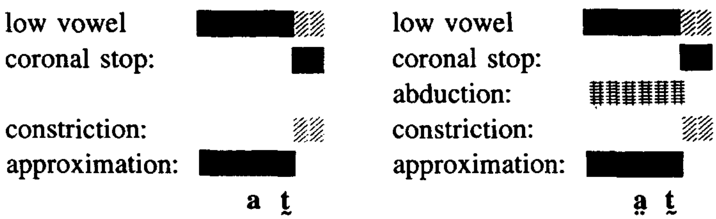
(21) *laryngealization with stop codas:*



examples:	kɤɤt^{2}	kɤːɤ̰t	shallow
	lɔɔp^{4}	lɔ̤ːɔ̰p	gadfly

Recall that voiceless oral occlusions possess no acoustic energy. Consequently, unlike vowels and sonorants, they cannot encode this contrastive laryngeal constriction.

(22) *unattested realization of laryngealized stop codas:*



Therefore, the laryngeal gesture is timed to precede the stop closure so that the otherwise unencoded gesture is rendered recoverable.

Summarizing the Chong data, in the context of a following stop closure, creaky registers are implemented on the vowel exclusively. Moreover, only this vowel's latter portion is creaked. If this vowel is breathy, then creaky phonation follows the period of breathiness. Additionally, post-vocalic sonorants may be partially creaked, or a glottal closure may stand alone in post-vocalic position.

The flowchart in (23) summarizes the distribution of creakiness in Chong.

(23)

supralaryngeally articulated post-vocalic consonant?

⇙ yes ⇩ creaky register okay

⇘ no ⇩ creaky register not okay (but glottal checking okay if no **h**)

⇘ post-vocalic consonant an oral stop?

⇙ yes ⇩ the latter portion of the vowel may be creaked

⇘ no ⇩ the latter portion of the vowel and first portion of the post-vocalic sonorant may be creaked

Finally, as ejectives are so salient, it might be predicted that the laryngeal constriction would be realized root-*initially*. Why might this pattern be unattested in Chong?

First, recall that vowels in Chong may be breathy. It seems to be the case that ejective stop-breathy-vowel sequences are universally unattested: ***t'a̤**. The impossibility of this pattern is probably due to the difficulty in maintaining the required control over the articulatory and aerodynamic systems. That is, reliably realizing a breathy vowel after a forceful ejective release is articulatorily difficult. Realizing the laryngeal constriction in this position would consequently allow for fewer contrastive configurations.

Second, recall that root-initial stops may be aspirated and that initial aspirates may co-occur with creaky register. However, were the laryngeal constriction realized at root-initial stop release, the co-occurrence of these two gestures would be impossible, thus again reducing the number of contrastive gestural configurations: ***t'ʰ**.

Finally, though auditorily quite salient, ejectives come at a high articulatory cost. Consequently, languages may value saving articulatory effort more highly than maximizing recoverability.

In the following section, I offer a full explanation for the patterning of laryngealization in Chong, based on the acoustic and auditory considerations discussed thus far, in conjunction with syllabic and morphological constraints.

2.2. *Syllabic and Morphological Constraints*

I now turn my attention to the important role that Chong syllabic and morphological structure plays in the realization of laryngealized coda stops.

Chong words are very short. Most roots are monosyllabic. Bisyllabic roots possess either **kə** or **rə** as the first syllable. Furthermore, syllable structure is quite simple. These short syllables consequently are likely to exploit non-canonical timing patterns in order to accommodate the number of contrasts that is required of the open class categories. Root-final laryngeal contrasts thus serve to expand the inventory of contrastive root types though in and of themselves they are auditorily sub-optimal.

But beyond these systemic considerations, what other aspects of the Chong grammar account for the fact that laryngealization here is timed to *precede* stop closures and not timed to *follow* stop closures, which is the auditorily optimal pattern? There are two independent aspects of the Chong grammar that pressure forms to be realized in this non-canonical fashion. **(1)** Chong coda stops are unreleased, as is the norm for related Mon-Khmer and areal languages. Unrelease is indicated in Thonkum's instrumental records, which do not typically possess the small, post-closure energy hump that is characteristic of final stop releases. **(2)** Mon-Khmer languages are strictly non-suffixing. That is, lexical morphological complexes are created primarily through prefixation, secondarily through infixation, but never through suffixation (Nghia (1976)). Therefore, despite the noted preference for realization at stop release, any contrast in post-vocalic position that is auditorily endangered must be sequenced to *precede* the offending gesture if it is to avoid complete neutralization. As root-final stops are unreleased and as no lexical morphological complex involves material following the root, there is no lexical environment in which contrastive information may be encoded *following* the root. Thus contrastive laryngealization in roots with final plosives is realized on the tautosyllabic or, more to the point, tauto*morphemic* vowel.

2.3. *Korean and Sanskrit*

If Chong *were* a suffixing language, root-final laryngeally contrastive stops could indeed be realized at stop release, provided these suffixes were vowel-initial. Two languages which display variants of this pattern are Korean and Sanskrit.

Kim-Renaud (1991) reports that obstruents (either plain, glottalized [tense], or aspirated) are neutralized syllable-finally in Korean, due to "unrelease". Thus, for example, all coronal plosives (**t, tʰ, t', tʃ, tʃʰ, tʃ'**) require release in order to encode their contrastive status within the coronal class; upon unrelease, all neutralize to **t** (as do s and s'). This occurs in word-final position, as well as upon the attachment of a consonant-initial suffix. Upon vowel-initial suffixation however, root-final obstruents may possess any laryngeal contrast.

(24)	**k'otʃʰ+i**	→	**k'otʃʰi/k'oʃi**[4]	flower (Nom.)
	k'ot˺			flower
	supʰ+i	→	**supʰi**	wood (Nom.)
	sup˺			wood
	pak'+iɾo	→	**pak'iɾo**	outside (Loc.)
	pak˺			outside

Due to the rich suffixation system in Korean, the proper lexical environment for stop release is commonplace, and so laryngeal contrasts may be recovered. Consequently, Korean need not resort to a sub-optimal timing pattern, even in the context of a word-final or pre-consonantal stop; neutralization in such contexts is not complete.

I note anecdotally that Sun Ah Jun informs me that free roots which display laryngeal contrasts upon suffixation come from a rather small set. Usually, only bound roots have root-final laryngeal contrasts, which are manifested *only* upon vowel-initial suffixation. She and I surmise that this distinction is primarily historical in origin. Free roots tend to be nouns, many of which are Chinese loans. Since Chinese did not possess coda obstruent laryngeal contrasts, none is present in Korean either. In contrast, roots which may possess final laryngeal contrasts are typically native Korean verbs. But most importantly, laryngeal neutralization does indeed occur upon consonant-initial suffixation of these roots. The Korean pattern thus fully supports the present approach: a laryngeal contrast in root-final stops may survive in canonical form (historically, if not in every synchronic alternation) *only* if the stop is released in *some* lexical environment.

Sanskrit took a rather more circuitous route to avoid complete neutralization in similar circumstances. As in Korean, Sanskrit possessed root-final aspirates. Also, as in Chong and Korean, root-final stops are presumed by some to have been obligatorily unreleased (see Collinge (1985) and references therein for analyses which seem to rely on this assumption). Now, for fully independent reasons, Sanskrit permitted the realization of only one aspirate per root. (Ohala (1992) offers some intriguing perceptually-based speculations on the origins of this pattern.) In roots with two voiced stops in which the first was non-palatal, aspiration could be realized in canonical fashion – that is, at stop release – but *only* if this release was followed by a vocoid or nasal (Whitney (1885, 1889)). Root-initial aspirates were thus freely allowed since they were necessarily followed by vocoids. However, root-final aspirates *required* suffixation involving release into a vocoid or nasal. (25) provides some examples from Whitney (1889).

(25)	√**dag**^{ɦ}	reach to	**dag**^{ɦ}**iṣjanti**	(Fut.)
	√**bud**^{ɦ}	know, wake	**bod**^{ɦ}**i**	(Aor.)
	√**dab**^{ɦ}	harm	**dab**^{ɦ}**ati**	(Pres.)

As is well known, this pattern is part of a much more complicated process eponymously known as Bartholomae's Law (see Collinge (1985) and references cited therein).

When these roots were unsuffixed, or suffixed by forms that did not permit root-final release into a vocoid or nasal, root-final stops were realized without aspiration. Thus far, the Sanskrit pattern would seem to bear a striking resemblance to that present in Korean. But Sanskrit departs from the Korean pattern in that these unsuffixed or inappropriately suffixed forms realized aspiration root-*initially*, thus salvaging the otherwise neutralized aspiration.

(26)	√**dag**^{ɦ}	reach to	**d**^{ɦ}**ak**	(root noun, Nom. Sing.)
	√**bud**^{ɦ}	know, wake	**b**^{ɦ}**ut**	(root noun, Nom. Sing.)
	√**dab**^{ɦ}	harm	**d**^{ɦ}**ap**	(root noun, Nom. Sing.)

This pattern is well known as Grassman's Law (again, see Collinge (1985) and references therein). The intimate interaction of Bartholomae's and Grassman's Laws, which produced a sizeable array of non-neutralized allomorphs, may thus be seen as a consequence of unrelease. That is, the generalization seems to hold that release was necessary for the realization of aspiration.[5]

But in Chong, unlike in Korean or Sanskrit, neither root-final release nor suffixation is *ever* available. Moreover, unlike Sanskrit, laryngeally contrastive onsets here are free to occur with laryngeally contrastive codas. Therefore, onset position cannot serve as a reliable site for the realization of laryngeals that suffer from root-final unrelease. Consequently, the language must resort to sub-optimal pre-laryngealization in order to accommodate root-final laryngealized stops, for coda neutralization here would indeed be complete.

3. Concluding Remarks

Chong is unusual in that root-final laryngeals are timed to *precede* stop closures, whereas laryngeal contrasts are usually timed to *follow* stop closures. Thus, for example, I am aware of no language which allows pre-aspirated stops to the exclusion of post-aspirates. I have argued herein that the exceptionality of the Chong pattern may be understood when considering the effect of a given timing pattern on the peripheral auditory system: those timing relations which evoke a stronger response at the level of the peripheral auditory system are better than those which evoke a weaker response since a more robust neural response is likely to be more perceptually salient. Laryngealization in Chong may thus be viewed as the exception which proves the rule.

I have motivated this exceptional patterning by appealing to language-specific constraints on syllabic and morphological structure. As Chong root-final stops are unreleased, and as the language is strictly non-suffixing, no lexical environment exists which would allow the canonical realization of laryngealized stops. If complete neutralization is to be avoided here, root-final laryngealization must precede stop closure.

In contrast, due to their suffix-taking behavior, Korean and Sanskrit may avoid the auditorily sub-optimal realization of word-final and pre-consonantal laryngeal contrasts, as the proper lexical environments and/or the proper root constraints elsewhere exist to avoid complete neutralization while enjoying optimal realization. The distinct behaviors of root-final laryngeals in Chong, Korean, and Sanskrit also indicate that morphological patterning *can* and *does* exert an influence on the realization of contrastive information.

NOTES

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[1] Many of the basic notions and devices of this theory, including gestural primitives, gestural score-like displays, phasing rules, and synchronic and diachronic phonological motivation, are prefigured in Henderson (1985).

[2] Transcriptions are based on Thonkum's descriptions. Vowels with laryngeal contours are transcribed with doubled vowels since typographic limitations prohibit the indication of a partially-creaked vowel, e.g., krɤt[4] **krɤ̤ɤ̤t** 'to leak', luuc[4] **lṳːṳc** 'soft'; laryngeal contours on post-vocalic sonorants are not indicated: tʰam[2] **tʰa̰a̰m̰** 'crab'.

[3] In contrast to Chong, the related Mon-Khmer language of Sedang (Smith (1968)) has a contrast between creaky vowels and post-vocalic glottal stop. Significantly, creakiness in Sedang persists for the entirety of the vowel, thus providing a phasing distinction that is sufficient for the two patterns to function contrastively.

[4] Sun Ah Jun tells me that either of these pronunciations is acceptable here.

[5] But see Lombardi (1991) for a purely formal account of the Sanskrit pattern.

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