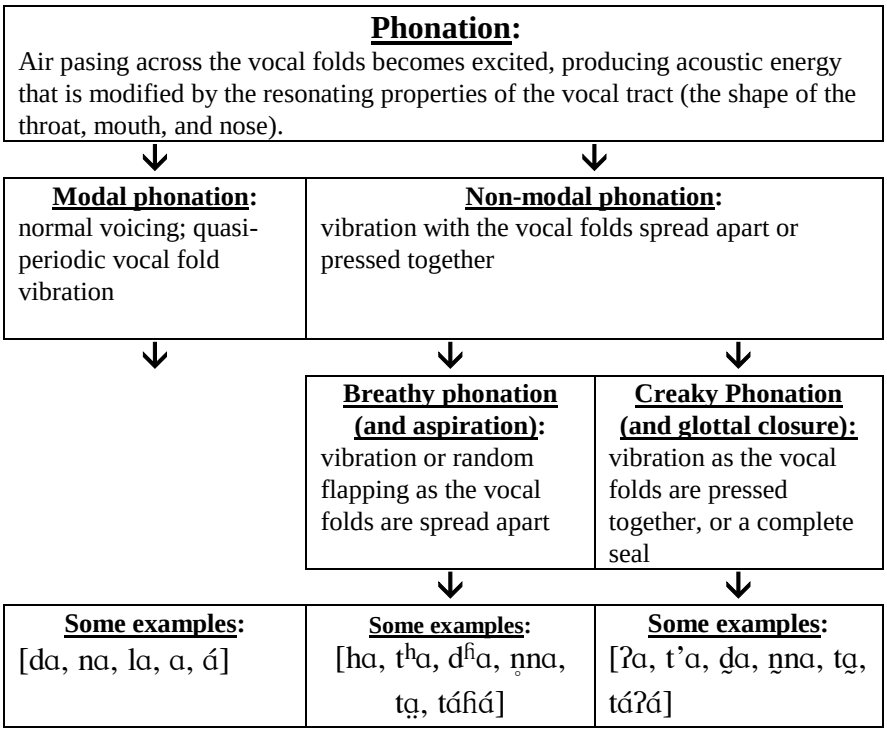
UTSC

Timing and Recoverability: Laryngeal and oral speech events

Daniel Silverman
daniel.doron.silverman@gmail.com

Introduction:



1. The vocal folds are always actively involved in speech production. They take on different postures, and are timed differently, depending on the posture of the oral articulators.

   stops, sonorants, and vowels

2. For plain stops they are spread apart, so that voicing is inhibited:

   {alveolar stop, laryngeal spreading} ⇨ **t** (all languages)

3. When vocal fold spreading is timed differently, it usually is timed *after the* stop closure.

{alveolar stop, laryngeal spreading} ⇨ t^h (many languages)

4. When there is an additional timing contrast, only then do we observe spreading *before* the stop closure:

   {alveolar stop, laryngeal spreading} ⇨ ^ht (very few languages)

5. The presence of pre-aspirated stops in a language implies the presence of post-aspirated stops.

   {alveolar stop, laryngeal spreading} ⇨ t >> t^h >> ^ht

6. The reasons why: aerodynamics, acoustics, and audition.

7. The presence of pre-aspirated stops in a language implies the presence of post-aspirated stops.

   {nasal, laryngeal spreading} ⇨ n >> n̥n >> nn̥

(3)

voiced nasals:		voiceless nasals:	
mə̂	lift up	m̥m̆ə̂	from
na	pain	n̥n̆a	nose
ɲa	right	ɲ̥ɲ̆a	considerate
ŋə̂	fish	ŋ̥ŋ̆ə̂	borrow

(4) morphological aspiration (h/non-h pairs--Okell 1969):

a. obstruent-initial:

pi	be pressed	phi	press, compress
pe	break off, be chipped	phe	break off (a piece)
po	appear	pho	reveal
ceʔ	be cooked	cheʔ	cook
sowʔ	be torn, shabby	showʔ	tear
suʔ	be damp	shuʔ	moisten, make damp
kwe	be split, separated	khwe	split, separate

b. nasal-initial:

mjin	be high, tall	m̥mjin	raise, make higher
niʔ	be submerged, sink	n̥͡niʔ	submerge, sink
ne	be loose	n̥͡ne	loosen (in socket, etc.)
naʔ	be completely cooked	n̥͡naʔ	complete cooking

(13)

ka˩w̥wen̥ʔ˩˧ neʔ˩		the animal was frightened
ʄjuːn̥˩˥la˥˩		this child
ʄjuːn̥˩˥zeʔ˦		sick child
pimʔ˥	(<..Nʔ + p)	he is tiny
ʄjuːm̥˩˥piŋʔ˥		small child
ʄjuːŋ̊˩˥kʌŋʔ˦		big children
w̰wiŋʔ˥		black child
ʄjuːŋ̊˩˥haŋʔ˦		perverse child
ni˩l̥lejn̥˦	(<..N̥ + ʐ)	he will tremble
ʔʌjn̥˩˧	(<..N̥ + ʐ)	he pulls (him)"

So Chinantec is not contradictory at all. Instead, since place of articulation is non-contrastive here, voicelessness is free to co-occur in full parallel with velic lowering: no contrasts are jeopardized.

4. today's inquiry: laryngeally complex vowels

{vowel, laryngeal spreading, tone} **hà** >> **àh** >> **à̤**

{vowel, laryngeal constriction, tone} ʔà >> àʔ >> a̰

laryngeally *simplex* class:

5. Neither contrastive tone nor contrastive phonation
   plain vowel (e.g., English): **a**

6. Contrastive tone, but no contrastive phonation
   toned vowel (Mandarin, Maddieson 1984): **à**

Mandarin tones

high level	tʰan˥		greedy
mid rising	tʰan˧˥		deep
dipping		tʰan ˨˩˦	perturbed
high falling	tʰan˥˩		spy
toneless	lə		(aspect)

7. Contrastive phonation, but no contrastive tone
   breathy vowel (Gujarati,Fischer-Jørgensen, 1970): **a̤**

(7)
Gujarati breathy vowels

tʃi̤r	mo̤r	dṳd
bi̤	do̤ɽ	pe̤lo
se̤dʒ	ko̤ɽ	ta̤ro
me̤k	ko̤	wa̤li
ba̤r	po̤r	kə̤ɽi

creaky vowel (Sedang, Smith 1968): **a̰**

(18)
Minimal triplets

V:		V̰:		Vʔ:	
o	young sibling	o̰	very	oʔ	daughter's husband
cʰa	basket	cʰa̰	wild cat	cʰaʔ	gate

8. Contrastive tone and contrastive phonation which do not cross classify:
   toned vowel **à**
   toned vowel **ā**
   toned vowel **á**
   breathy vowel **a̤**
   creaky vowel **a̰**

9. White Hmong (Lyman 1974, Smalley 1976, Huffman 1987, Ratliff 1992):

High	**tau^{55}**	pumpkin
Rising	**tau^{35}**	to dam up (water)
Low	**tau^{22}**	axe
Mid (normal)	**tau^{33}**	to be able
Falling (normal)	**tau^{42}**	sp. of grass
"Creaky"	**tau^{31}**	bean
"Breathy"	**tau^{32}**	to follow

Ratliff: For male speakers, the breathy tone is implemented as a low, whispered pitch fall: **V̤^{31}**; For female speakers, the breathy tone is implemented as a high, whispered fall: **V̤^{53}**

10. Question: What might be the acoustic and articulatory consequences of implementing a laryngeally complex vowel?

11. **Acoustics of laryngeally complex vowels:**

a. Toned vowels: F0 may be recovered from the pulse period the frequency range between 400 and 1000 Hz. is the most important for pitch perception (Ritsma 1967, Remez and Rubin 1984, 1993).	b. Breathy vowels: The acoustic signal possesses harmonics and noise, with weakening of harmonics above H1, and increased bandwidth of surviving harmonics Kirk, Ladefoged, and Ladefoged (1993:445): "The breathy vowel [in Jalapa Mazatec] is characterized by an onset of indiscernible pulses."	c. Creaky vowels: when a pulse period varies, or jitters, by more than 10%, a stable pitch is not reliably discernible (Rosenberg 1966 Cardozo and Ritsma 1968)

Toned Vowel			Breathy Toned Vowel			Creaky Toned Vowel		
Formant	Harmonic	Frequency	Formant	Harmonic	Frequency	Formant	Harmonic	Frequency
	...	**...**		...	...		**...**	**...**
	H9	**1125**		H9	1125⇳		**H9**	**1125↑↓↑↓**
	H8	**1000**		H8	1000⇳		**H8**	**1000↑↓↑↓**
	H7	**875**		H7	875⇳		**H7**	**875↑↓↑↓**
	H6	**750**		H6	750⇳		**H6**	**750↑↓↑↓**
	H5	**625**		H5	625⇳		**H5**	**500↑↓↑↓**
F1	**H4**	**500**	F1	H4	500⇳	**F1**	**H4**	**375↑↓↑↓**
	H3	**375**		H3	375⇳		**H3**	**375↑↓↑↓**
	H2	**250**		H2	250⇳		**H2**	**250↑↓↑↓**
	H1	**125**		**H1**	**125⇳**		H1	125↑↓↑↓

12. Languages which possess both contrastive tone and contrastive non-modal phonation (breathiness/creakiness) such as Mazatec, Chinantec, and Trique, may sequence their tonal and non-modal phonatory gestures, so that both tone and phonation are recoverable.

13. **Articulation of laryngeally complex vowels**:

tone with breathy phonation:	V́:	V̰:	V̀:	V̰:
vocal fold tension:	higher: ✓		higher:	
	lower:	✓	lower: ✓	✓
glottal aperture:	higher: ✓	✓	higher:	✓
	lower:		lower: ✓	
intercostal flexion:	higher: ✓	✓	higher:	✓
	lower:		lower: ✓	
larynx height:	higher: ✓		higher:	
	lower:	✓	lower: ✓	✓

14. summary:
attempting to reach a particular pitch target and a breathy target simultaneously involves conflicting articulatory demands

15.

tone with creaky phonation:	V́:	V̰:	V̀:	V̰:
vocal fold tension:	higher: ✓	✓	higher:	✓
	lower:		lower ✓	
glottal aperture:	higher: ✓		higher:	
	lower:	✓	lower: ✓	✓
intercostal flexion:	higher: ✓	✓	higher:	✓
	lower:		lower: ✓	
larynx height:	higher: ✓	✓	higher:	✓
	lower:		lower: ✓	

16. summary: Attempting to reach a particular pitch target and a creaky target simultaneously involves conflicting articulatory demands

17. Question: given these acoustic and articulatory incompatibilities, what are the consquences for laryngeally complex vowels?

18. realization of laryngeally complex vowels:

{vowel, laryngeal spreading/ constriction, tone}	Mazatec:		Chinantec:		Trique:	
	spreading:	constriction:	spreading:	constriction:	spreading:	constriction:
optimal; unmarked	hà	ʔà	hà	ʔà	hà	ʔà
sub-optimal; marked	àh	àʔ	àh	àʔ	àh	àʔ
less optimal; more marked	àhà	àʔà	àhà	àʔà	àhà	àʔà
least optimal; most marked	a̰	a̰	a̰	a̰	a̰	a̰

19. **Jalapa Mazatec** (Pike and Pike 1947, Kirk 1966, Bull 1983, 1984, Steriade 1992, Silverman 1994a, Kirk, Ladefoged, and Ladefoged 1993, Silverman, Blankenship, Kirk, and Ladefoged 1995):

Jalapa Mazatec segment inventory (Silverman, Blankenship, Kirk, and Ladefoged 1995):

(p)	t	ts	tʃ	k	i	u
(pʰ)	tʰ	tsʰ	tʃʰ	kʰ		o
(ᵐb)	ⁿd	ⁿdz	ⁿdʒ	ᵑg	æ	a
	s		ʃ			
m	n		ɲ	ŋ		
	(l)					
w		j				

h,ʔ

(parenthesized segments are limited to loanwords)

20. tones (Kirk 1966): **H**, **M**, **L**, **LM**, **LH**, **ML**, **MH**, **HL**, **HM**, **LML**, **LHL**, **MHL**

21.

toned breathy vowel:		toned creaky vowel:	
mæ̤æ̤ː	wants	mo̰o̰sḛḛ	eviction
na̤á	my tongue	næ̰æ̰	he says
ɲV̤V	(no examples)	ɳV̰V	(no examples)
jæ̤è	boil	jw̰a̰ʲtsḛ̃ːj	he remembers
wV̤V	(no examples)	wV̰V	(no examples)

22.

23. summary:

{vowel, laryngeal spreading/ constriction, tone}	Mazatec:	
	spreading:	constriction:
optimal; unmarked	hà	ʔà
sub-optimal; marked	àh	àʔ
less optimal; more marked	àhà	àʔà
least optimal; most marked	à̰	à̰

24. **Comaltepec Chinantec** (Anderson 1989, 1990, Anderson, Martinez, and Pace 1990, Silverman 1994a,b, 1995):

Comaltepec segment inventory:

p	t	tʃ		k	i	ɨ	u
ᵐb	ⁿd	ⁿdʒ		ᵑg	e	ʌ	o
(f)	s	(ʃ)	(ʂ)	(x)	æ		a
			ʐ				
m	n			ŋ			
	l						
		j		w			

h,ʔ

(Parenthesized forms are major allophonic or free variants)

25. tones:

L	**hì**	book
H	**l̥ló́ʔ**	pretty
M	**ⁿdʒœ̄ː**	earthen jar
LM	**ᵑgi̋ŋʔ**	swing
LH	**lǐ**	tepejilote palm shoot
HLH	**ʔŋǐːh**	rope

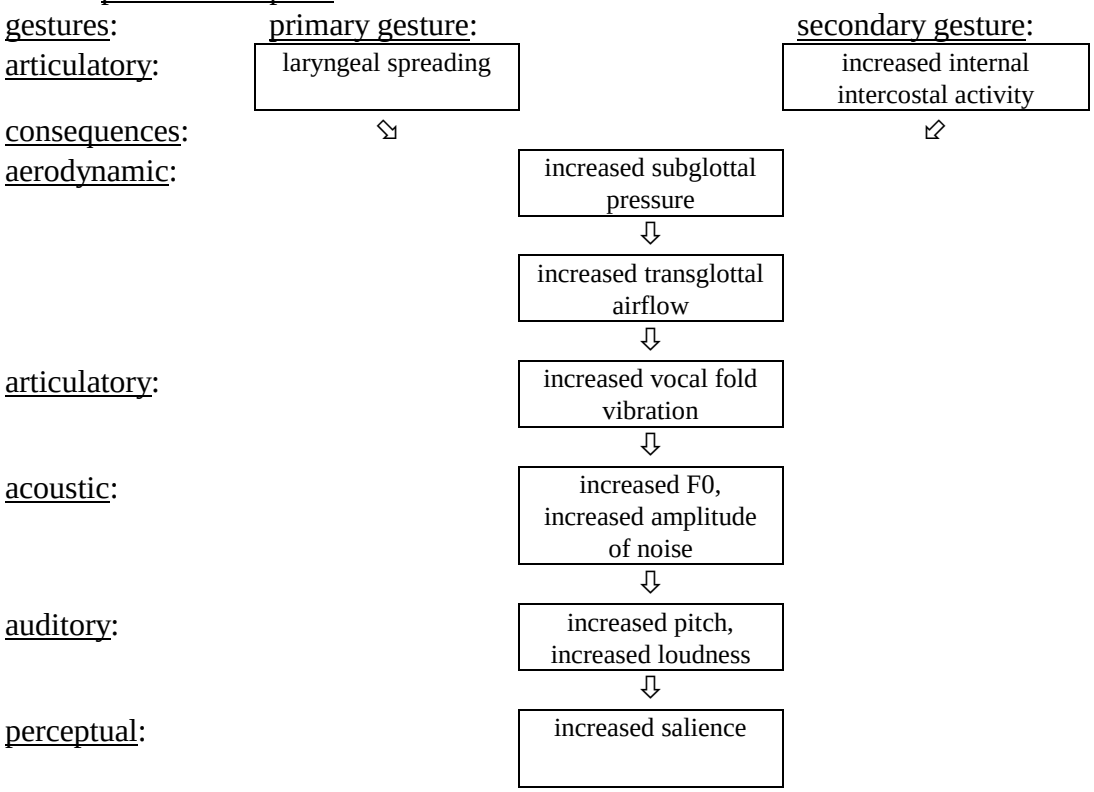
26.

kòːhò	I am playing	**kòːʔ**	you (sg) are playing
nì kǒːhó	I will play	**nì kóːʔ**	you (sg) will play
kà kōhò	I played	**kà kōːʔ**	you (sg) played
kōːʔ	we are playing	**kòːʂ**	he/she/they are playing
nì kóhóʔ	we will play	**nì kōʂ**	he/she/they will play
kà kóhóʔ	we played	**kà kòːʂ**	he/she/they played

27.

toned vowels:		toned with post-vocalic aspiration:	
ᵑgwoː	good (i)	**ᵑgjɑ̄ŋ̊**	hand
hɛ̀ʔ	frog	**lɨ́h**	flower

28. "Ballistic syllables"; syllables with post-vocalic aspiration--consequences for subglottal pressure and pitch:



29.

30. summary:

{vowel, laryngeal spreading/ constriction, tone}	Mazatec:		Chinantec:	
	spreading:	constriction:	spreading:	constriction:
optimal; unmarked	hà	ʔà	hà	ʔà
sub-optimal; marked	àh	àʔ	àh	àʔ
less optimal; more marked	àhà	àʔà	àhà	àʔà
least optimal; most marked	à̤	à̰	à̤	à̰

31. **Trique (**Longacre 1952, 1957, 1959, Hollenbach 1978):

San Juan Copala Trique segment inventory:

(p)	t				k		i ɨ	u
(b)	d				g		e	o
		tʃ	cç	ʈʂ			a	
	s	ʃ		ʂ				
	z	ʒ						
				ɾ				
m	n							
	l							
			j		w			

ʔ, h

(parenthesized segments are limited to loanwords)

32. tones: **21**, **32**, **3**, **34**, **35**, **4**, **5**, **53** (where **1** is highest, **5** is lowest)

33. Only the laryngeals (ʔ and h) may close syllables, and only final syllables may be closed.

waʔ^{5}	the right	ʒu^{2}kwah^{1}	to be twisted
jaʔ^{34}	teeth	jah^{3}	ashes
ni^{5}kaʔ^{5}	five	rah^{21}	to grind

34. Open final syllables are long

ma^{4}ɾeː^{3}	red
gu^{3}naː^{23}	to remain
ɾa^{3}ʔaː^{3}	hand
ɾi^{3}oː^{43}	trough, manger

35. Final vowels may be laryngeally "interrupted," in which h or ʔ intrude on the vowel (i.e., VhV, VʔV).

ga^{3}tu^{4}ʔu^{3}	incense-burner
ri^{3}u^{5}hu^{3}	hollow reed
na^{3}ʔa^{4}ha^{3}	conversation

36. Six reasons to interpret interrupted vowels as laryngeal gestures phased to interrupt a single vocalic gesture, rather than one involving two distinct vowel gestures

a. Interrupted forms do not undergo final lengthening

interrupted vowel:		true **V-ʔ-V** sequence:	
we^{3}ʔe^{3}	house	**we^{3}ʔeː^{2}**	beautiful
ja^{3}ha^{3}	flower	**da^{3}ʔaː^{34}**	cord, root
na^{3}ki^{4}hi^{3}	atole	**ʔu^{5}ʔuː^{5}**	five
jo^{3}ʔo^{3}	year	**jo^{3}ʔoː^{53}**	the gummy deposit made by smoke from a wood fire

b. Interrupted forms lose their second vocalic component in phrasal contexts

ja^{3}ha^{3}	but	**ja^{3}h zi^{3}ŋa^{2}**	nasturtiums
jo^{3}ʔo^{3}	but	**jo^{3}ʔ ga^{3}ci^{23}**	the past year
naki^{4}hi^{3}	but	**naki^{4}h ru^{4}ne^{43}**	bean-atole

This elision is not reported for true **V-ʔ-V** sequences

c. Interrupted vowels often appear in otherwise canonical bisyllabic words, whereas true trisyllabic words are quite rare

na^{4}ki^{3}hi^{3}	atole	**ga^{3}u^{4}ʔu^{3}**	incense burner
gi^{3}ʔja^{4}ha^{3}	holy day, festival	**ɾe^{3}ka^{4}ʔa^{3}**	stick
na^{2}nɨ^{5}hɨ^{4}	open	**ɾe^{3}ke^{4}ʔe^{3}**	splinter
da^{3}ku^{5}hu^{4}	ascent		

d. Tonal sequences occurring on interrupted forms are limited to those which occur on single vowels

e. Voiceless obstruents and "fortis" nasal consonants may occur before interrupted sequences. Elsewhere, these consonants are limited to word-final syllables. If interrupted vowels are single nuclei, then a strong generalization may be made regarding the distribution of voiceless and fortis consonants; they are limited to final syllables.

f. Interrupted vowels always possess but a single vowel quality, whereas true sequences may possess two vowel qualities (reported in Longacre 1957, no examples given)

37. summary:

{vowel, laryngeal spreading/ constriction, tone}	Mazatec:		Chinantec:		Trique:	
	spreading:	constriction:	spreading:	constriction:	spreading:	constriction:
optimal; unmarked	hà	ʔà	hà	ʔà	hà	ʔà
sub-optimal; marked	àh	àʔ	àh	àʔ	àh	àʔ
less optimal; more marked	àhà	àʔà	àhà	àʔà	àhà	àʔà
least optimal; most marked	a̰	a̤	a̰	a̤	a̰	a̤

57. **Conclusions:**

- A functional link may be established between recoverability and markedness
- In laryngeally complex vowels, tone and phonation are phased away from each other, so that all contrasts are recoverable
- The more contrastive timing patterns added, the more marked (the less recoverable) the added patterns are, but they remain optimally distinct from each other

References

Anderson, J.L. (1989) *Comaltepec Chinantec Syntax*. Studies in Chinantec Languages v. 3. Summer Institute of Linguistics.

Anderson, J.L., I.H. Martinez, and W. Pace (1990) "Comaltepec Chinantec Tone," in W.R. Merrifield and C.R. Rensch, eds., *Syllables, Tone, and Verb Paradigms.* Studies in Chinantec Languages v.4. Summer Institute of Linguistics, 3-20.

Bauernschmidt, A. (1965) "Amuzgo Syllable Dynamics," Language 41.3:471-483.

Bickley, C. (1982) "Acoustic Analysis and Perception of Breathy Vowels," MIT Speech Communication Working Papers 1:73-83.

Bladon, A. (1986) "Phonetics for Hearers," in G. McGregor, ed., *Language for Hearers*. Oxford : Pergamon Press, 1-24.

Blankenship, B., P. Ladefoged, P. Bhaskararao
, and N. Chase (1993) "Phonetic Structures of Khonoma Angami," Linguistics of the Tibeto-Burman Area 16.2:69-88.

Browman, C.P., and L. Goldstein (1986) "Towards an Articulatory Phonology," Phonology Yearbook 3:219-252.

Browman, C.P., and L. Goldstein (1989) "Articulatory Gestures as Phonological Units," Phonology 6:201-251.

Browman and Goldstein (1990a) "Gestural Specification Using Dynamically-Defined Articulatory Structures," Journal of Phonetics 18:299-320.

Browman, C.P. and L. Goldstein (1990b) "Tiers in Articulatory Phonology, with some Implications for Casual Speech," in J. Kingston and M.E. Beckman, eds., *Papers in Laboratory Phonology I: Between the Grammar and the Physics of Speech*. Cambridge University Press, 341-376.

Browman C.P., and L. Goldstein (1992) "Response to Commentaries," Phonetica 49:222-234.

Buckley, E. (1990) "Glottalized and Aspirated Consonants in Kashaya," in J.E. Redden, ed., Occasional Papers in Linguistics (Proceedings of the 1990 Hokan-Penutian Languages Workshop). University of Southern Illinois.

Buckley, E. (1991) "Kashaya Laryngeal Increments and the Timing Tier," Manuscript, UC Berkeley.

Bull, B.E. (1983) "Constraint-Governed Rule Application: Principles Underlying the Application of Phonological Rules in San Jerónimo Mazatec. Linguistics 21:431-486.

Byrd, D. (1994) *Articulatory Timing in English Consonant Sequences*. Ph.D. dissertation, University of California at Los Angeles, published as UCLA Working Papers in Phonetics 86.

Cao, J. and I. Maddieson (1992) "An Exploration of Phonation Types in Wu Dialects of Chinese," Journal of Phonetics 20:77-92.

Danstuji, M. (1982) "An Acoustic Study on Glottalized Vowels in the Yi (Lolo) Language," Studia Phonologica XVI:1-11.

Delgutte, B. (1982) "Some Correlates of Phonetic Distinctions at the Level of the Auditory Nerve," in R. Carlson and B. Granström, eds., *The Representation of Speech in the Peripheral Auditory System*. Amsterdam : Elsevier Biomedical, 131-150.

Dhall, G.B. (1966) *Aspiration in Oriya*. Utkal University, Bhubaneswar, Orissa, India.

Diehl, R.L. (1991) "The Role of Phonetics within the Study of Language," Phonetica 48:120-134.

Eglund, S. (1978) *La Intelegibilidad interdialectal en México: Resultados de Algunos Sondeos*. Summer Institute of Linguistics, Mexico.

Fernandez de Miranda, M.T., (1956) *Glotocronologia de la Familia Popoloca*. Seria Cientifica 4. Museo Nacional de Antropologia, Mexico.

Fischer-Jørgensen, E. (1970) "Phonetic Analyses of Breathy (Murmured) Vowels in Gujarati," Indian Linguistics 28:71-140.

Flemming, E. (1995) *Auditory Representations in Phonology*. Ph.D. dissertation, University of California at Los Angeles. Also to appear, *UCLA Occasional Papers in Linguistics, Dissertation Series*.

Foris, D. (1973) "Sochiapan Chinantec Syllable Structure," International Journal of American Linguistics 39-4:232-235.

Fujimura, O. (1979) "Physiological Functions of the Larynx in Phonetic Control," in H. and P. Hollien, eds., *Current Issues in the Phonetic Sciences: Proceedings of the IPS-77 Congress, Miami Beach Florida, 17-19th December 1977, Part I.* Amsterdam : John Benjamins B.V., 129-163.

Fujimura, O. and M. Sawashima (1971) "Consonant Sequences and Laryngeal Control," Annual Bulletin of the Research Institute of Logopedics and Phoniatrics 5:1-7.

Glover, W.W. (1971) "Register in Tibeto-Burman Languages in Nepal: A Comparison with Mon-Khmer," *Papers in South East Asian Linguistics* 2:1-22.

Goldstein, L. (1990) "On Articulatory Binding: Comments on Kingston's Paper," in J. Kingston and M.E. Beckeman, eds., *Between the Grammar and Physics of Speech--Papers in Laboratory Phonology I.* Cambridge University Press, 445-450.

Goldstein, L., and C.P. Browman (1986) "Representation of Voicing Contrasts Using Articulatory Gestures," Journal of Phonetics 14:339-342.

Gregerson, K.J. (1976) "Tongue-Root and Register in Mon-Khmer," in P.N. Jenner, L.C. Thompson, and S. Starosta, eds., *Austroasiatic Studies, Part I.* University of Hawaii Press, 323-369.

Gudschinsky, S.C. (1959) *Proto-Popotecan--A Comparative Study of Popolocan and Mixtecan*. Indiana University Publications in Anthropology and Linguistics. International Journal of American Linguistics Memoir 15. Baltimore : Waverly Press.

Halle, M., and K.N. Stevens (1971) "A Note on Laryngeal Features," Quarterly Progress Report, Research Laboratory of Electronics, Maasachusetts Institute of Technology v.101:198-212.

Haudricourt, A.G. (1954) "De L'Origine des Tons en Vietnamien," Journal Asiatique 242:69-82.

Henderson, E.J.A. (1985) "Feature Shuffling in Southeast Asian Languages," in S. Ratanakul, D. Thomas, and S. Premsrirat, eds., *Southeast Asian Linguistic Studies Presented to Andre-G. Haudricourt*. Bangkok : Mahidol University, 1-22.

Hixon, T.J., J. Mead, and D.H. Klatt (1971) "Influence of Forced Transglottal Pressure Changes on Vocal Fundamental Frequency," Journal of the Acoustical Society of America 49:105.

Hollenbach, B.E. (1977) "Phonetic vs. Phonemic Correspondence in Two Trique Dialects," in W.R. Merrifield, ed., *Studies in Otomanguean Phonology*. Summer Institute of Linguistics/University of Texas at Arlington, 35-68.

Hollenbach, E.E. de (1987) "La Duración Vocalica en el Trique de Copala," Summer Institute of Linguistics Mexico Workpapers 8:15-30.

Hombert, J.-M. (1978) "Consonant Types, Vowel Quality, and Tone," in V. Fromkin, ed., *Tone: A Linguistic Survey*, Academic Press 77-111.

Hombert, J.-M., J.J. Ohala, and W.G. Ewan (1979) "Phonetic Explanations for the Development of Tones," Language 55.1:37-58.

Huffman, M.K. (1987) Measures of Phonation Types in Hmong," Journal of the Acoustical Society of America 81.2:495-504.

Jun, J. (1995) *A Constraint-Based Analysis of Place Assimilation Typology*. Ph.D. dissertation, University of California at Los Angeles. Also to appear, *UCLA Occasional Papers in Linguistics, Dissertation Series*.

Kingston, J. (1985) "The Phonetics and Phonology of the Timing of Oral and Glottal Events," Ph.D. dissertation, University of California at Berkeley.

Kingston, J. (1990) "Articulatory Binding," in J. Kingston and M.E. Beckman, eds., *Between the Grammar and Physics of Speech--Papers in Laboratory Phonology I*. Cambridge University Press, 406-434.

Kingston, J., and A.H. Cohen (1992) "Extending Articulatory Phonology," Phonetica 49:194-204.

Kirk, P.L. (1969) "The Development of Jalapa Mazatec Voiced Aspirates," Linguistic Society of America Annual Meeting, San Francisco.

Kirk P.L. (1966) *Proto-Mazatec Phonology*. Ph.D. dissertation, University of Washington.

Kirk, P.L., J. Ladefoged, and P. Ladefoged (1984) "Phonological Representations of Breathy and Creaky Vowels in Jalapa Mazatec," Paper presented at the 23rd Conference on American Indian Languages, Denver.

Kirk, P.L., J. Ladefoged, and P. Ladefoged (1991) "Acoustic Analysis of Jalapa Mazatec Complex Vowels," Paper Presented to the 47th International Congress of Americanists, New Orleans.

Kirk, P.L., J. Ladefoged, and P. Ladefoged (1993) "Quantifying Acoustic Properties of Modal, Breathy, and Creaky Vowels in Jalapa Mazatec," in A. Mattina and T. Montler, eds., *American Indian Linguistics and Ethnography in Honor of Lawrence C. Thompson*. Occassional Papers in Linguistics 10, University of Michigan, 435-450.

Ladefoged, P. (1958) "Syllables and Stress," Misc. Phonetica 3:1-14.

Ladefoged, P. (1962a) "Sub-Glottal Activity During Speech," in *Proceedings of the Fourth International Congress of Phonetic Sciences*. Mouton and Company, 76-91.

Ladefoged, P. (1963) "Some Physiological Parameters in Speech," Language and Speech 6:109-116.

Ladefoged P. (1968) "Linguistic Aspects of Respiratory Phenomena," Annals of the New York Academy of Sciences 155, Article 1:141-151.

Ladefoged, P., I. Maddieson, and M. Jackson (1988) "Investigating Phonation Types in Different Languages" in O. Fujimora, ed., *Voice Production, Mechanisms, and Functions*. New York : Raven Press, Ltd., 297-317.

Laver, J. (1980) *The Phonetic Description of Voice Quality*. Cambridge University Press.

Lee, C.Y. and T.S. Smith (1971) "A Study of Subglottal Air Pressure in Korean Stop Consonants," Preliminary version, presented at the 82nd meeting of the Acoustical Society of America, Denver.

Lieberman, P., R. Knudson, and J. Mead (1969) "Determination of the Rate of Change of Fundamental Frequency with Respect to Subglottal Air Pressure During Sustained Phonation," Journal of the Acoustical Society of America 45.6:1537-1543.

Lisker, L., A.S. Abramson, F.S. Cooper, and M.H. Schvey (1969) "Transillumination of the Glottis in Running Speech," Journal of the Acoustical Society of America 45.6:1544-1546.

Löfqvist, A. (1980) "Interarticulator Programming in Stop Production" Journal of Phonetics 8:475-490.

Lombardi, L. (1991) "Laryngeal Features and Laryngeal Neutralization," Ph.D. dissertation, University of Massachusetts at Amherst.

Longacre, R. (1952) "Five Phonemic Pitch Levels in Trique," Acta Linguistica VII,1-2:62-82.

Longacre, R. (1957) *Proto Mixtecan*. Indiana University Research Center in Anthroplogy, Folklore, and Linguistics 5.

Longacre, R.E. (1959) "Trique Tone Morphemics," Anthropological Linguistics 1.4:5-42.

Longacre, R.E. (1966) "On the Linguistic Affinities of Amuzgo," International Journal of American Linguistics 32:46-49.

Longacre, R.E., and R. Millon (1961) "Proto-Mixtecan and Proto-Amuzgo-Mixtecan Vocabularies," Anthropological Linguistics 3.4:1-44.

Lyman, T. (1974) *Dictionary of Hmong Njua*. The Hague : Mouton.

Maddieson, I. (1984) *Patterns of Sounds*. Cambridge University Press.

Maddieson, I. (1986) "The Size and Structure of Phonological Inventories: Analysis of UPSID," in J.J. Ohala and J.J. Jaeger, eds., *Experimental Phonology*. Academic Press, 105-124.

Maddieson, I. (1993a) "Sequence in Simultaneity: Phonetic 'Enhancements" in Ewe Doubly-Articulated Stops," Paper presented at Linguistic Society of America Annual Meeting.

Maddieson, I. (1993b) "Investigating Ewe Articulations with Electromagnetic Articulography," Forschungsberichte des Instituts für Phonetik und Sprachliche Kommunication der Universität München 31:181-214.

Maddieson, I., and P. Ladefoged (1985) "'Tense' and 'Lax' in Four Minority Languages of China," Journal of Phonetics 13:433-454.

Mak, C., and R. Longacre (1960) "Proto-Mixtec Phonology," International Journal of American Linguistics 26.1:23-40.

Martinet, A. (1952) "Function, Structure, and Sound Change," Word 8.1:1-32.

Mattingly, I.G. (1981) "Phonetic Representations and Speech Synthesis by Rule," in T. Myers, J, Laver, and J. Anderson, eds., *The Cognitive Representation of Speech*. Amsterdam : North Holland Publishing Company, 415-419.

McCarthy, J.J., and A.S. Prince (1993) "Prosodic Morphology I," Manuscript, University of Massachusetts at Amherst, and Rutgers University.

Mugele, R.L. (1982) "Tone and Ballistic Syllable in Lalana Chinantec," Ph.D. dissertation, University of Texas at Austin.

Ohala, J. (1975) "Phonetic Explanations of Nasal Sound Patterns," in C.A. Ferguson, L.M. Hyman, and J.J. Ohala, eds., *Nasálfest: Papers from a Symposium on Nasals and Nasalization*. Language Universals Project, Stanford University, 289-316.

Ohala, J.J. (1978) "Production of Tone, " in V. Fromkin, ed., *Tone: A Linguistic Survey*, Academic Press.

Ohala, J. (1983) "The Origins of Sound Patterns in Vocal Tract Constraints," in P.F. MacNeilage, ed., *The Production of Speech*. Springer-Verlag.

Ohala, J.J. (1990) "Respiratory Activity in Speech," in W.J. Hardcastle and A. Marchal, eds., *Speech Production and Speech Modeling*. Amsterdam : Kluwer Academic Publishers, 23-53.

Ohala, J.J. (1992) What's Cognitive, What's Not, in Sound Change," in G. Kellerman and D. Morrissey, eds., *Diachrony Within Synchrony: Language and Cognition*. Frankfurt/M : Peter Lang Verlag, 309-355.

Ohala, J.J. and W.G. Ewan (1973) "Speed of Pitch Change," Abstract, Journal of the Acoustical Society of America 53:345.

Patel, M.S. and J.J. Mody (1961) *The Vowel System of Gujarati*. Faculty of Education and Psychology, Maharaja Sayajirao University of Baroda, Baroda.

Pace, W.J. (1990) "Comaltepec Chinantec Verb Inflection," in W.R. Merrifield and C.R. Rensch, eds., *Syllables, Tone, and Verb Paradigms.* Studies in Chinantec Languages v.4. Summer Institute of Linguistics, 21-62.

Parker, S. (1994) "Laryngeal Codas in Chamicuro," International Journal of American Linguistics 60.3:261-271.

Pike, K.L. and E.V. Pike (1947) "Immediate Constituents of Mazateco Syllables," International Journal of American Linguistics 13.2:78-91.

Plomp, R. (1967) "Pitch of Complex Tones," Journal of the Acoustical Society of America 41.6:1526-1533.

Prince, A., and P. Smolensky (1993) "Optimality Theory--Constraint Interaction in Generative Grammar," Manuscript, Rutgers University, and University of Colorado at Boulder.

Ratliff, M. (1992) *Meaningful Tone: A Study of Tonal Morphology in Compounds, Form Classes, and Expressive Phrases in White Hmong*. Center for Southeast Asian Studies, Monograph Series on Southeast Asia, Special Report 27, Northern Illinois University.

Remez, R.E. and P.E. Rubin (1993) "On the Intonation of Sinusoidal Sentences," Journal of the Acoustical Society of America 94.4:1983-1988.

Rensch, C.R. (1968) *Proto Chinantec Phonology*. Papeles de la Chinantla VI. Seria Cientifica 10. Museo Nacional de Antropologia, Mexico.

Rensch, C.R. (1976) *Comparative Otomanguean Phonology*. Indiana University, Bloomington.

Rensch, C.R. (1977) "Classification of the Otomanguean Languages and the Position of Tlapanec," in *Two Studies in Middle American Comparative Linguistics*, Summer Institute of Linguistics/University of Texas at Arlington, 53-108.

Rensch, C.R. (1978) "Ballistic and Controlled Syllables in Otomanguean Languages," in A. Bell and J.B. Hooper, eds., *Syllables and Segments*. Amsterdam : North Holland Publishing Company, 85-92.

Rensch, C.R. (1989) *An Etymological Dictionary of the Chinantec Languages*. Studies in Chinantec Languages v.1. Summer Institute of Linguistics.

Rensch, C.R., and C.M. Rensch (1966) "The Lalana Chinantec Syllable," in *Summa Anthropologica en homenaje a Roberto J. Weitlaner*. Instituto Nacional de Antropologia E Historia, Mexico, 455-463.

Ritsma, R.J. (1967) "Frequencies Dominant in the Perception of the Pitch of Complex Sounds," Journal of the Acoustical Society of America 42.1191-198.

Rosenberg, A.E. (1965) "Pitch Discrimination of Jittered Pulse Trains," Journal of the Acoustical Society of America 39.5:920-928.

Rothenberg, M. (1968) *The Breath-Stream Dynamics of Simple Released-Plosive Production*. Basel : S. Karger.

Ruiz de Bravo Ahuja, G. (1975) *Trique--San Juan Copala, Oaxaca*. Instituto de Investigacion e Integracion Social del Estado de Oaxaca, Mexico.

Sawashima, M. and H. Hirose (1983) "Laryngeal Gestures in Speech Production," Annual Bulletin of the Research Institute of Logopedics and Phoniatrics 14:29-51.

Sawashima, M. and H. Hirose (1983) "Laryngeal Gestures in Speech Production," in P.F. MacNeilage, ed., *The Production of Speech*. Springer-Verlag, 11-38.

Sawashima, M. and S. Miyazaki (1973) "Glottal Opening for Japanese Voiceless Consonants," Annual Bulletin of the Research Institue of Logopedics and Phoniatrics 7:1-9.

Shipp, T., and R.E. McGlone (1971) "Laryngeal Dynamics Associated with Voice Frequency Change," Journal of Speech and Hearing Research 14:761-768.

Silverman, D. (1994a) "A Case Study in Acoustic Transparency: [spread glottis] and Tone in Otomanguean Languages," presentation at North Eastern Linguistics Society 24.

Silverman, D. (1994b) "A Case Study in Acoustic Transparency: [spread glottis] and Tone in Chinantec," in M. Gonzalez, ed., *Proceedings of North Eastern Linguistics Society 24*, 559-572.

Silverman, D. (1995a) "Optimal and Sub-Optimal Timing Relations Between Stops, Vowels, and Vocal Fold Spreading," NELS 26, Harvard University, and Massachusetts Institute of Technonology.

Silverman, D, (1995b) Timing and Recoverability. UCLA Occassional Papers in Lingusitcs #15, Dissertation Series #1.

Silverman, D. (1995c) "Comaltepec Chinantec Tonology," Manuscript, University of California at Los Angeles.

Silverman, D., B. Blankenship, P. Kirk, and P. Ladefoged (1995) "Phonetic Structures in Jalapa Mazatec," Anthropological Linguistics 37.1:70-88.

Smith, K.D. (1968) "Laryngealization and De-Laryngealization in Sedang Phonemics," Linguistics 38:52-69.

Steriade, D. (1990) "Gestures and Autosegments: Comments on Browman and Goldstein's Paper," in J. Kingston and M.E. Beckman, eds., *Papers in Laboratory Phonology I: Between the Grammar and the Physics of Speech*. Cambridge University Press, 382-397.

Steriade, D. (1992) "Segments, Contours and Clusters," Manuscript, University of California at Los Angeles.

Steriade, D. (1994c) "Complex Onsets as Single Segments: The Mazateco Pattern" in J. Cole and C. Kisseberth, eds., *Perspectives in Phonology*. CSLI Publications, Stanford University, 203-292.

Sundberg, J. (1973) "Data on Maximum Speed of Pitch Changes," Quarterly Progress and Status Reports, Speech Transmission Laboratory, Stockholm, Sweden 4:39-47.

Swadesh, M. (1960) "The Oto-Manguean Hypothesis and Macro-Mixtecan," International Journal of American Linguistics 26:79-111.

Taylor, G.P. (1985) *The Student's Grammar of Gujarati*. Asian Educational Services, New Delhi.

Thelin, A. (1980) "Tlacoatzintepec Chinantec Syllable Structure," Summer Institute of Linguistics Mexico Workpapers 4:1-8.

Titze, I.R. (1989) "On the Relation Between Subglottal Pressure and Fundamental Frequency in Phonation," Journal of the Acoustical Society of America 85.2:901-906.

Tyler, R.S., Q. Summerfield, E.J. Wood, and M.A. Fernandez (1982) "Psychoacoustic and Phonetic Temporal Processing in Normal and Hearing-Impaired Listeners," Journal of the Acoustical Society of America 72:740-752.

Zsiga, E.C. (1993) Features, Gestures, and the Temporal Aspects of Phonological Organization," Ph.D. dissertation, Yale University.

Zsiga, E.C., and D. Byrd (1990) "Acoustic Evidence for gestural Overlap in Consonant Sequences," Journal of the Acoustical Society of America 88.10.