[1]TONOGENESIS REVISTED: REVISING THE MODEL AND THE ANALYSIS

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This paper is a revised and updated version of a paper on tonogenesis that appeared in *Diachronica* in 2002. That paper generated considerable useful feedback, supportive of the general thesis, but critical of various specific aspects; this invaluable feedback[1] has resulted in a number of major and numerous minor revisions.[2]

Until recently the most widely-used model of tonogenesis is based on Haudricourt's 1954 classic analysis of the origins of the tones of Vietnamese. That paper derives the Vietnamese tones from segments, specifically, the consonants that follow and precede the vocalic nucleus. This paper first examines Haudricourt's This paper examines Vietnamese data, argues that the Haudricourt analysis of Vietnamese analysis should be recast in terms, not of segments, but of laryngeal features. The paper then argues that, in general, segmentally-driven models of tonogenesis should be replaced by laryngeally-based models, in which tones are correlated directly with the effects of voice quality distinctions on vowels, with segmental distinctions playing an indirect role, a role related to the development of the voice quality distinctions themselves.

A laryngeally-driven model gives us phonetically-plausible paths of change, not only for the origins of the Vietnamese, but also for the wide spread correlations between initial voicing and pitch height, between voice quality and vowel quality, and between tone systems and phonation systems. The existence of voice quality distinctions as an intermediary between segments and tones in the tonogenesis process provides an explanation for the attested correlations between certain segments and certain tonal patterns: thus, the existence of a laryngeal intermediate stage provides a phonetic motivation for the preference for the development of low tones from breathy voiced stops and for the preference for breathy voiced stops over both voiced sonorants and voiced fricatives as a source of low tone. In wider terms, a laryngeally-driven model is not limited to Southeast Asia, but provides insights into a geographically dispersed region.

1.0 Updating Haudricourt's model of tonogenesis

The classic account of the mechanisms of tonogenesis developed out of

[1] I happily acknowledge that the merits of this work own much to the contributions of Peter Ladefoged, Arthur Abramson, Theraphan Thongkum, Gérard Diffloth, Marc Hideo Miyake, George Grace, Ricky Jacobs, Christopher Court, Gregg Lee, Blaine Erickson, Marc Brunelle, Jimmy Harris, and Phil Rose. Theraphan Thongkum supplied me with a number of valuable papers and pointed me to others. The works of Theraphan Thongkum, Keith Denning, Eugénie Henderson, Kenneth Gregerson, Ian Maddieson, Jean-Pierre Hombert, John Ohala, and James Matisoff—even where I have disagreed with them in one way or another, have been the foundations for this study. Last, but not least, I wish to thank Martha Ratliff for reading an earlier version and for catching some egregious errors.

[2] This is an update, largely, but not completely rewritten.

André-Georges Haudricourt's 1954 paper on the origins of Vietnamese tones. In this now classic account, the consonants play a direct role in pitch assignment: the final consonants determine pitch contours and the initials determine pitch height, and final consonants determine pitch contours. The model developing out the Haudricourt paper also notes the loss of the voicing distinction in the process of developing tones (cf. also Hombert, Ohala, and Ewan 1979).

This widespread, consonant-based account of tonogenesis did not start with Haudricourt. As early as 1912, Maspero had noted that Vietnamese tones correlated with the voicing of initial obstruents, and even earlier Edkins (1853:6-54, esp. 47) had made similar, although not as clear, observations for Chinese. The correlation with initials has been emphasized in recent authors, but it is important to recognize that this is a correlation, not an immediate cause. However, the correlation is robust: Hombert (1978:78) observes that the loss of voicing distinctions in prevocalic obstruents is the best documented path for the development of contrastive tones,[3] adding that voiceless initials lead to relatively high and voiced initials lead to relatively low pitch; these patterns are attested in Chinese, in various Tibeto-Burman languages (Karen, Gurung, and so on), Austronesian (Phan Rang Cham; Hainan Cham [Tsat]), Tai-Kadai languages (Thai, Lao, and so on), Hmong-Mien, Mon-Khmer (Vietnamese), and Khoisan. Countless other languages could be added to this list: Hyman (1978:265-266), but with respect to West African tone systems, makes a similar but not identical observation, “A tone can undergo modification if it is adjacent to or occurs on a segment of a given type. The effect of consonant types on tone has been studied by a number of scholars, who generally agree that voiceless consonants exert a pitch-raising effect on the following tone, while voiced consonants (especially breathy and obstruent) exert a pitch-lowering effect.” Hyman's quote picks out, not voicing but whether a consonant is breathy voiced or an obstruent, as the prime correlation with pitch lowering; this emphasis on what is in effect a correlation with voice quality foreshadows much of the discussion to follow.

Although the segmental interpretation of Haudricourt’s account of Vietnamese is now the most prevalent model of tonogenesis, some time ago within Mon-Khmer specialists modified the account, realizing that an adequate account requires one to recognize the central role of voice quality distinctions.

This paper builds on the insightful correlations between segments and tones in Haudricourt's tonogenetic model, extending it into a model in which consonant classes correlate with specific vowel qualities, which in turn are the primary mechanism for the differences in pitch assignment. These augmentations to the tonogenetic history of Vietnamese are paralleled by augmentations in our general model of tonogenesis in which it is the laryngeal gestures accompanying voice quality distinctions playing an intermediate role between consonant classes and the ultimate evolution of tones. This augmentation results phonetically more plausible model of tonogenesis while accounting for a number of otherwise odd typological and distributional characteristics of existing tone systems.

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[3] The key word here is "contrastive"; pitch differences that correlate with the different classes of initials certainly can exist prior to the loss of voicing contrasts but it is only with the loss of these contrasts that these become contrastive.

In the segmental interpretation of Haudricourt's classic account of Vietnamese (see Figure 1), tones are correlate directly with earlier classes of finals and initials. In the initial stage, the three-way distinction among classes of post-vocalic finals (open finals, nasal finals; stopped finals; voiceless fricatives) led to the emergence of a three-way distinction in pitch contours, a level, a rising, and a falling pattern, respectively.

Finals:	open finals, nasal finals [level]	stopped finals; final glottal stop [rising]	voiceless fricatives [falling]
Initials: proto-voiceless [high pitch]	*pa > pa "ngang"	*pak > pắk "sắc"	*pas > pả "hỏi"
Initials: proto-voiced [low pitch]	*ba > pà "huyền"	*bak > pạk "nặng"	*bas > pã "ngã"

Figure 1: Vietnamese tonogenesis

Haudricourt 1954; Matisoff 1973:74-75; Diffloth 1989:146. The diacritics accompanying the syllable "pa" indicate the Vietnamese tones; the names in the quotation marks are the native Vietnamese names for the tones. The hỏi and ngã tones have fused in Saigon Vietnamese but are still kept distinct in Hanoi.

The next split correlates with the voicing contrast in the initials: proto-voiceless initials developed higher pitch and proto-voiced initials developed lower pitch.

Although the Haudricourt analysis accounts for some of the data, as specialists in Mon-Khmer are well aware, it does not account for all of it. As Figure 1 shows, forms in the *ngang* and *huyền* tones should come either from open syllables or from syllables with final proto-voiced sonorants. However, as Gage (1985) writes, elsewhere in Mon-Khmer (MK) many of the related forms actually end in final glottal stops; given the final glottal stops found elsewhere, the distribution in Figure 1 predicts incorrectly that the Vietnamese forms should have the *sắc* or *nặng* tone category. In a similar way, Vietnamese forms in the *sắc* or *nặng* tones should come from syllables with final proto-stops. Again, as Gage writes, many of the Vietnamese forms with *sắc* or *nặng* tones are related to forms in Chong, a Pearic language, which have glottalization (as expected) but with a final continuant (certainly not expected stop final; see Figure 1). From this interesting data, Gage (1985) concludes that Haudricourt's consonantal finals alone are insufficient to account for either the *ngang-huyền* category or for the *sắc-nặng* category.

Diffloth (1982, 1989, 1990) also recognized that a more sophisticated model was needed and he responded by reconstructing earlier distinctions between clear and creaky (tense) voice to account for most of the problems that Gage and others had noted. Diffloth (see Figure 2) reconstructs the *ngang* and *huyền* items with an earlier clear voice, and the sắc and nặng items with an earlier creaky voice. The evidence for an old distinction between clear and creaky is widespread and ancient; this distinction is at least as old as proto-Vietic, the subgroup that includes Vietnamese. What makes Diffloth's reanalysis significant is that it recognizes that it is the voice quality distinctions, not the final consonantal distinctions, that are behind the division in Vietnamese into the *ngang-huyền* and *sắc-nặng* categories. Under the new analysis, the *sắc-nặng* items result either from inherited creakiness or from final stops. The proto-clear voice quality correlates with the *ngang-huyền* category. Finally, of course, the voicelessness of the voiceless final fricatives accounts for the *hỏi-ngã* category.

Finals:	proto-voiced sonorants; open syllables	proto-voiced sonorants; open syllables	stopped finals	voiceless fricatives
Register:	proto-clear	proto-creaky	(?) (> creaky)	(?)
Initials: proto-voiceless	pa "ngang"	pá "sắc"	pắk "sắc"	pả "hỏi"
Initials: proto-voiced	pà "huyền"	pạ "nặng"	pạk "nặng"	pã "ngã"

Figure 2: Vietnamese tonogenesis (Diffloth 1989:148)

In short, the analysis has been changed completely: the three-way tonal split Haudricourt analyzed as due to three classes of finals has been reanalyzed as due to three types of laryngeal configurations: one type of laryngeal configuration, the sonorant finals, led to the *ngang* and *huyền* tone classes; the voiceless finals, another laryngeal configuration, led to the *hỏi* and *ngã* tone classes; and the creaky voice and final stops resulted in the *sắc-nặng* tone classes. The original final stops found in the *sắc* and *nặng* tone classes are still found as final stops in modern Vietnamese, but, as will be argued later in this paper, these stop finals are accompanied by simultaneous glottal closure and that it was actually this glottal closure that caused these forms to merge with the creaky-voiced forms and produce the *sắc-nặng* category.

Finals:	proto-voiced sonorants; open syllables	proto-voiced sonorants; open syllables	stopped finals	non-stopped voiceless finals
Register:	proto-clear	proto-creaky	(?) (> creaky)	(?)
Initials: proto-voiceless (clear)	pa "ngang" (clear)	pá "sắc"	pắk "sắc"	pả "hỏi"
Initials: proto-voiced > breathy	pà "huyền" (breathy)	pạ "nặng"	pạk "nặng"	pã "ngã"

Figure 3: Vietnamese tones and voice quality distinctions

The role of the initials also needs reanalysis. In the Haudricourt model, the pitch height differences came directly from the distinction between proto-voiceless and the proto-voiced initials. However, this is oversimplified: the role of initials in tonogenesis is not a direct one but instead the connection between initial classes and tones has typically been mediated through a voice quality stage. For instance, in Vietnamese the evidence suggests that it was the distinction between clear and breathy voice that split each of the three earlier categories into a high-pitched and a low-pitched variant (Figure 3).

There is fairly clear evidence for an earlier Vietnamese distinction between clear and breathy voice. Ratliff (1997) noticed that Vũ Thê Thạch (1992) provides the evidence for a two-way voice quality distinction, one in which the three tones correlated with prevocalic proto-voiceless stops (*ngang*, *sắc*, and *hỏi*) are in opposition to the three tones correlated with proto-voiced initials (*huyền*, *nặng*, and *ngã*).

Tone of root:		Tone of bound morpheme:	Bound morpheme (example):
ngang, sắc, or hỏi	>	ngang	-ang 'very'
huyền, nặng, or ngã	>	huyền	
ngang, sắc, or hỏi	>	sắc	-âp 'perfect and pleasant'
huyền, nặng, or ngã	>	nặng	

ngang, sắc, or hỏi	>	hỏi	-e 'very (with positive quality)'
huyền, nặng, or ngã	>	ngã	

Table 1: Voice quality harmony in Vietnamese reduplicatives (Vũ 1992)

Vũ Thê Thạch (1992) describes the data in terms of what he calls 'tone harmony,' noting patterns in some 4000 Vietnamese lexical items in which the tones of the bound morphemes harmonize with the tones of the roots. Vũ notes (see Table 1) that his harmony patterns involve the division of Vietnamese tones into the *ngang-sắc-hỏi* group, that is, the forms correlated with proto-voiceless initials and the *huyền-nặng-ngã* group, that is, the forms correlated with the proto-voiced initials. In a parallel way, each of the bound morphemes has two tonally-distinct variants, one from the *ngang-sắc-hỏi* group and a corresponding variant from the *huyền-nặng-ngã* group: If root is from the *huyền-nặng-ngã* group, so is the bound morpheme; if the root is from the *huyền-nặng-ngã* group, again so is the bound morpheme. For example, the suffix *-ang* 'very' is in the *sắc* tone when the root is in the *ngang*, *sắc*, or *hỏi* tone; however, it is in the *nặng* tone when the root is in the *huyền*, *nặng*, or *ngã* tone.

Synchronically, Vũ is correct in describing the alternations as tone harmony. However, these alternations could not have started out as tone harmony. Historically, the alternations are the modern reflexes of an earlier system, not of pitch spreading to the bound morpheme, but rather of voice quality spreading. Thus, the alternations are reflexes of an earlier voice quality distinction that once existed after the initials of an earlier stage of Vietnamese. In the paired *ngang* and *huyền* tones, we can still see the original phonetics: the higher-pitched *ngang* tone is still accompanied by clear voice, while the lower-pitched *huyền* tone is still accompanied by breathiness. It is reasonable to assume that the remaining pairs of tones were also split in the same way: breathy voice developed after the proto-voiced initials, producing a lower pitch on those forms and putting them into contrast with the forms after proto-voiceless initials.

In sum, in the Vietnamese model of tonogenesis, the role of consonantal classes is an indirect one; the actual pitch characteristics in the tones come from the phonetics of the voice quality distinctions, and only indirectly from earlier distinctions in the consonants.[4]

2.0 Toward a laryngeal account

Within phonetics, specialists also have their reservations about how consonants would directly assign pitch to neighboring vowels.[5] Gandour and

[4] Sagart (1986) compares and contrasts the Vietnamese and the Chinese tonal developments, arguing for Mei's (1970) position that Chinese rising tone developed from the loss of a final glottal stop and for the suggestion that the departing tone developed from glottalization, that is, a phonation type. Sagart (1986) also uses Haudricourt's model of Vietnamese tonogenesis as support for his interpretation of the Chinese data, a match that has some problems, but which do not seem to seriously undermine Sagart's interesting conclusions about the origins of Chinese tones.

[5] Maddieson (1984) provides a succinct survey of the problems faced by consonant-based accounts.

Maddieson (1976), Riordan (1980), and others have argued that neither the magnitude nor the timing of larynx height adjustments provides a model that would correlate well with the effect of consonants on pitch. Similarly, Hombert and Ladefoged (1977) and others have established that, for voiced obstruents, the degree of voicing does not correlate well with the degree of pitch lowering. In more general terms, Hombert, Ohala, and Ewan (1979) state that no existing model provides an adequate account of how the laryngeal movements associated with consonant production could become pitch distinctions on vowels.

The problem lies in the fact that, on the one hand, consonant classes correlate with tone classes, but, on the other, consonants in and of themselves cannot explain tonogenesis; the key lies in the fact that it is virtually never individual consonants that correlate with pitch assignment but instead it is the consonant classes. This correlation, in turn, suggests it is distinctive laryngeal gestures associated with the particular classes of consonants that is the crucial factor in pitch assignment. The role is always indirect, with the occasional exception of certain postvocalic consonants. Voiced obstruents (particularly stops), for instance, result in breathy voice, which with its resultant lower pitch, with the breathiness being the immediate source of the lower pitch, not the original voiced obstruent.

The claim is that it is a laryngeal model of tonogenesis with its voice quality distinctions that adequately accounts for tonogenesis (and, of course, registrogenesis). As early as 1971, Egerod wrote that tone splitting often correlated with phonation types rather than with tones per se. Thongkum (1990:13) and other scholars have argued that phonation types are central to tonogenesis, writing, "…lexically contrastive pitches have developed primarily from voice register [voice quality] governing the whole syllable."[6] In short, the path of change involves distinct consonant types leading to register distinctions and then the phonation or voice quality[7] component of the register distinctions producing the pitch distinctions.

This overview both of tonogenesis and, as is probably obvious, at least the early stages of registrogenesis is compatible with what we know about phonetics. The central mechanism for pitch production is laryngeal gestures, including but certainly not restricted to both laryngeal tension—tightening and loosening, and to laryngeal movement, primarily upward and downward.

2.1 Laryngeals (< final consonants)

As is well-known, only the postvocalic consonants that involve a distinctive laryngeal adjustment contribute directly to pitch generation, specifically, glottal stops and -h. Upon initial inspection, the Vietnamese data

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[6]Thongkum relegates the voicing of consonants to a secondary role, noting that only in tone splitting do consonant play a direct role., the only place in which the voicing of consonants plays a direct role is in tone splitting. Even here, however, it is likely that in many cases tone splitting may also be mediate through voice quality distinctions.

[7]An excellent source of information on the diachronic development of voice quality distinctions is Denning (1989), which includes references to such systems in many parts of the world.

seems to be an exception to this generalization. Initially, it appears that distinctive tones developed directly from the final stops of Vietnamese. However, it is more likely that the Vietnamese final stops co-occurred with glottal closure and it is this glottal closure that resulted in the distinct tonal reflex.

In general it is not at all unusual for final stops in Southeast Asia to be accompanied by glottal closure, something indicated by their rather conspicuously unreleased, unexploded character. Harris (personal communication) and Phil Rose (personal communication) have commented on this co-occurring glottal closure, I have observed it myself in some Thai speakers, and Michailovsky, among others, has written about it. Diehl (1992b:6, cited in Wannemacher (1998:28) also notes this phenomenon; "anyone who has done much language study in East and Southeast Asia knows that a syllable-final stop is often an abandoned companion to a former (co-articulated) oral stop." Ebert (2003) notes the existence of glottalized final stops in various Kiranti languages; Wannemacher (1998) notes their existence in Zaiwa specifically, and in Tibeto-Burman in general. Similarly, Denning (1989:61, footnote 37) also suggests that rising contours may also come from conditioning by a glottally-constricted final consonant.

As Michailovsky (1975:214) suggests in a paper on Khaling, such glottal closure may result in tonogenesis. In Khaling, for example, at least on the verb roots, the two-way tone system is "correlated with the finals and derived from them." Michailovsky suggests that "since final stops per se have not been observed to have a phonetic pitch-raising effect" the motivation for the Khaling tones might be found in the simultaneous glottal closure that accompanies final stops in closely-related Hayu and in many of the Kiranti languages. Michailovsky suggests that the earlier existence in Khaling of this simultaneous glottal closure is a likely source of the Khaling tones, drawing a parallel in passing with Haudricourt's analysis of the tonogenetic effect of final stops in Vietnamese!

In theory, final laryngeal features could either lower pitch or raise it. Further, in contrast to laryngeal states resulting from prevocalic consonants, which produce a voice quality (with its accompanying pitch) that is usually (always?) distributed over the whole syllable, the pitch lowering or raising effect is sometimes restricted to the end of the syllable, resulting in a falling or rising contour. In the literature, specific laryngeal consonants have been connected with specific effects on pitch. For instance, in the early literature, Matisoff (1973:76) and Ohala (1973:3) speculated that final glottal stops would be exclusively associated with pitch raising and final -h with pitch lowering, but this speculation has not been borne out: although there is variation in the effects of final glottal stops and final -h, the clearest and the bulk of the evidence seems to show final glottal stops associated with falling contours and the one etymologically clear case of final -h being associated with a high level pitch.

In the 2002 version of this paper, there was an attempt not altogether successful to deal with the variability of an enriched typology of final laryngeals. While a raising contour from final glottal stop is attested, there are also cases of a resulting falling contour. As Mazaudon (1977:65-66) suggests, this apparent discrepancy is reconcilable if the abrupt, complete glottal closure accompanying a final glottal stop is distinguished from the less complete, less abrupt glottal stricture found, for example, in Burmese ‘creaky’ tone. This incomplete constriction, which results in a tense voice (sometimes termed creakiness), is usually but not always diachronically derived from a final glottal stop and resembles what is often termed vocal fry. Again, as Mazaudon (1977:66) observes, the more abrupt, more complete glottal stop leads to pitch raising, while the more imperfect, less abrupt variant leads to often-sharp pitch lowering accompanied by tenseness.

The effects of these laryngeal finals are still not well understood, nor are the speculations above intended to account for all instances of creakiness. Largely unrelated to adjacent consonants, secondarily developed creakiness sometimes develops when pitch dips low enough. For example, the third tone of Mandarin often has a creaky component apparently only conditioned by the lowness of the dip in pitch.

The reflexes of final -h show an even less well-understood variability. However, in two well-documented cases, final -h leads to a high rather than a low reflex. Ohala points out (1973:11), in Punjabi high tones, not low tones, appear on vowels which were followed by -h or by breathy-voiced stops in Middle Indo-Aryan (Arun 1961; Gill and Gleason 1969, 1972). Similarly, final -h in the Chamic languages has led to a high tone reflex in Hainan Cham (that is, Tsat; Thurgood 1996). Vietnamese provides an example of a falling tone reflex, with the Vietnamese final *-s > *-h apparently leading to a low tone, as did the other voiceless final sonorants. One question in the Vietnamese case, however, is what is the phonetic nature of the segment reconstructed as *-h, a question that has to be answered for more than just the Vietnamese data. In general, it would be useful to know whether a final -h represents a non-breathy final [-h] or breathiness [-˙]. Little unambiguous evidence exists for the development of a falling contour from final -h, and the one clear tonal reflex of final -h is the high-level 55 tone of Hainan Cham, related to the final -h of Indonesian and Malay.

Nonetheless, certain conclusions can safely be drawn. The contribution of the final consonants to pitch modification is laryngeally based. And, the effect of a final glottal stop probably depends upon whether it is accompanied by significant creakiness or not during the time tones are emerging. Similarly, the effects of so-called final -h undoubtedly relate to the phonetic nature of the segment, something not always clear in the literature.

2.2 The prevocalic consonants

Prevocalic consonants may induce voice quality distinctions on the following vowel; three of these are of particular relevance to our current understanding of tonogenesis.[8] In reference to Southeast Asian languages,[9]

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[8] It is quite possible that, as better descriptions of voice quality emerge, more voice quality distinctions will be regularly and reliably reported in the literature.

[9] My own admittedly cursory survey of languages in other areas (cf. Denning 1989; Gregerson 1976, and so on) seems to suggest a similar situation pertains elsewhere. This is not, however, to say that there are not significant phonetic differences in the various manifestations, but only to note that there is a basically breathy voice quality, a basically constricted voice quality, and, of course, a modal voice quality.

Thongkum writes (1988:321) that, although more exist, only three basic voice qualities seem to play a major role in tonogenesis:[10] breathy, clear (or normal or modal), and tense voice. Breathiness, produced with abducted arytenoid cartilages, typically but certainly not always is accompanied by a lowering of the larynx that correlates with the lowering of pitch; tenseness (or creakiness), produced with adducted arytenoid cartilages, typically but certainly not always is accompanied by a raising of the larynx (Abramson, personal communication) that, when it occurs, correlates with the raising of pitch; and, a clear voice neither raises nor lowers the larynx significantly; thus, it does not alter pitch.[11]

It is, of course, not just the raising and lowering of the larynx that determines pitch height: adjustment of the tension in the vocal cords would affect pitch height as would adjustment to the configuration of any one of various parts of the vocal tract. In producing various voice qualities more than just the vocal cords are adjusted (cf. for examples and discussion, see Esling and Harris 2005); since adjustments made in the course of producing vowel quality distinctions almost inevitably influence the tension, these same adjustments correlate with changes in pitch height. In general constrictions would be expected to increase pitch height; expansions would be expected to decrease it.

As just one example, Abramson (personal communication) mentions the research of Löfqvist, Baer, McGarr, and Story 1989, which has indicated that varying degrees of contraction of the cricothyroid muscle of the larynx help with the maintenance or suppression of voicing; in this research it is argued that using greater contraction to suppress voicing, combined with aerodynamic consequences upon opening the glottis, causes higher vibration rates. Thus, it is certainly not just raising and lowering of the larynx that produces pitch distinctions; however, when the mechanism is laryngeal movement, the gesture often leaves an identifiable signature behind in the form of a distinctive voice quality.

It is important to realize that the voice quality distinction with its distinctive pitch height is a characteristic of the whole vowel, the pitch height is also a characteristic of the whole vowel, not just its onset. This is significant because, although voiced and voiceless initials also induce pitch perturbations on following vowels, these are only manifested on the onset of the vowel. In contrast, voice quality distinctions such as breathiness and creakiness are manifested on the whole vowel, as are pitch perturbations. This experimental finding presents at least two problems if one attempts to derive tones directly from initials: first, how and why does the pitch height get distributed evenly over the whole vowel, and, second, why don't at least some initials result in contour tones, as might be expected given that prevocalic consonants only seem to affect vowel onsets.

The three laryngeal configurations accompanying the three voice qualities are sufficient to provide the pitch distinctions which frequently co-occur with voice quality distinctions, not just in Southeast Asia, but throughout the world.

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[10]Ladefoged (1971) has argued that there are seven linguistically-significant states of the glottis. However, of these, only three play any central role in Southeast Asian registrogenesis and, should it occur, subsequently in tonogenesis.

[11]Although this is a simplified picture of an enormously complicated literature, it does nonetheless represent the general patterns.

Breathiness tends to co-occur with the lowering of pitch, tenseness with the raising of pitch, and clear voice without significant modification of pitch. Of course it is also possible to produce breathy voice with a high or mid pitch, but breathy voice typically occurs with low pitch; it is also possible to produce tense voice with a low pitch, but it typically occurs with high pitch.

It is worth noting that few languages are described as having even three voice quality distinctions. However, the presence of just one non-modal voice quality provides an opposition between modal (clear) and the non-modal quality. If, for example, a language has both breathy and clear voice and the breathy voice quality is accompanied by low pitch, the contrasting clear voice counterpart is automatically relatively high. And, once the system has been brought into existence the likelihood of perceptually induced restructuring exists, maximizing the perceptual salience of the pitch differences. Thus, after their creation, many modern systems have restructured in various ways. Nonetheless, the phonetic mechanisms outlined here are more than sufficient for developing the basic two-way pitch height distinction that still characterizes many modern systems.[12]

It is the primarily, although not exclusively, as Haudricourt's modal would lead us to expect, the initial consonants that produce the voice quality distinctions responsible for pitch height distinctions and it is primarily laryngeal consonants in postvocalic position that produce the voice quality distinctions responsible for contours.

3.0 Phonetic evidence for a laryngeal model

There an abundance of evidence for tones evolving out of the laryngeal gestures associated with earlier voice qualities. (1) The laryngeal model accounts rather nicely for the phonetic nature of many tone systems. (2) It provides a plausible source for many otherwise inexplicable pitch distinctions. (3) The model explains why vowel quality differences appear, not just widely in register complexes, but also quite frequently in tone systems. (4) It explains much of what would otherwise be inexplicable about certain cases of 'tone' spreading. (5) It accounts for part of the asymmetrical behavior between voiced obstruents and voiced sonorants in tonogenesis: Although voiced obstruents and sonorants usually pattern together, when they pattern differently, the lower tone usually occurs after voiced obstruents, not after voiced sonorants. Finally, (6) the most obvious piece of evidence is the phonetics of known historical cases in which tone systems have come from earlier register systems.

3.1 The phonetic nature of tone systems

The awareness of phonation characteristics within tonal systems dates

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[12]I see no evidence whatsoever that tonogenesis, as opposed to tone splitting, ever initially involves more than a two-way opposition. Not only are there no apparent diachronic instances of a three-way system evolving but the prevalence of two-way pitch height distinctions both in register and tone languages also suggests an initial two-way split. In those cases of Southeast Asian tone systems with more than two levels of pitch height we usually, but not always, can account for the additional pitch height distinctions in terms of subsequently tone splitting.

back over thirty years. Many tone systems contain clusters of phonetic features that are quite similar to the feature clusters that constitute the typical register complexes. As Eugénie Henderson (1967:171) wrote with reference to Southeast Asian tone systems:

> It is important to recognize that pitch is frequently only one of the phonetic components of ‘tone’ as a phonological category. A phonological tone is in our area very frequently a complex of other features besides pitch—such as intensity, duration, voice quality, final glottal constriction and so on.

In fact, in many cases, the difference between a tone system and a register complex seems to lie more in what seems to constitute the organizing principle in each system than in the list of features *per se*. In a tone system, the speakers have come to treat the pitch characteristics as salient; in a register system, it is the voice quality differences.

Such configurations are found in tone systems throughout the world, not just Southeast Asia, making the standard definition of tone as the lexical phonemicization of pitch distinctions at best a misleading simplification, at worst a serious impediment to understanding. Even a cursory examination of tone systems in the Americas, in Africa, and even in Europe makes it clear that most, if not all, tone systems contain similar clusters of features.

Notice that the listing of the phonetic characteristics of a register system in Figure 4 contains the same range of phonetic features as does Henderson's characterization of the typical Southeast Asian tone system (Figure 4 is a modified composite of Henderson (1952, 1977), Matisoff (1973:76), Edmondson and Gregerson (1993:61-63), and Bradley 1982).

	Tense Register	Unmarked	Breathy Register
original initials:	proto-voiceless		proto-voiced
voice quality:	tense (creaky)	modal (clear)	breathy
vowel quality:	lower (open);		higher (closed);
	more fronted vowels;		more backed vowels;
	tendency to		tendency to
	diphthongization;		to centralization;
	often shorter		often longer
pitch distinctions:	higher pitch;		lower pitch;
	associated with -ʔ (?)		association with -h (?)
state of larynx:	larynx tense and/or		larynx lax and/or

raised (= reduced supraglottal cavity)	lowered (= increased supraglottal cavity)

Figure 4: The three most common register complexes

Of course, the most frequent register is the unmarked modal or clear voice. Although there certainly are systems in which all three registers or even four registers occur, the contrast in a typical register system is between the unmarked modal voice and one of the two marked registers described in Figure 4. In the two marked register complexes certain sets of features typically cooccur: In the tense register complex the vowels have a tense, laryngealized, or creaky voice quality, are more open (lower), have a higher pitch, and a tendency toward vowel fronting and diphthongization. In the breathy register complex the vowels have a breathy voice quality, are more closed (higher) vowels, have a lower pitch, and a tendency toward vowel backing. The tense-voiced vowels are derived historically from final glottal stops or, less frequently, from voiceless onsets; the breathy voiced vowels are derived from voiced obstruent onsets. Not too surprisingly, when the tense-voiced vowels are shorter, the tenseness is often derived from a final glottal stop. The final feature (modified from Matisoff (1973:76)) is the state of the larynx; with tense voice the larynx is often raised (and/or tense), thereby reducing the supraglottal cavity, while with breathy voice the larynx is often lowered (and/or lax), thereby increasing the supraglottal cavity.

Register complexes are also referred to by a variety of names, but these terms must often be used with some caution as they are often used, not with cross-linguistic comparison in mind, but instead simply to describe a two-way register contrast in a specific language. Maddieson and Ladefoged (1985), for instance, discuss problems with regard to the cross-linguistic variability in the use of the terms tense and lax. At times, tense and lax are used to describe a relative contrast in tenseness rather than the presence of specific voice qualities. For example, if a language has a distinctive breathy register complex contrasting with clear voice, the breathy complex will be labeled lax and the contrasting clear register will be labeled tense. However, if a language has a distinctive tense register complex contrasting with clear voice, the tense register will be labeled tense with the contrasting clear voice being labeled lax. However, for cross-linguistic comparisons it is crucial to know if, for example, the term tense refers to a creaky voice quality or to a clear voice quality that happens to be in opposition to a breathy voice quality. Similar indeterminacies exist with the terms first register versus second register, which are associated with tense and breathy voice, respectively.

If we compare this characterization of register complexes with Henderson's earlier characterization of Southeast Asian tones, we discover that tones, like register complexes, frequently consist of a cluster of features including pitch, voicing, duration, voice quality, and final glottal constriction. In short, the comparison of tonal systems with register systems shows the two systems have striking typological similarities. The realization that tone systems often evolve out of voice quality distinctions provides an explanation for the widespread presence of voice quality distinctions in tone systems. Note that for a register complex to evolve into a tonal system, it is only necessary for the pitch component to become more salient than the voice quality component.

3.2 A plausible source for pitch height distinctions

Part of the argument in this paper rests on the assumption that, even if pitch is not an invariable feature of voice quality distinctions and thus of register systems, it is at least a widely present feature. When Gregerson (1976:54) states that, for Mon-Khmer languages, "pitch is never a major feature", this claim seems to say little more than voice quality features are more important than pitch features in a register system, something that is almost definitional.[13] However, when he further notes that pitch is more often absent than present in descriptions of register languages, it seems that the comment is more about the descriptions in question than about the widespread presence of pitch in register languages. Insofar as Gregerson is claiming pitch differences are absent in the majority of register languages, this does not appear to be true. For the languages of Southeast Asia, Thongkum (1988:328) directly challenges Gregerson's claim; she states that, in her opinion, "pitch differences are always present in register languages. Unfortunately, it has always been ignored or unheard by Mon-Khmer specialists." Certainly, the presence of pitch distinctions correlated with voice quality distinctions is widely attested in Southeast Asia (see various examples in this paper). In most cases the evidence is impressionistic; in others it is instrumental, for example, Lee (1985) provides instrumental evidence for such pitch distinctions in Mon, a Mon-Khmer language. More often than not the data has been recorded by a field linguist. Huffman (1976) records some 15 Mon-Khmer dialects; in comparing these, he contrasts the first register with the second register, noting that when phonetic features are manifested, high pitch and tense vowels occur with the first register while low pitch and breathy register occur with the second. Denning (1989) surveys the world's voice quality systems, using a sample that includes languages of Asia, North Africa, West Africa, and North and Central America. He too divides voice quality systems into contrasting sets, one relatively lax, with significant spectral tilt (an indication of breathiness), relatively low larynx, and lower pitch, the other relatively tense, with slight spectral tilt, relatively high larynx, and higher pitch (1989:60).

In short, it is clear that voice quality distinctions are widely accompanied by pitch distinctions. More specifically, breathy voice is associated with lower pitch and the lowering of the larynx, while tense voice is associated with higher the pitch and raising of the larynx. And, as Laver (1980:27-31) notes, lower pitch

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[13]It is crucial to realize that for languages which contain both voice quality and pitch features, the question of whether the major feature is voice quality or pitch cannot be determined solely by the linguist's ear or even by instrumental studies, but instead must be determined by perceptual experiments designed to determine what the speakers of the language use as their so-called primary cues. Even here, however, there is likely to be a surprising (to some disturbing) variability.

correlates with the laxing and/or lowering of the larynx, while higher pitch correlates with the raising and/or of the larynx.[14]

3.3 An acoustic explanation for vowel quality differences

The literature documents two correlations between voice quality and vowel quality, one universally attested and the other more marginally attested. The most accurate statement of these correlations is found in Bradley (1982:120), who describes the vowels deriving from the older voiced and, as is obvious from the modern phonetics, breathy-voiced register as "higher" and "more fronted", while describing the vowels deriving from the older creaky-voiced register as "lower" and "more backed". The correlation between voice quality and vowel height, that is, F1 is widely attested and uncontroversial: countless scholars have observed that breathy-voiced vowels tend to be relatively higher (e.g., /i/ versus /I/), while tense-voiced vowels tend to be relatively lower (Henderson (1952, 1977), Huffman (1976), Denning (1989), Hombert (1978), Bradley (1982) and so on). The correlation of tenseness (laryngealization) with lower vowels is seen in Mpi, a language in the Lolo-Burmese branch of Tibeto-Burman; Denning (1989:29-33) examined the two-way phonation contrast between modal and tense voice in Mpi and noted that Mpi the tense-voiced vowels showed lowered vowels, that is, the tense-voiced vowels had a higher F1.

The second correlation, between voice quality and vowel fronting, that is F2, is neither as often observed, nor as clearly designated: in Bradley's terms (1982:120), breathy-voiced vowels tend to be more backed, while tense-voiced vowels tend to front. Henderson (1952, 1977:259) describes what seems to be the same correlation but in different terms; the breathy-voiced vowels have a "tendency to diphthongize", while the tense-voiced vowels have a "tendency to centralize". Similar tendencies observed by other authors (e.g. Huffman 1976) tend to parallel either Bradley's or Henderson's characterization.

Although the literature does contain examples in which these correlations do not hold, such cases are marked as atypical, not only by their rarity, but also by the fact that such putative exceptions are invariably restricted to a small subset of the language's vowels. More important in terms of this paper is the fact that such vowel quality differences are also present, although not as widely attested, in tone systems. For instance, the correlation of breathiness with higher vowels is seen in Hani, a language in the Lolo-Burmese branch of Tibeto-Burman. Maddieson and Ladefoged (1985:67-70) established instrumentally that their Hani breathy vowels are higher, that is, the breathy-voiced vowels have a lower F1.

There are two factors that help explain the correlations. To a large degree, the differences correlate with vocal cord tension; breathy voice is associated with laxer vocal cord tension, and thus with lower pitch. Probably to a lesser degree,

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[14] The correlation of breathiness with higher, rather than lower, vowels is seen in Hani, a language in the Lolo-Burmese branch of Tibeto-Burman; Maddieson and Ladefoged (1985:67-70) established instrumentally that their Hani breathy vowels not only have lower pitch but also are higher, that is, the breathy-voiced vowels have a lower F1.

when the breathiness is accompanied by larynx lowering, the tube is longer, the time to travel the tube is longer and slower, and the frequency goes down even further.[15] Conversely, creaky voice is associated with more constricted vocal cord tension, and thus with higher pitch; when creaky voice involves larynx raising, the tube is shorter, the time to travel the tube is shorter and quicker, and thus the frequency is somewhat higher.

Thus, breathy voice correlates with high vowels; creaky voice with lower vowels. The vowel chart[16] in Figure 5 is added for ease of exposition; those with expertise in acoustic phonetics will not need it but those without the acoustic facts at their fingertips will find it useful. As Figure 5 makes clear, vowel height differences correlate with F1. Thus, when the larynx is laxer and/or lowered under breathy voice, the vocal tract is lengthened; the lengthened vocal tract lengthens the wave lengths of the sounds and generally lowers the formants. Thus, all other things being equal, with the lowering of the larynx under breathy voice the F1 would be lower, making the vowels higher (Figure 5). Conversely, when the larynx is tenser and/or raised under tense voice, the vocal tract is shortened; the shortened vocal tract shortens the wave lengths of the sounds and generally raises the formants. Consequently, with the raising of the larynx under tense voice the F1 would be higher with the vowels lower.[17]

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[15] I suspect that historically the lowering that is sometimes accompanied by venting in the attempt to maintain voicing comes first, but I cannot imagine what the experimental data to prove this position would look like.

[16] Neither the precise positions of the vowels on the chart, nor the particular set of vowels chosen for exposition is of any particular significance. That is, it does not represent a particular language, nor necessarily a typical register system.

[17] I wish to thank Peter Ladefoged in particular for discussing this with me, but also Arthur Abramson for his help. More recently, Marc Brunelle sent some very useful feedback. I also want to thank Theraphan Thongkum also alludes to these correlations in one of her many outstanding papers on register systems, on tonogenesis, and on their interaction.

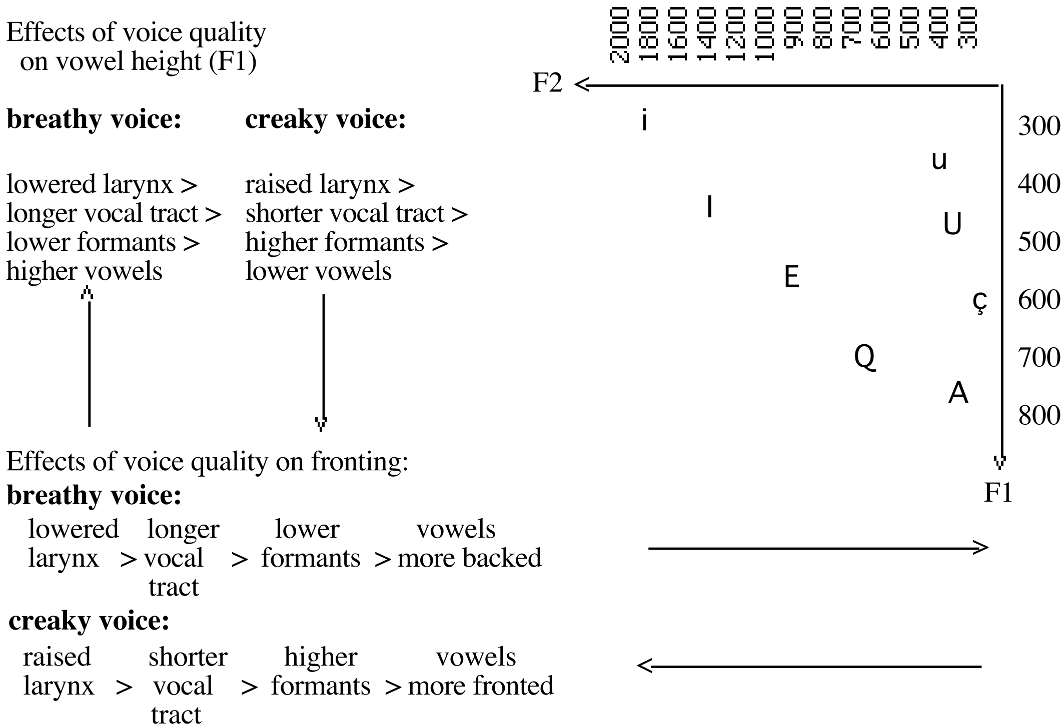

Figure 5: The effects of voice quality on vowel height and fronting

Exactly the same considerations also affect the fronting of the vowels, except that it is the effect on the F2, not on F1, that determines vowel fronting: the larynx is laxer and/or lowered in producing breathy voice; if the vocal tract is lengthened, the lengthened vocal tract lengthens the wave lengths, lowering the formants even further. As Figure 5 makes clear, vowels with a lower F2 are more backed. Conversely, the tensing and/or raising of the larynx in producing tense voice, the consequent shortening of the vocal tract, and the resulting shortened wave lengths, produce higher formants. As Figure 5 shows, vowels with a higher F2 are more fronted.

Insofar as the correlation is between voice quality and what Bradley (1982) describes for Burmese as fronting, this model accounts for it. However, the connection between this model and what Henderson (1977 and elsewhere) and others have labeled as diphthongization (with tenseness) and centralization (with breathiness) is more problematic. Under the influence of voice quality differences it is the front vowels that move most noticeably, and insofar as it is primarily the movement of the front vowels, the model provides at least a partial account of the patterns: the front vowels move toward the front under tenseness and toward the back under breathiness. However, if the back vowels are described as centralizing, their movement should be toward the front, not toward the back. The instrumental data found in Bradley ed. (1982) is consistent with his terms fronting and backing and will be used here. Cf. also Thurgood (2000) for the effects of voice quality on vowel quality.

In part for the fact that in register and tone languages, breathy vowels have a tendency toward backing, while tense-voiced vowels tend to front. However, it is less clear why tense vowels tend not just to front but to diphthongize (Henderson 1952, and so on; Huffman 1976). I suspect the answer lies in the fact that breathiness almost always develops from a prevocalic consonant, but tenseness may develop from a post-vocalic segment; however, solution to this problem will be left for another time, if not another researcher.

In summary, there is a widely-noted causal relationship between the vocal cord tenseness and/or direction of laryngeal gestures involved in the production of specific voice qualities and vowel height and fronting. As a result, because tone systems have frequently evolved out of the phonetics of voice quality distinctions, specific tones are sometimes associated with specific vowel quality features.

3.4 An account of certain cases of 'tone' spreading

Upon closer examination, certain cases of tone spreading are better analyzed as the spreading of voice quality, not pitch. One example already discussed is what Vũ (1992) described as tone harmony; while the synchronic distribution of forms could certainly be called tone harmony, as tone harmony was the result, the tone harmony came about as the spread of voice quality distinctions, which only subsequently turned into tones. Some particularly clear examples are found in Phan Rang Cham and in Hainan Cham (Tsat), two Chamic languages of Vietnam (Thurgood 1996, 1999). The historical analysis shows the spreading of voice quality and the subsequent develop of tones from the voice qualities determined the modern tones. In both languages voiced stops induce breathiness on the following vowel, with the breathy voice quality spreading from the presyllable to the main syllable under certain conditions: if the breathy voiced presyllable precedes a the main syllable begins with a voiced sonorant onset, the main syllable also develops the tone expected for forms with voiced initial stops, a finding perhaps not that striking.

More interestingly, in Hainan Cham, even if the main syllable begins with a voiceless obstruent the main syllable develops the tone expected for forms with voiced initial stops. In this last case, it cannot be voicing that spread; it must be voice quality spreading from the presyllable to the main syllable, with the tones developing only later.

Malay	PC	Chru	N. Roglai	Tsat	
dĕpa	*dəpa	təpa	tupa	pa^{11}	'armspan'
---	*batĕy	pətəi	pitəi	u^{11} tai^{11}	'banana'
bĕsi	*bəsĕy	pəsəi	pisəi	sai^{11}	'iron'
buta	*buta	---	---	ta^{11}	'blind'
---	*batɔ	pətɔ	pato	to^{11}	'teach'
batu	*batɔ̆w	pətəu	patəu	tau^{11}	'stone'
batuk	*batuk	pətuʔ	lituʔ	$tuʔ^{43}$	'cough'

dikit	*dikit	təki:ʔ	tiki:ʔ	kiʔ43	‘few; little’

Table 2: Spreading through Tsat voiceless stops.

In the examples of Table 2, it is the voiced stop of the presyllable, not the voiceless stop of the main syllable, that correlates with the Tsat 11 low-level and the 43 falling tone. Thus, in these examples, in which the Proto-Chamic presyllable begins with a voiced stop and the main syllable begins with a voiceless stop, it is obviously the breathiness, not voicing, that has spread from the presyllable to the main syllable.

The parallels between voice quality spreading and tone spreading are quite striking: As with ‘tone’ spreading, the tendency is for voice quality to spread from left to right, although prefixes sometimes pick up their voice quality from a following root. As with ‘tone’ spreading, voice quality spreading is subject to boundary phenomena, that is, the domain for spreading is a word or a phrase; however, in voice quality systems boundaries do little more than impose a limit on spreading, while in tone systems boundary phenomena sometimes interact with pitch and induce changes.

Finally, as with ‘tone’ spreading, certain consonants are more compatible with voice quality spreading, while other consonants tend to block it. Thus, there is a hierarchy for voice quality spreading, with breathy voice spreading most readily through sonorants, less readily through /s/, /h/, and, intriguingly, ///, and least readily through voiceless stops. In a similar way, tense voice spreads readily through sonorants but far less readily through voiced obstruents. Strikingly parallel patterns have also been reported, not for voice quality spreading, but for tone spreading in African tone languages. Thus, for West African languages, Hyman and Schuh (1974:108) report that the spreading of low tone can be blocked by voiceless consonants, while the spreading of high tone can be blocked by voiced consonants, typically voiced obstruents. For instance, in Ikalanga (Hyman and Mathangwane 1998:204), there is a set of what Bantuists call “depressor consonants”. The typical effect of these consonants is either to lower a high tone or to stop the spread of a high tone. It is not all the voiced consonants but rather specifically the voiced obstruents that constitute the depressor consonants, just the class of consonants most closely associated with breathy voice.[18]

Thus, where tones have evolved out of voice quality differences, certain tone spreading patterns are the historical residue of an earlier pretonal stage that involved voice quality, not tonal, spreading.

3.5 Voiced stops versus voiced sonorants

In tonogenesis, voiced sonorants do not always pattern like voiced stops.

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[18]The reverse correlations are seen with the “uplifter consonants”. As Hyman and Mathangwane (1998:227) note, the uplifter consonants, e.g. voiceless obstruents and implosives, block low tone spreading and raise pitch. However, it is not obvious that these are historically associated with a distinctive voice quality. It is more likely that the high tone is a default class, consisting of just those items not in the phonetically more marked low tone class.

In writing about West Africa patterns, Hyman (1978:266) notes that among the voiced consonants, it is particularly the voiced obstruents and breathy voiced stops that tend to lower pitch. This seems true generally: When the obstruents and sonorants differ in their behavior, the lower tone usually occurs after voiced stops, but not after voiced sonorants. This is certainly true for Southeast Asia (cf. Phan Rang Cham and for Hainan Cham (Tsat) of Southeast Asia (Thurgood, 1996)). The converse, if indeed it exists, is far, far rarer. Other related asymmetries also exist: It is frequently only the voiced stops, not the voiced sonorants or voiced fricatives, that develop breathy voice.

These asymmetries are, I believe, related to the phonetics of the voiced stops, specifically, the problems involved in maintaining voicing in the face of total occlusion. The difficulties are obvious typologically: while all systems have voiceless stops, many do not have the voiced stops. The problems are obvious historically: it is not at all uncommon historically for voiced stops to simply lose their voicing. And, it is not uncommon for voiced stops to develop into breathy voiced stops: the most common voice quality found in register systems is the development of breathy voice from a series of voiced stops.

It is relatively well-known that it is the airflow across the vocal folds that causes voicing, the Bernoulli effect, but as various scholars have pointed out the airflow only exists when there is a sufficient difference in pressure between the thoraic cavity and the supraglottal cavity. If there is an insufficient pressure differential between the thoraic cavity and the supraglottal cavity, voicing will cease. As Westbury (1983) pointed out, in the production of voiced stops the maintenance of a sufficient transglottal pressure differential is a problem. The very closure that makes a stop a stop cuts off airflow and causes the pressure in the supraglottal cavity to increase rapidly, which, in turn, stops the airflow and leads to the cessation of voicing. Note that this problem is at its greatest with stops; fricatives and nasals both involve the continual venting of air, and thus have a far less damping effect on the maintenance of voicing. On the basis of estimates of the volume of the supraglottal cavity, the rate and volume of airflow, and knowledge of the length of voicing during the production of voiced stops, Westbury (1983) argued that the supraglottal cavity does not have a sufficient volume to maintain voicing for as long as it actually occurs in natural speech. Thus, speakers must be making some additional adjustments in order to maintain voicing.

The general conclusion of Westbury (1983:1332) was that during the production of voiced stops there was an overall increase in the volume of the supraglottal cavity, while in some voiceless stops there was a decrease in volume, but with the voiceless stops the change was of far smaller magnitude. Much more specifically, Westbury found that in his one subject two basic factors played a role in increasing the surpraglottal volume and thus in maintaining voicing, with larynx movement playing a major role and tongue root movement playing a more minor one. Summarizing his more detailed account, it is important to note that Westbury (1983:1327) found that the larynx tended to be lower during voiced than voiceless stops. The findings for larynx movement, rather than larynx position, are mixed at other syllable positions, but utterance-initial /b,d,g/ all show "the larynx moved steadily downward during the closures". This movement, characteristic of utterance-initial voiced stops, is the same gesture characteristic of breathy-voiced stops; in fact, the transition from voiced stops to breathy-voiced stops would only require that this downward gesture be augmented by allowing the passage of air to precede through the laxer glottal closure with slightly less resistance than otherwise. It is this slightly increased volume of air that has the potential of developing into breathy voice.

This mechanism for the phonetic transition from voiced stops to breathy-voiced stops to breathy-voiced vowels receives further support from the phonetics of the change. Typically, it is in the oldest historical layer that fully voiced stops are found, but the ultimate outcome of the string of changes is a layer characterized by voiceless aspirated stops followed by breathy-voiced vowels. Not only is the voicing completely lost from the former voiced stop but there is a trace left behind from the slight increase in the volume of air allowed to escape from the subglottal cavity---the aspiration of the aspirated voiceless stop now constituting the onset of breathiness. Note that the claim is not that there was a jump directly from lax phonation to voiceless aspiration on the preceding stop; the initial stage was probably a voiced stop followed by a voiced breathy release.

These phonetic findings also provide an explanation for what is otherwise a distributional anomaly: the fact that former voiced stops often have lower tones than voiced sonorants. This asymmetry follows from the fact that voiced stops are more likely than voiced sonorants to develop breathy voice and it is the breathiness, not the voicing, that has produced the lower pitch.

3.6 The phonetics of other historical parallels

The typological and the phonetic evidence is supplemented by historical examples. For example, if we return to the phonetics of Vietnamese tones just examined, it is clear that the six modern tones are still complexes of various features, not just pitch (Thompson 1984-1985:16): among the forms without final stops the low-pitched *huyền* tone, described as "often accompanied by breathy voice quality", is in contrast with the mid or high-mid pitched *ngang* tone, while among the forms with final stops, the low-dropping-pitched nặng tone which "ends in [a] stop or is cut off abruptly by [a] glottal stop" is in contrast with the high-rising-pitched *sắc* tone. That is, the Vietnamese "tone" system still contains a variety of voice quality oppositions, some of which have contributed to the modern pitch patterns of Vietnamese.

Burmese offers a clear example of a tone system whose phonetics suggests an earlier origin as a register system. Maddieson (1984:10) writes, "Traditionally, Burmese has been regarded as having four "tones" but the differences between them include vowel length and other properties of the syllables besides the pitch level and contour (cf. Javkin and Maddieson 1983)."

tone 1 'level'	tone 2 'heavy'	tone 3 'creaky'	tone 4

voice quality	clear	breathy	creaky	clear
vowel length	average	long	short	extra-short
pitch	low onset, rises at end	high onset, falling contour	high onset, falling contour	high, abrupt, short
diachronic correlates	proto-voiceless initials	proto-voiced initials	*s- prefix before proto-voiced initials	final stops > final glottal stop

Figure 6: The phonetic properties of the Burmese tone system

The tones themselves differ not just in pitch, but also in vowel length (Haas, p.c.) and, in part, in voice quality types, although the voice quality distinctions are at times not particularly salient. Were the Burmese voice quality differences to be more salient than the pitch differences, Burmese would have a register system. In short, the Burmese tonal system looks to be strikingly similar to a register system (cf. Bradley 1982).

4.0 Conclusions

First, the paper replaces the older, segmentally-based account of Vietnamese tonogenesis with an updated, laryngeally-based account. Then, on the basis of data from a widely distributed selection of the world's languages, the paper replaces a consonantally-based account of tonogenesis with a laryngeally-based one. It is argued that distinctive laryngeal gestures are the primary mechanism of tonogenesis and that in most, if not all cases, these gestures have developed in the context of voice quality distinctions. Such a laryngeally-based model helps provide phonetically plausible explanation for the widely-attested correlation of pitch height and initial voicing and for correlations between voice quality and vowel quality.

In the course of providing a laryngeally-based account, the paper also correlates data already existing in the literature, suggesting that these same laryngeal considerations provide a phonetic explanation for the preference for developing breathy voice from voiced stop onsets rather than sonorants or fricatives. In addition, tension in the vocal folds and/or larynx raising and lowering provide at least a partial explanation of the effects of breathy, modal, creaky voice on vowel quality. Such a model also accounts for various cases of tone spreading, which turn out to be the residue of earlier voice quality spreading patterns. The model provides phonetic and acoustic explanations for tonogenesis, for some instances of vowel harmony, and for the structure of many modern tone systems, while being equally applicable in Southeast Asia, East Asia, South Asia, Africa, Europe, and the Americas.

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