University of Connecticut
April 8, 1996

Phasing and Recoverability:
Laryngeal Complexity in Otomanguean Vowels

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Introduction:

1. The timing (phasing) patterns between lexical contrasts optimize the salience of a given gesture, maximizing recoverability

   {coronal stop, laryngeal abduction} ⇨ tʰ (Kingston 1985, 1990)

2. Phasing patterns optimize the contrastiveness of one configuration with another

   {coronal stop, laryngeal abduction} ⇨ tʰ and ʰt (Silverman 1995a,b)

3. As particular phasing patterns result in less recoverable contrasts, they become more marked

   {coronal stop, laryngeal abduction} tʰ >> ʰt (Silverman 1995a,b)

4. today's inquiry: laryngeally complex vowels

   {vowel, laryngeal abduction, tone} hà >> àh >> a̤
   {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

7. Contrastive phonation, but no contrastive tone
breathy vowel (Gujarati,Fischer-Jørgensen, 1970): **a̤**
creaky vowel (Sedang, Smith 1968): **a̰**

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}**
Pitch is thus not the primary cue to the contrast.

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:		b. Breathy vowels:		c. Creaky 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).		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."		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:	V̤:	V̀:	V̤:
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 abduction/ constriction, tone}	Mazatec:		Chinantec:		Trique:	
	abduction:	constriction:	abduction:	constriction:	abduction:	constriction:
optimal; unmarked	**hà**	**ʔà**	**hà**	**ʔà**	**hà** **-loans only-**	**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:	
mæ̤æ̰ː	wants	mo̰o̰sḛḛ	eviction
na̤a̰	my tongue	næ̰ǣ	he says
ɲV̤V	(no examples)	ɳV̰V	(no examples)
jæ̤æ̀	boil	jw̰a̰jtsḛ̃ːj	he remembers
wV̤V	(no examples)	wV̰V	(no examples)

22.

23. summary:

{vowel, laryngeal abduction/ constriction, tone}	Mazatec:	
	abduction:	constriction:
optimal; unmarked	hà	ʔà
sub-optimal; marked	àh	àʔ
less optimal; more marked	àhà	àʔà
least optimal; most marked	a̰	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
			ʐ̩				
m	n			ŋ			
	l						
		j		w			

h,ʔ

(Parenthesized forms are major allophonic or free variants)

25. tones:

L	hi˩	book
H	l̥loʔ˥	pretty
M	ⁿdʒœː˧	earthen jar
LM	ᵑgiŋʔ˩˧	swing
LH	li˩˧	tepejilote palm shoot

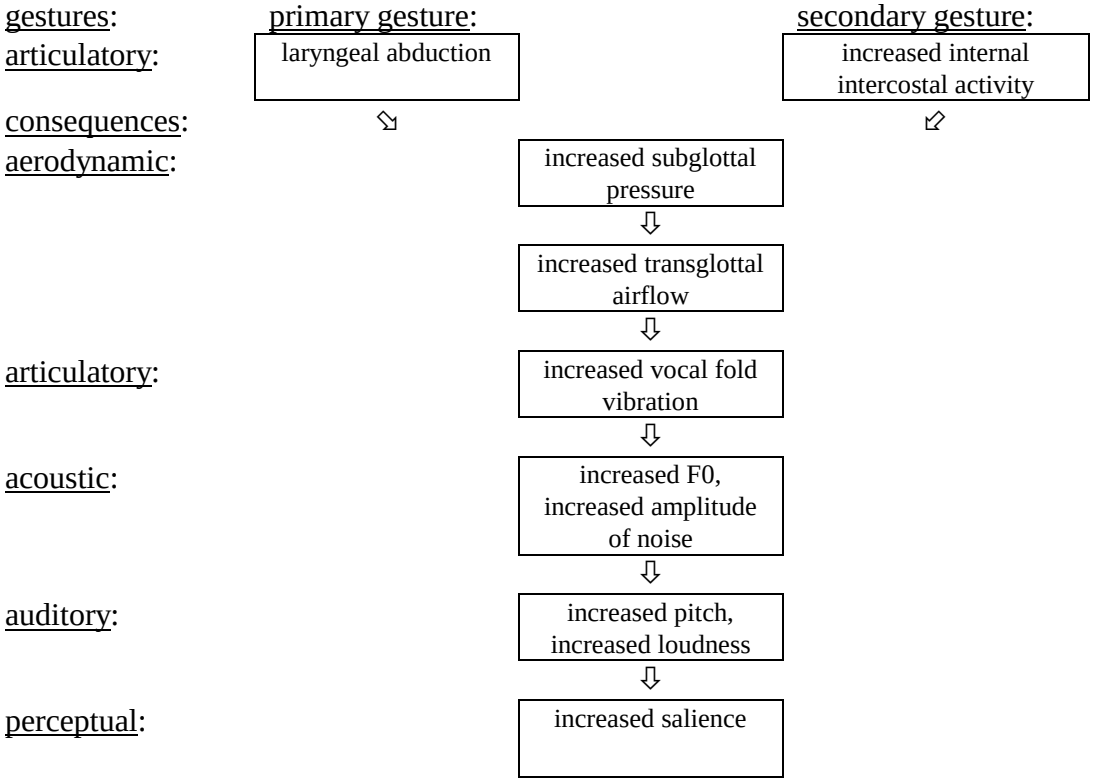
26. laryngeals:

hi˩	book	ʔoː˧	papaya

27. toned vowels:

		toned with post-vocalic aspiration:	
ᵑgwoː˩	good (i)	ᵑgjʌŋ̊˧	hand
heʔ˩˧	frog	lih̥˥	flower

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



29.

30. summary:

{vowel, laryngeal abduction/ constriction, tone}	Mazatec:		Chinantec:	
	abduction:	constriction:	abduction:	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	a̰	a̰	a̰	a̰

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. laryngeals may precede the toned vowel.

		-loans only-	
ʔũ	nine	a^{2}hu^{3}	garlic
ʔu^{5}ʔuː^{5}	five	hu^{3}lja^{3}	Julia
ʔweʔe^{5}	ice, frost	gaw̰we^{32}	coffee
ʔnɨh^{5}	inside of		

34. 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}	short	ɾah^{21}	to grind

35. 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

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

ga³tu⁴ʔu³	incense-burner
ri³u⁵hu³	hollow reed
na³ʔa⁴ha³	conversation

37. 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:	
we³ʔe³	house	**we³ʔeː²**	beautiful
ja³ha³	flower	**da³ʔaː³⁴**	cord, root
na³ki⁴hi³	atole	**ʔu⁵ʔuː⁵**	five
jo³ʔo³	year	**jo³ʔoː⁵³**	the gummy deposit made by smoke from a wood fire

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

ja³ha³	but	**ja³h zi³ŋa²**	nasturtiums
jo³ʔo³	but	**jo³ʔ ga³ci²³**	the past year
naki⁴hi³	but	**naki⁴h ru⁴ne⁴³**	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

na⁴ki³hi³	atole	**ga³u⁴ʔu³**	incense burner
gi³ʔja⁴ha³	holy day, festival	**ɾe³ka⁴ʔa³**	stick
na²nɨ⁵hɨ⁴	open	**ɾe³ke⁴ʔe³**	splinter
da³ku⁵hu⁴	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)

38. summary:

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

39. **Formalism**

Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993):

- The forces which determine the shape of phonological systems center on a struggle between ease of perception and ease of production (Martinet 1952, Lindblom 1990)
- Optimality Theory allows us to encode these forces in the grammar

40. *Ersatz* Optimality Theory: perceptually-based universal hierarchies of *lexical phasing contrasts*, thus functionally constraining the system of lexical contrasts ("inputs"), *not* surface ("output") constraints on an infinite set of inputs.

41. constraints which characterize gestural phasing relationships:

recover	***maximize auditory recoverability of contrastive cues***
economize	***maximize articulatory ease in order to conserve energy***
overlap	***maximize parallel production in order to increase speaking rate***

42. Auditory phonetics (Bladon 1986):

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

CV >> VC

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

V >> **V**ᵢ >>> **V**ᵢᵢ

43. generalization: acoustic signals that involve *abrupt increases in acoustic energy* trigger maximal auditory nerve response

44. Laryngeally complex vowels involving abductions and tones:
- Recoverability remains only a relative value, and not in any way a quantified value.

45. **recover**: - every gesture that is not optimally recoverable receives a star (*)

recover {vowel, abduction, tone}	**recover** {vowel, abduction, tone}	**recover** {vowel, abduction, tone}	**recover** {vowel, abduction, tone}
hà	**àh**	**àhà**	**a̤**
vowel	vowel	vowel	vowel
formants	formants	formants	formants
tone	tone	tone	tone
pitch	pitch	pitch	*pitch
abduction	abduction	abduction	abduction
broadband noise	*broadband noise	*broadband noise	*broadband noise

recover: **hà** >> **àh/àha** >> **a̤**

46. **economize**: - every implemented gesture receives a star (*)
- simultaneous tone and non-modal phonation receive two stars each (**)

economize {vowel, abduction, tone}	**economize** {vowel, abduction, tone}	**economize** {vowel, abduction, tone}	**economize** {vowel, abduction, tone}
hà	**àh**	**a̤**	**àhà**
vowel	vowel	vowel	vowel
*opening	*opening	*opening	*opening
tone	tone	tone	tone
*tension	*tension	*tension	*tension, *tension
abduction	abduction	abduction	abduction
*opening	*opening	*opening	*opening

economize: **hà** >> **àh/a̤** >> **àhà**

47. **overlap**: - every cue not fully overlapped with the maximally expanded cue receives a star (*)

overlap {vowel, abduction, tone}	**overlap** {vowel, abduction, tone}	**overlap** {vowel, abduction, tone}	**overlap** {vowel, abduction, tone}
à̰	**hà**	**àh**	**àhà**
vowel	vowel	vowel	vowel
formants	formants	formants	formants
tone	tone	tone	tone
pitch	*pitch	*pitch	*pitch
abduction	abduction	abduction	abduction
broadband noise	*broadband noise	*broadband noise	*broadband noise

overlap: **à̰** >> **hà/àh/àhà**

48. Question: What ranking of constraints do the attested patterns correspond to?
recover >> **economize** >> **overlap** (Chinantec, Trique, Mazatec)
recover >> **overlap** >> **economize** (Mazatec, Tamang, Mpi)

49. 16 logically possible selections from {**hà**, **àh**, **àhà**, **à̰**}:

English	Mazatec	unattested	unattested	unattested	Chinantec	unattested	Tamang
	hà				**hà**	**hà**	**hà**
		àh			**àh**		
			àha			**àha**	
				à̰			**à̰**

unattested	unattested	unattested	Trique	unattested	unattested	unattested	unattested
			hà	**hà**	**hà**		**hà**
àh	**àh**		**àh**	**àh**		**àh**	**àh**
àha		**àha**	**àha**		**àha**	**àha**	**àha**
	à̰	**à̰**		**à̰**	**à̰**	**à̰**	**à̰**

50. possible system expansions of laryngeally complex vowels involving abductions:

Ersatz tableaux:
- tables represent possible system expansions, not individual forms
- more than one winner is possible
- highest ranking candidate is optimal, and candidates decrease in optimality as list descends
- systems may expand their lexical phasing contrasts only in strict decreasing order of optimality

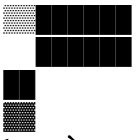
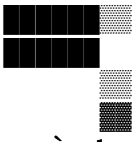
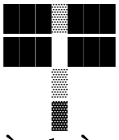
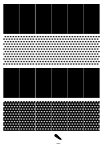
51. Articulatory Phonology (Browman and Goldstein):

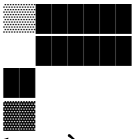
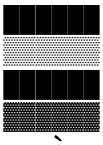
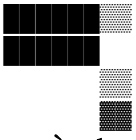
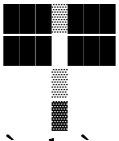
= auditorily optimally encoded gesture

= auditorily sub-optimally encoded gesture

= auditorily uncoded gesture

52. system expansions involving vowels, abductions, and tone:

1	{vowel, abduction, tone}	**recover** {vowel, abduction, tone}	**economize** {vowel, abduction, tone}	**overlap** {vowel, abduction, tone}
a Chinantec Mazatec Trique	vowel: tone: abduction: intercostals:  **h à**	**hà** vowel formants tone pitch abduction broadband noise	**hà** vowel *opening tone *tension abduction *opening	**hà** vowel formants tone *pitch abduction *broadband noise
b Chinantec Trique	vowel: tone: abduction: intercostals:  **à h**	**àh** vowel formants tone pitch abduction *broadband noise	**àh** vowel *opening tone *tension abduction *opening	**àh** vowel formants tone *pitch abduction *broadband noise
c Trique	vowel: tone: abduction: intercostals:  **à h à**	**àhà** vowel formants tone pitch abduction *broadband noise	**àhà** vowel *opening tone *tension, *tension abduction *opening	**àhà** vowel formants tone *pitch abduction *broadband noise
d	vowel: tone: abduction: intercostals:  **a̤**	**a̤** vowel formants tone *pitch abduction *broadband noise	**a̤** vowel *opening tone *tension abduction *opening	**a̤** vowel formants tone pitch abduction broadband noise

2	{vowel, abduction, tone}	**recover** {vowel, abduction, tone}	**overlap** {vowel, abduction, tone}	**economize** {vowel, abduction, tone}
a Mazatec Tamang	vowel: tone: abduction: intercostals:  **h à**	**hà** vowel formants tone pitch abduction broadband noise	**hà** vowel formants tone *pitch abduction *broadband noise	**hà** vowel *opening tone *tension abduction *opening
b Tamang	vowel: tone: abduction: intercostals:  **à̤**	**à̤** vowel formants tone pitch abduction *broadband noise	**à̤** vowel formants tone pitch abduction broadband noise	**à̤** vowel *opening tone *tension abduction *opening
c	vowel: tone: abduction: intercostals:  **à h**	**àh** vowel formants tone pitch abduction *broadband noise	**àh** vowel formants tone *pitch abduction *broadband noise	**àh** vowel *opening tone *tension abduction *opening
d	vowel: tone: abduction: intercostals:  **à h à**	**àhà** vowel formants tone pitch abduction *broadband noise	**àhà** vowel formants tone *pitch abduction *broadband noise	**àhà** vowel *opening tone *tension, *tension abduction *opening

53. Laryngeally complex vowels involving constrictions and tones:
recover:
every gesture that is not optimally recoverable receives a star (*)

recover {vowel, constriction, tone}	**recover** {vowel, constriction, tone}	**recover** {vowel, constriction, tone}	**recover** {vowel, constriction, tone}
ʔà	**àʔ**	**àʔà**	**a̰**
vowel	vowel	vowel	vowel
formants	formants	formants	formants
tone	tone	tone	tone
pitch	pitch	pitch	*pitch
constriction	constriction	constriction	constriction
silence	*silence	*silence	*silence

recover: **ʔà** >> **àʔ/àʔa** >> **a̰**

54. **economize**:
every implemented gesture receives a star (*)
simultaneous tone and non-modal phonation receive two stars each (**) (underlined)

economize {vowel, constriction, tone}	**economize** {vowel, constriction, tone}	**economize** {vowel, constriction, tone}	**economize** {vowel, constriction, tone}
ʔà	**àʔ**	**a̰**	**àʔà**
vowel	vowel	vowel	vowel
*opening	*opening	*opening	*opening
tone	tone	tone	tone
*tension	*tension	*tension	*tension, *tension
constriction	constriction	constriction	constriction
*closure	*closure	*closure	*closure

economize: **ʔà** >> **àʔ/a̰** >> **àʔà**

55. **overlap**:
every cue not fully overlapped with the maximally expanded cue receives a star (*)

overlap {vowel, constriction, tone}	**overlap** {vowel, constriction, tone}	**overlap** {vowel, constriction, tone}	**overlap** {vowel, constriction, tone}
a̰	**ʔà**	**àʔ**	**àʔà**
vowel	vowel	vowel	vowel
formants	*formants	*formants	*formants
tone	tone	tone	tone
pitch	*pitch	*pitch	*pitch
constriction	constriction	constriction	constriction
silence	*silence	*silence	*silence

overlap: **a̰** >> **ʔà/àʔ/àʔà**

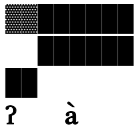
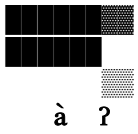
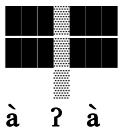
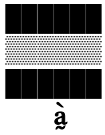
56. 16 logically possible selections from {ʔa, aʔ, aʔa, a̰}:

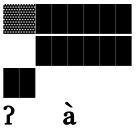
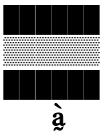
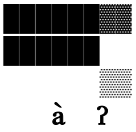
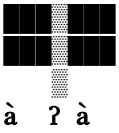
English	Mazatec	unattested	unattested	unattested	Chinantec	unattested	Mpi
	ʔà				ʔà	ʔà	ʔà
		àʔ			àʔ		
			àʔa			àʔa	
				a̰			a̰

unattested	unattested	unattested	Trique	unattested	unattested	unattested	unattested
			ʔà	ʔà	ʔà		ʔà
àʔ	àʔ		àʔ	àʔ		àʔ	àʔ
àʔa		àʔa	àʔa		àʔa	àʔa	àʔa
	a̰	a̰		a̰	a̰	a̰	a̰

- all possible system expansions that do not expand in strict order of recoverability are unattested (except Mpi)

57. system expansions involving vowels, constrictions, and tone:

1	{vowel, constriction, tone}	**recover** {vowel, constriction, tone}	**economize** {vowel, constriction, tone}	**overlap** {vowel, constriction, tone}
a Chinantec Mazatec Trique	vowel: tone: constriction:  ʔ à	**ʔà** vowel formants tone pitch constriction silence	**ʔà** vowel *opening tone *tension constriction *closure	**ʔà** vowel *formants tone *pitch constriction *silence
b Chinantec Trique	vowel: tone: constriction:  à ʔ	**àʔ** vowel formants tone pitch constriction *silence	**àʔ** vowel *opening tone *tension constriction *closure	**àʔ** vowel *formants tone *pitch constriction *silence
c Trique	vowel: tone: constriction:  à ʔ à	**àʔà** vowel formants tone pitch constriction *silence	**àʔà** vowel *opening tone *tension, *tension constriction *closure	**àʔà** vowel *formants tone *pitch constriction *silence
d	vowel: tone: constriction:  a̱	**a̱** vowel *opening tone *tension constriction *closure	**a̱** vowel *opening tone *tension constriction *closure	**a̱** vowel formants tone pitch constriction silence

2	{vowel, constriction, tone}	**recover** {vowel, constriction, tone}	**overlap** {vowel, constriction, tone}	**economize** {vowel, constriction, tone}
a Mazatec Mpi	vowel: tone: constriction:  ʔ à	**ʔà** vowel formants tone pitch constriction silence	**ʔà** vowel *formants tone *pitch constriction *silence	**ʔà** vowel *opening tone *tension constriction *closure
b Mpi	vowel: tone: constriction:  à̰	**à̰** vowel formants tone pitch constriction *silence	**à̰** vowel formants tone pitch constriction silence	**à̰** vowel *opening tone *tension constriction *closure
c	vowel: tone: constriction:  à ʔ	**àʔ** vowel formants tone pitch constriction *silence	**àʔ** vowel *formants tone *pitch constriction *silence	**àʔ** vowel *opening tone *tension constriction *closure
d	vowel: tone: constriction:  à ʔ à	**àʔà** vowel formants tone pitch constriction *silence	**àʔà** vowel *formants tone *pitch constriction *silence	**àʔà** vowel *opening tone *tension; *tension constriction *closure

58. **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 phasing patterns added, the more marked (the less recoverable) the added patterns are, but they remain optimally distinct from each other

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