A Cue-Based Approach to the Phonotactics of Upper Necaxa Totonac

Robert Kirchner & Eleni Varelas
University of Alberta

In this paper we extend Steriade's (1999) Licensing-by-Cue approach to the phonotactics of Upper Necaxa Totonac, a member of the Totonacan-Tepehuan language family, spoken in Puebla State, Mexico (Beck 2001). We argue that a number of phonotactic generalizations in this language are problematic for a standard sonority-based account, but are straightforwardly accounted for in terms of Licensing-by-Cue.

1. Problems with sonority

1.1. Sonority sequencing in syllabification.

The notion of sonority sequencing has long played a central role in analyses of phonotactic patterns and related phonological processes. That is, many phonotactic generalizations are standardly accounted for in terms of a set of constraints requiring segments to be sequenced within syllables according to a "sonority cycle," rising sharply in sonority from the beginning towards the nucleus, and falling in sonority within the coda, if any. To take a familiar example, the well-formedness of [blɪk] as a possible word of English, vs. *[bnɪk] (and *[lbɪk]), is attributable to a requirement that English onset clusters rise by a distance of at least two steps on the following sonority scale: *vowel* > *glide* > *liquid* > *nasal* > *obstruent* (Clements 1990). [blɪk] satisfies this Sonority Sequencing and distance requirement (obstruent-to-liquid); while *[bnɪk] has an insufficient sonority distance (obstruent-to-nasal), and *[lbɪk] has a sonority fall.

Despite its widespread deployment, however, the principle of Sonority Sequencing has always been problematic. Firstly, the sonority scale, though it corresponds loosely to acoustic intensity, and degree of constriction, has no straightforward phonetic definition. For example, fricatives can have relatively high intensity, but still pattern as low-sonority segments; and nasals have maximal oral constriction, but relatively high sonority (see generally Keating 1983 for discussion of problems with proposed phonetic correlates of sonority). Secondly, the details of the sonority scale appear to vary from language to language. For example, Steriade 1982 argues that in Latin, coronals patterned as higher sonority than noncoronal consonants, while in Attic Greek, voiced obstruents patterned as higher than voiceless, although many other languages observe no place or voicing distinctions in their sonority scale; see also Levin 1985, proposing a language-specific sonority scale for Klamath.[1] The foregoing considerations suggest that sonority is not a

[1] Clements (1990:296) suggests that a universal sonority scale can nevertheless be maintained, by decomposing apparently sonority-based phonotactic patterns such as Greek and Klamath in terms of language-specific interaction between Sonority Sequencing and some independent markedness scales. This strategy, however, is essentially compatible with our stance: we too unpack phonotactic patterns into a set

single property; rather, Sonority Sequencing should be broken down into a set of constraints referring to distinct phonetic dimensions, which interact to yield the phonotactics of particular languages.

A further problem with Sonority Sequencing is its typological under- and over-generation. As for under-generation, it fails to predict typologically common sonority reversals, particularly sibilant+stop onset clusters, as in English [skɪp]. Such reversals are less obviously problematic in a framework with violable constraints, such as Optimality Theory, than in frameworks which treat Sonority Sequencing as an inviolable principle. In OT, a constraint requiring an [s]+stop cluster to be syllabified, ranked above Sonority Sequencing, gives the correct result. The point is, though, that Sonority Sequencing, by itself, can not derive such patterns; the SYLLABIFY [S]+STOP constraint is essentially a kluge. A more insightful approach to phonotactics would account for the typologically common acceptability of both sibilant+stop and stop+liquid clusters in terms of the same general principles. As for over-generation, sonority-based accounts of phonotactics must invariably be supplemented with other phonotactic constraints, such as the prohibition on [tl] and [dl] onset clusters in English. Again, it would be preferable to account for the phonotactic unacceptability of [tl], vs. the acceptability of [tɹ], in terms of the same general principles. Further consider the (relatively fine-grained) sonority scale posited by Dell & Elmedlaoui (1985) for Tashlhiyt Berber (also adopted in Prince & Smolensky's (1993) OT reanalysis): *low vowels > high vowels/glides > liquids > nasals > voiced fricatives > voiceless fricatives > voiced stops > voiceless stops*. Applying this particular scale to a language which requires a sonority distance of two steps in the onset, as in the English example above, we predict [tf], [bz], [fn], [ɣl], and [nw] onset clusters (but not [vn], [ml], or [lj]). Moreover, assuming that the sonority distance requirement obtains between the onset and the nucleus (as, e.g., Clements 1990 assumes), we predict a language which permits [la] and [nu] but not [lu]; while [ju] or [wi] would constitute a sonority plateau, which violates Sonority Sequencing, even with a sonority distance requirement of just one step. With a more stringent sonority distance requirement, we predict languages with only stops, or only obstruents, in onset position. All of the foregoing predicted patterns are, to our knowledge, unattested.

1.2. The cue-based alternative

A promising direction for rethinking sonority emerges from the Licensing-by-Cue proposal of Steriade 1995, 1997, 1999, 2000a, 2000b, 2001. Standard theorizing about sonority has been largely within the context of a syllable-based approach to phonotactics: as in the account of the ill-formedness of *[bnɪk] above, segment sequencing must conform to the sonority cycle *in order for the segments to be syllabified*. Steriade 1999 argues, however, that phonotactic patterns are not predicated on syllabification, but rather follow from *the restriction of phonological contrasts to contexts where they enjoy sufficient auditory cues*, thus facilitating recoverability. For example, Steriade shows that a pre-aspiration contrast is typically restricted to post-sonorant position, and post-

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of constraints referring to a number of phonetic scales; we merely take the unpacking a few steps further than Clements does.

aspiration to pre-sonorant position.[2] Presumably the partial devoicing of the adjacent sonorant provides an important cue to the aspiration contrast. Crucially, the typology of aspirated stop phonotactics shows no sensitivity to the syllable position of the stop itself or to the tauto- or heterosyllabicity of the sonorant which licenses it.

Steriade formalizes the Licensing-by-Cue proposal in terms of Optimality Theoretic hierarchies of context-sensitive featural correspondence constraints: if the cues to some contrast F in context K are stronger than the cues in context K', then Max(F)/K » Max(F)/K', universally. Interleaved with articulatory markedness constraints (reflecting some notion of effort minimization, cf. Kirchner 1998), this constraint system results in a greater propensity for neutralization of a contrast (to the articulatorily less marked value) the weaker its cues in that context. In the case of pre-aspiration, for example, the ranking Max(pre-asp.)/+son__ » *Effort(pre-asp. stop) » Max(pre-asp.)/-son__ results in restriction of the preaspirated stops to post-sonorant position. With alternative rankings of the *Effort constraint, pre-aspirated stops surface in a broader or narrower range of contexts; but the implicational generalization, "if preaspirated stops are allowed in post-obstruent position, they also occur in post-sonorant position," is captured. This general approach is applied to the distribution of a broad range of laryngeal contrasts, to height contrasts in nasalized vowels, and to retroflexion and apical/laminal contrasts in Steriade 1995; to further analysis of laryngeal contrasts in Steriade 1997 and 2000a (including reanalysis of cases of voicing neutralization previously argued to be conditioned by syllable position); to place contrasts in consonant clusters in Jun 1995 and Steriade 2000b; and to epenthesis in Steriade 2001. A similar approach is applied to the distribution of vowel F2 contrasts (i.e. frontness and rounding) in Flemming 2001.

2. Data

2.1. Background

The data presented in this study are from Beck's (2001) dictionary of UNT, audio recordings, and an electronic database developed by David Beck. UNT's consonant inventory is shown in Table 1.

	Labial	Alveolar	Lateral	Alveopalatal	Palatal	Velar	Glottal
Stop	p	t				k	ʔ
Fricative		s s'	ɬ ɬ'	ʃ ʃ'		x	
Nasal	m	n				ŋ	
Liquid		(ɾ)	l				
Glide	w				j		

Table 1: UNT consonant inventory

[2] Steriade actually motivates a more detailed hierarchy of contexts for aspiration, further supporting the general claim made here, that contrasts occur preferentially in contexts with stronger cues.

The consonant inventory is unusual in that it contains ejective fricatives, but no ejective stops. Beck 2000 argues that these ejectives diachronically arose from fricative + glottal stop clusters, whereas stop + glottal stop clusters, which otherwise might have developed into ejective stops, were not phonotactically permitted in Proto-Northern Totonacan. (To simplify the terminology, we henceforth refer to these ejective fricatives simply as "ejectives," while the term "fricatives" denotes the plain fricatives unless otherwise indicated.) Note that [ɾ] is found only in Spanish loanwords, and that /x/ frequently weakens to a more [h]-like allophone, though the context for this weakening remains unclear.

The vowel inventory, shown in Table 2, involves length and glottalization contrasts.

		Front		Central		Back	
		Modal	Glottalized	Modal	Glottalized	Modal	Glottalized
High	Short	i	ḭ			u	ṵ
	Long	iː	ḭː			uː	ṵː
Mid	Short	e	ḛ	[ə]	[ə̰]	o	o̰
	Long	eː	ḛː			oː	o̰ː
Low	Short			a	a̰		
	Long			aː	a̰ː		

Table 2: UNT vowel inventory

The allophonic status of schwa is still under investigation. The other mid vowels are relatively marginal, rarely occurring except in loanwords, and adjacent to velar and glottal consonants (qua reflexes of uvulars), which triggered familiar allophonic lowering in Proto-Northern Totonacan.

2.2. Word initial position

Examples of consonants occurring in word-initial position are given in (1):

(1) Word-initial consonants

/p/	piʃʔáta̰	‘large (bunch or bouquet of flowers, etc.)’
/t/	texeʃkán	‘bedbug’
/k/	káʃlḭ	‘hen’
/ʔ/	ʔeɬtaʃtú	‘fade (colour)’
/s/	sḛʔsḭ	‘sweet’
/ɬ/	ɬénɬwa	‘very fat’
/ʃ/	ʃaɬtaʔalá tʃiwíʃ	‘type of large, flat stone’
/x/	xa:ʃli:má:n	‘pregnant’
/s’/	s’áɬwa	‘slow of movement or thought’
/ɬ’/	ɬ’entiɬ’enti	‘a dumb person doing something’
/ʃ’/	ʃ’onunʔó:	‘white louse’

/m/	míʃtʃa:	‘by any chance’
/n/	nikpuʃú	‘cut down fruit with a stick’
/l/	li:ʃkúl̰i̱	‘tobacco’
/w/	wiʃká:	‘right?’
/j/	ja:st̰á̱	‘cross-sex brother / sister-in-law’

The only unattested initial consonant is /ŋ/.[3] Vowels, too, may occur word-initially:

(2)	/a/	akpá:n	‘top surface, top edge’
	/i/	iʃlapáʃn̰i̱	‘made with pork’
	/u/	utunún	‘they, those’

Word-initial clusters are exemplified in (3).

(3) a. Fricative + stop:

/ʃʔ/	ʃʔeɬtʃaʔán ʃmakán	‘space between first finger and thumb’
/ʃp/	ʃpipil̰é̱	‘butterfly’
/sp/	spulumakán	‘finger’
/ɬp/	ɬpu:p̰ó̱ʔo	‘grey’
/ʃt/	ʃtalakʃtím	‘the same’
/st/	stákų̱	‘star’
/ɬt/	ɬtak̰á̱la̱	‘board’
/ʃk/	ʃkan	‘water’
/sk/	skáux	‘rabbit’
/ɬk/	ɬkakán	‘ashes’

b. Fricative + Nasal:

/ʃm/	ʃmakan misín	‘tiger’s paw’
/sm/	smantáxwa	‘purple’
/ɬm/	ɬmit	‘exposed’
/ʃn/	ʃnoxót	‘vein’
/sn/	sn̰a̱ʔá	‘lick’

c. Fricative + Approximant:

/ʃw/	ʃwakn̰á̱	‘carpenter’
/sw/	swilú:n	‘drill’
/ɬw/	ɬwiláxwa	‘happy, energetic’
/ʃl/	ʃlamu	‘to wet’
/sl/	slumá:	‘glue’

[3] There are no examples with word-initial /ɾ/ either, though we attribute this to /ɾ/'s marginal status in UNT.

d. Stop + Fricative: [4]

/ts/	tsintsipa̰ʔɬtʃa	‘cuatomate (small, tomato-like fruit)’
/tʃ/	tʃintáʃna̰	‘a stride, a pace’

e. Stop + Approximant:

/kɾ/	kɾistianu[5]	‘person’
/kl/	(i)klakaskinpaláx	‘1subj+want+rpt’
/kw/	kwé:nta	‘importance, reason’
/tw/	twintiwín	‘small brown bird found by the river’

The characterization of homorganic stop + fricative sequences as clusters rather than affricate consonants will prove to be immaterial to our analysis, since the analysis depends upon the perceptual salience of the acoustic events, namely an interval of (near-) silence followed by friction, not on assumptions about covert segmental structure.

In sum, we identify the following generalizations concerning word-initial position:

- All vowels, and consonants other than [ŋ] can occur.
- Strident fricatives, [s,ʃ,ɬ], can be followed by any other non-fricative or non-ejective consonant.
- Stops can be followed by homorganic strident fricatives, or by approximants.

Note that our treatment of UNT [ɬ] as strident is supported by acoustic evidence: the lateral fricative is comparable in total energy (= intensity × duration) to the sibilants; whereas the the velar fricative is significantly lower:

	Mean Total Energy (dB×ms)
s	8237.46
ʃ	6878.21
ɬ	7082.86
x	4414.12

Table 3: Total energy of UNT fricatives (N = 40, $p < .01$)

As far as we are aware, previous classifications of fricatives have not seriously examined the question of whether lateral fricatives are strident. We leave open the question of whether lateral fricatives in other languages might have much quieter realizations, in which case we would expect them to pattern with non-strident fricatives.

[4] The database contains one form with an apparent initial heterorganic stop + fricative cluster, [k ɬ̰imapí:] (‘crush something’). However, David Beck (p.c.) regards this as a probable mistranscription.

[5] The UNT rhotic tap [ɾ] can be regarded as an approximant, notwithstanding complete closure, in that the closure is only fleeting. The tap thus contains clear formant structure in its approach and release, and it is substantially open for all but a small portion of its duration.

2.3. Word-final position

In word-final position, the single consonants are restricted to stops, fricatives, and nasals, as is exemplified in (4).

(4) a. Stops:

/p/	kạ̲psnáp	‘paper, letter, document’
/t/	ʃkexét	‘an herb’
/k/	ʃkiwák	‘large black ant’
/ʔ/	ɬpi:pé̲ʔ	‘suprisingly, suddenly, startingly’

b. Fricatives:

/s/	ʃli:mạ̲ʔá̲:s	‘a long time’
/ʃ/	iʃta:ta wa:káʃ	‘bull’
/ɬ/	paʃkatkatsí:ɬ	‘thank you’
/x/	swatáx	‘suddenly’

c. Nasals:

/m/	ʃtum	‘different’
/n/	ma:wayán	‘feed someone’
/ŋ/	ɬamáŋ	‘rounded, full’

The set of final clusters is exemplified in (5):

(5) a. Stop + Fricative:

/ʔʃ/	lulo̲ʔʃ	‘squash or melon seed fibres’
/ʔɬ/	po̲ʔɬ	‘dark, in shadow’
/ʔs/	pi̲pé̲ʔs	‘scale’
/kʃ/	tʃilí̲kʃ	‘white crystalline stone, used for lime’
/kɬ/	akaku:lúkɬ	‘scorpion’
/ks/	puks	‘overcast, gloomy’
/pʃ/	tʃipʃ	‘a lot’
/pɬ/	lapɬ	‘completely wet’
/tɬ/	atutʃijétɬ	‘mint’

b. Nasal + Fricative:[67]

/nɬ/	ɬenɬ	'very fat'
/nʃ/	tanlunʃtanlunʃ	'person hopping on one leg'
/ŋʃ/	ɬa̱ʔapu:lúŋʃ	'face down'

c. Stop + Geminate fricative:

/tʃʃ/	pa̱tʃʃ	'something popping suddenly'

The form in (5c) appears to be an ideophone, imitative of a popping noise; and word-final (or initial) sequences of fricatives are otherwise unattested in UNT. We therefore treat this example as an exception to the normal phonotactics of UNT.

In sum, we identify the following generalizations concerning word-final position:

- Any stop, fricative, or nasal (or any vowel) can occur.
- A stop or nasal may be followed by a strident fricative.

2.4. Word-medial position

All the consonants except /ŋ/ can occur intervocalically, as exemplified in (6):

(6)

/p/	stapún	'bean'
/t/	sputút	'end (time)'
/k/	stáku̱	'star'
/ʔ/	staʔa	'unripe (fruit)'
/ʃ/	taʃi̱ti̱wa̱ʔni:ni	'go sliding along on one's behind'
/s/	kuksa:sá:ŋka̱	'grey-haired'
/ɬ/	kaɬá:ʃku̱	'wherever'
/x/	staxán	'tail'
/ʃ'/	ʔeɬʔó:ʃ'a̱	'lips'
/s'/	ma:s'e̱ʔní:	'take shade under'
/ɬ'/	ɬ'entiɬ'enti	'a dumb person doing something'
/m/	ʃlámu̱	'sprinkle of water'
/n/	sta:ná̱	'merchant'
/ŋ/	--	

[7] There are, in addition, a few forms transcribed as ending in an [ŋkʃ] or [ŋks] cluster (e.g. [taŋkúŋkʃ] 'tamal made with fat and salt', [tsajáŋks] 'deserted, empty'). But waveforms of recordings of [ŋks] vs. [ŋs] clusters appear to have comparable oral closure durations and (weak) release bursts – indeed, the [ŋs] token had a slightly higher amplitude burst than the [ŋks] token. This suggests that all the nasal + fricative clusters have some excrescent oral release in the transition from nasal to fricative (an cross-linguistically common phonetic process), and that these clusters are not actually in contrast with nasal + stop + fricative clusters; however, a definitive resolution of this issue requires further data collection and acoustic analysis.

/ɾ/	paɾakxáxa	‘making a farting sound’
/l/	sta:lá	‘go behind’
/w/	stiwí	‘swinging’
/j/	stája̱	‘squirrel’

Two-consonant medial clusters are listed in (7)

(7) a. Fricative + Stop:

/ʃʔ/	iʃʔe:niʃmakán	‘back of one’s hand’
/ʃk/	tʃiʃkú̱	‘man’
/ʃp/	li:ʃpatán	‘pestle’
/ʃt/	ʔeɬtaʃtú	‘fade (colour)’
/ɬʔ/	ʔeɬʔó:ʃ’a̱	‘lips’
/ɬk/	ʔeɬkután	‘smell of sweat’
/ɬp/	kiɬpa̱nɬú̱lu̱	‘toothless person’
/ɬt/	iɬtín	‘faeces’
/sp/	tuspúɬ	‘toes’
/st/	ʃastánku̱	‘youngest sibling’
/sk/	li:skaláxwa	‘danger’
/xʔ/	lakapaxʔá̱ɬa̱	‘far apart’
/xp/	kiɬtʃúxpi̱	‘beak’
/xt/	waxtaʃtutʃá	‘last’
/xk/	kujuxkí̱wi̱	‘tree’

b. Fricative + Fricative:

/ɬʃ/	kiɬʃaká	‘wipe edge with a cloth’
/xɬ/	laxɬíki̱	‘unravelled, frayed’
/xs/	lakapá̱xso̱	‘close by’

c. Fricative + Ejective:

/ɬs’/	taʔeɬs’olín	‘whistled’
/ɬʃ’/	taʔeɬʃ’apá̱ʔ-	‘yawn’
/xs’/	tixs’ojá:	‘a type of witch’

d. Fricative + Nasal:

/ʃm/	taʃmú̱ta̱	‘flexible’
/ʃn/	pá̱ʃni̱	‘pig’
/ɬm/	tapu:ɬma:ní:	‘sink’
/ɬn/	ʔá̱ɬni̱	‘blood’
/sm/	ʔesmantáx	‘fruit’
/sn/	ʔosnú̱	‘flyer’

/xm/	la̱ʔɬta̱ʔaxmapí:	‘lay something face down’
/xn/	awaxní	‘disgust’

e. Fricative + Approximant:

/ʃl/	ka:ʃlawá	‘build’
/ɬl/	kiɬlakaʃtán	‘hook’
/sl/	a̱ʔa̱sliwít	‘earring’
/xl/	ka:naxlá	‘believe, be sure of’
/ʃw/	la:ʃáʃwa	‘orange’
/ʃj/	ka:ʃjáɬ	‘well-dressed’
/ɬw/	ʔaɬwáɬ	‘egg’
/ɬj/	kiɬja:wá:	‘put something into someone’s mouth’
/sw/	taswá̱ʔa̱	‘ground’
/xw/	ɬkáxwa	‘disgusting’
/xj/	lakataxjáɬ	‘stand slightly inclined to the front’

f. Stop + Stop:

/ʔp/	a̱ʔpiʃán	‘throat’
/ʔt/	pó̱ʔtu̱	‘all’
/ʔk/	la̱ʔkuʃtunú	‘July’
/kʔ/	kukʔaɬaɬá	‘bare-headed’
/kp/	lakpa:tajáɬ	‘be inclined, sloping’
/kt/	laktáx	‘limping’
/kk/	kukkatsán	‘have a headache’
/tk/	tapu:s̱itkú:tu̱	‘hollowed out’

g. Stop + Fricative:

/ʔʃ/	la̱ʔʃaʔá	‘polish’
/ʔs/	ma̱ʔs̱in	‘fingernail, claw’
/ʔɬ/	pa̱ʔɬá:t	‘coffin’
/ʔx/	la̱ʔxú:	‘top of climb’
/kʃ/	ʃí:kʃ̲i	‘bile’
/ks/	kuksuntáɬ	‘dandruff’
/kɬ/	lakɬawanán	‘do harm’
/kx/	lakxu:kiwá̱	‘cramp in leg’
/pʃ/	nípʃ̲i	‘squash’
/ts/	ma:tso̱ʔni:ni	‘sign up, register’
/tʃ/	tʃutʃutsipéx	‘town, city’

h. Stop + Ejective:

/ʔɬ'/	la̱ʔɬ'o̱p-	'melt (ice, sugar)'
/ʔʃ'/	tala̱ʔʃ'á:n	'cut and piled wood'
/kʃ'/	kukʃ'aʔáx	'halo (of saint)'

i. Stop + Nasal:

/ʔm/	a̱ʔmulú	'gourd'
/ʔn/	ʃte̱ʔní	'leave something to someone'
/km/	lakmín	'come on foot'
/kn/	ʃwakná̱	'carpenter'
/pn/	pu:típni	'bow (weapon)'
/tm/	mutmút	'Blue-crowned Motmot'
/tn/	ʃlitnín	'shred'

j. Stop + Approximant:

/pl/	liplip	'a diamond or piece of glass sparkling'
/tl/	taxata̱tlá:	'be sick'
/kl/	aklukút	'skull'
/ʔl/	tʃa̱ʔlí:	'paint'
/ʔw/	laʔwá:	'many, lots'
/ʔj/	la̱ʔjúx-	'come down to'
/kw/	lakwán	'clean'
/kj/	stakja:wa:ná̱	'punish'
/tw/	slítwa	'straight'
/tj/	tala̱ʔspi̱já	'be standing and turning from side to side'

k. Nasal + Stop:

/ŋʔ/	a̱ʔtsaŋʔá:	'get lost'
/np/	sti:li:npú:	'spinning top'
/nt/	ʃantíɬ	'witch'
/ŋk/	ʃáŋka	'very well'
/mp/	ʃtampún tʃiɬ	'arrive just in time'
/ŋt/	toŋtoŋ	'heart beating'

l. Nasal + Fricative:[8]

/nʃ/	tanʃu̱kú̱	'manually check hens for eggs'
/nɬ/	lunɬól	'completely wet'
/ŋʃ/	mo:ŋʃú̱	'owl'

[8] As in word-final position, there are also some forms transcribed as containing nasal + stop + fricative clusters, though it seems doubtful that these phonetically differ from nasal + fricative clusters (see fn. 6).

m. Nasal + Ejective:

/ns'/	ʔens'alíɬ	'edible vein'

n. Nasal + Nasal:

/nm/	tanma:nú:	'put inside someone's behind'
/nn/	tsanna	'insects humming'
/mn/	lakatʃimnín	'blink'
/ŋm/	stoŋmá:ɬ	'lie spreadeagled'
/ŋn/	lóŋn̰i	'cold'

o. Nasal + Approximant:

/nl/	ʔe:sti:pu:nlukút	'spinal column'
/ml/	ʔe:ʃtimlá:	'come together into a group'
/nw/	ʃká:nwa	'transparent'
/nj/	tatanja:wá:	'be a certain way about the bottom'
/mw/	piʃpamwá	'person with long hair, puffy hair'
/ŋw/	téŋwa	'humid'

p. Liquid + Stop:[9]

/ɾp/	tantu:kaɾponsíju	'huaraches made from carboncillo tree'
/ɾt/	ʔa̰stikaɾtón	'house with roof made of compressed fibres'

Triple-consonant clusters are listed in (8).

(8) a. Fricative + Fricative + Stop:

/ɬʃk/	kiɬʃkután	'have bad breath'
/ɬʃt/	ʔeɬʃtím	'level'
/ɬsk/	kiɬskawí	'bend into an arc or circle'
/ɬst/	ʔeɬstilí:l̰i	'round, circular (area, opening)'
/xʃk/	texʃkán	'bedbug'
/xsp/	sipexspú:n	'Great Curassow'

b. Fricative + Fricative + Nasal:

/ɬsm/	ma:ʔeɬsmaní:	'make someone like some food or drink'

c. Fricative + Fricative + Approximant:

/ɬʃl/	ʔeɬʃlatáʔa	'stick out tongue'

[9] In addition, one form is transcribed as having a liquid + nasal cluster, [ʃʔélnn̰i pá̰ɬma] 'ephiphyte'. However, other examples of this same root are transcribed elsewhere in the database as /ʔéɬni/. Further data collection is required to verify that [ʃʔélnn̰i pá̰ɬma] is correctly transcribed.

/ɬsl/	ʔeɬslatáʔa	‘stick out tongue(repeatedly)'
/ɬsw/	kiɬswé̲ʔe̲	‘baby without teeth’

d. Fricative + Stop + Fricative:

/ʃts/	ʃkí̲ni̲ iʃtsí̲ki̲	‘nipple’
/ɬts/	ʔeɬtsáni̲	‘chin’
/ɬtʃ/	ʔeɬtʃa̲á:n	‘brush one’s teeth’
/sts/	tapistsí:	‘be hoarse, have a sore throat’
/stʃ/	tsoʔostʃáux	‘kneecap’
/xts/	tsixtsíxwa	‘warm’

e. Stop + Fricative + Stop:

/pʃk/	tantʃipʃkí̲wi̲	‘type of tree’
/tʃk/	litʃkut xá:ka	‘regular mamey’
/tst/	pu:lakatstákni̲	‘birthplace’
/tsp/	a:tʃutʃutspun	‘Brewer’s Blackbird’
/kʃk/	le:kʃkí̲	‘comb’
/kʃp/	makʃpán	‘forearm’
/kʃt/	ta̲ta̲:kʃtún	‘steep’
/kɬk/	makɬkután	‘smell bad’
/kɬp/	akɬpa:tsunáx	‘low to the ground’
/kɬt/	tamakɬtítní̲	‘cracked’
/ksk/	akski̲tít	‘brain’
/ksp/	kukspuxúxu	‘pointed, having a sharp end’
/kst/	ʔákstu̲	‘oneself’
/ʔʃk/	la̲ʔʃkút-	‘untangle, unwind, unroll’
/ʔʃp/	a̲ʔʃtá:n	‘armpit’
/ʔɬk/	pu:la̲ʔɬku:jú:	‘burn the insides out of something’
/ʔɬt/	a̲ʔɬtalá	‘crush’
/ʔsp/	a̲ʔspula:nán	‘happen’
/ʔsk/	ma̲ʔski̲tí̲	‘cook’
/ʔst/	xa:ma̲ʔstín	‘never’

f. Stop + Fricative + Nasal:

/ʔʃn/	ma̲ʔapa̲ʔʃnán	‘applaud’
/ʔɬm/	a̲ʔɬmá:n	‘loud’
/ʔɬn/	po̲ʔɬnú̲	‘cloud’
/ʔsm/	makpé̲ʔsma̲	‘scales of snakes, etc.’
/ʔsn/	tapé̲ʔsni̲	‘peeled, cleaned’
/kʃn/	akʃní̲	‘then’

/kɬm/	a̲kɬmá:n	‘long’
/kɬn/	púkɬni	‘Leather Plant’
/ksn/	takupúksni̲	‘bent over’
/pʃn/	ma:tankipʃní	‘type of cricket’
/psn/	tatsa̲psní̲	‘piled up’

g. Stop + Fricative + Approximant:

/ʔʃl/	pe̲ʔʃlámu	‘epiphytic vine’
/ʔsl/	a̲ʔslumá	‘chrysalis, cocoon’
/kʃl/	makʃlú:t-	‘brush down (animal), wipe’
/kɬl/	kikɬla̲ʔtsín	‘to be envious of someone’
/ksl/	makslítwa	‘striped (body)’
/tʃw/	ʃwatʃwat	‘someone dragging self along the ground’
/kʃw/	akʃwilít	‘tire, wheel’
/kɬw/	makɬwáka̲	‘liver’
/ksw/	ka:ká̲kswa	‘still, quiet place’
/ʔʃw/	pe̲ʔʃwikí	‘left (side)’
/ʔɬw/	po̲ʔɬwanán	‘get dark’
/ʔsw/	wilé̲ʔswa̲	‘twisted, warped (radially)’

h. Stop + Stop + Fricative

/ʔts/	a̲ʔtsí:s	‘flea’
/ktʃ/	a̲ktʃán	‘honestly, fully measured’
/ttʃ/	paɾattʃáxa	‘making a farting sound’

i. Stop + Stop + Nasal:

/ʔtn/	pé̲ʔtni̲	‘leaves, shoots (of tree)’

j. Nasal + Fricative + Stop:

/nʃt/	tanlunʃtanlunʃ	‘a person hopping along on one leg’
/nɬk/	kalanɬkalanɬ	‘a person biting through hard food’
/nɬt/	tanɬtoxólu	‘baggy around the bottom (pants)’
/nsp/	ʃatsimarón tsilinspu:n	‘Brown-backed solitaire’
/nst/	tanstoxólu	‘deep’

k. Nasal + Fricative + Nasal:[10]

[10] In addition, there is one form in the database transcribed as containing an / ŋxn/, [li ŋxnín] ‘limp’, however, this word is transcribed elsewhere as [liŋsnín]. Further data collection is therefore required to verify that [liŋxnín] is correctly transcribed.

/nʃn/	ʃnonʃnon	'a cord or elastic being stretched'
/ŋʃn/	luŋʃnún	'jump'
/ŋsn/	tsi:ŋsní:	'die of hunger'

l. Nasal + Fricative + Approximant:

/msl/	slimslim	'something twinkling'
/nɬl/	linɬlinɬ	'a person hopping around on one foot'
/ŋʃl/	luŋʃluŋʃ	'a person jumping around'
/nɬw/	ɬénɬwa	'very fat'
/ŋɬw/	pa:ɬéŋɬwa	'pot-bellied man'
/ŋʃj/	luŋʃjúx-	'jump down'

m. Nasal + Stop + Approximant:

/mpl/	tʃamplu̱lu̱	'bush bearing berries'
/ŋkw/	tsiŋkwá	'Cacomistle'

The only example we have found of a four-consonant cluster is given in (9):

(9) Stop + Fricative + Stop + Fricative:

/ʔɬtʃ/	pa̱ʔɬtʃa̱	'tomato'

In sum, we identify the following generalizations concerning word-medial position:

- Any single consonant other than /ŋ/ can occur.
- Any fricative, stop, or nasal can be followed by any other consonant, or any cluster permitted in word-initial position.
- The foregoing clusters may also occur, preceded by a glottal stop.

3. Preliminaries

3.1. Pause and citation form

Our analysis proceeds upon the assumption that word-initial position can be equated with post-pausal position, for purposes of considering the distribution of cues. In post-pausal position, a consonant enjoys no preceding formant transition cues. This is not the case, however, in word-initial but phrase-medial position if the preceding word ends in a vowel. Nevertheless, Steriade 1998 has shown that a cue-based account of post-pausal phonotactics can be generalized to the word-initial context (and pre-pausal to word-final) using Output-Output Correspondence constraints (Flemming 1995, Benua1997) which relate the citation form of a word to its realization in phrasal contexts. For example, consider a language which prohibits word-initial stop + stop clusters. This post-pausal pattern can be captured in terms of a partial hierarchy, Max(stop)/V__stop ("don't delete the first of two stops if it follows a vowel, which thus provides it with formant transition

cues") » Max(stop)/__stop ("don't delete the first of two stops, even in post-pausal position"), with a *Effort constraint interleaved:

(10) First stop deletes post-pausally but not post-vocalically

		Max(stop)/V__stop	*Effort(stop)	Max(stop)/__stop
	pta pta		**!	
☞	pta ta		*	*
☞	apta apta		**	
	apta ata	*!	*	*

This account of a post-pausal pattern can then be extended to word-initial position, even when the preceding word ends in a vowel, through interaction with a high-ranked Dep-OO constraint:

(11)

/a pta/ Citation form: [ta]	Dep-Citation-Phrasal form	Max(stop)/V__stop	*Effort(stop)
a pta	*!		**
☞ a ta		*	*

By the same reasoning, an account of a pre-pausal pattern can be extended to word-final position through interaction with a high-ranked Dep-OO constraint. (Correspondence constraints not explicitly identified as some form of Output-Output correspondence refer to Input-Output correspondence.)

3.2. Ranking schemata

Further note that throughout the remainder of our analysis, where we motivate some fixed ranking of constraints, the claim should be understood to refer to constraint *schemata*, and does not imply that the constraints in question are not amenable to further elaboration. For example, Jun 1995 shows that coronals and labials are more likely than velars to undergo deletion or regressive assimilation as the first of a cluster of stops. The perceptually based ranking schema Max(stop)/V__stop » Max(stop)/__stop, then, could be further elaborated as Max(velar stop)/V__stop » {Max(stop)/V__stop, Max(velar stop)/__stop} » Max(stop)/__stop. The Max(velar stop) constraints might be broken down yet further into [k] and [g], if there is any basis for distinguishing the salience of their cues. On the other hand, the schema Max(stop)/V__stop » Max(stop)/__stop can itself be regarded as an elaboration of an even more general perceptually based ranking schema, Max(C)/V__ » Max(C).

Moreover, ranking schemata should be understood to hold true, *all else being equal;* if, however, there are countervailing perceptual considerations in particular sub-cases, these override the general schema. For example, Max(C)/V__ » Max(C) means that a given consonant in post-vocalic position will be preserved above that same consonant without a preceding vowel, all else being equal; it does not mean that all consonants in post-vocalic position will be preserved above all consonants in all non-postvocalic

positions. As mentioned in §1.2, a post-aspirated stop (indeed, most other consonantal contrasts, cf. §5.1) preferentially occur in *pre*-vocalic position. A more elaborated hierarchy therefore would be: Max(C)/V__V » Max(C)/__V » Max(C)/{__V, V__} (i.e. before or after a vowel) » Max(C). And even this hierarchy is overridden by the observation that contrasts with predominantly preceding cues, such as pre-aspiration, occur preferentially in post-vocalic position, motivating further elaboration: Max(consonant with preceding-cued contrasts)/V__ » Max(C w/ preceding-cued contrasts)/__V, while Max(C w/ other contrasts)/__V » Max(C w/ preceding-cued contrasts), and so on.

3.3. Fortition

Note that Steriade's approach, solely involving context-sensitive correspondence constraints interacting with *Effort constraints, is intended to capture surface phonotactic generalizations, under the assumption that, if a contrast is perceptually too weak in a certain context, the segment will be deleted, or otherwise reduced to a less effortful output. Once we concern ourselves with the behaviour of particular morphemes in alternations, however, we must recognize that sound systems also respond to perceptual weakness with fortition, modifying the context in which the contrast occurs so that it receives stronger cues. This outcome requires an enrichment of Licensing-by-Cue, by inclusion of perceptually based markedness constraints, penalizing representations which contain sounds which are perceptually insufficiently distinct from other sounds, similar in function to the Minimum Distance constraints of Flemming's (1995) Dispersion Theory (see tableau (22) and surrounding text).

4. Analysis: word-initial position

4.1. Strident fricative + consonant clusters

As noted in §1.1, the cross-linguistic prevalence of s + stop clusters (cf. Morelli 2000, documenting this typological claim) poses a problem for sonority-based approaches to phonotactics. Moreover, as UNT, a fricative-rich language, demonstrates, immunity from sonority sequencing is not a property of [s] in particular, nor of fricatives in general, but precisely the class of strident fricatives (in UNT [s,ʃ,ɬ] but not [x]). Indeed, prior to the entry of Spanish loanwords into Totonac, it appears that strident fricative + consonant clusters (and affricates, if these are regarded as clusters) were the only initial clusters in the language.

Under Licensing-by-Cue, the phonotactically privileged status of strident fricatives follows from their acoustic stridency (i.e. loudness) itself. While other word-initial consonants typically require a following approximant or vowel, whose formant transitions provide cues to the consonant's identity, strident fricatives have particularly salient internal cues, in their characteristic high-intensity friction, and in the frequency of this friction noise, and thus are relatively recoverable even in the absence of formant-transitional cues. (For fricatives with lower amplitude and more diffuse spectra, transitional cues are necessary for listeners to reliably distinguish the place of

articulation, see Harris 1958.) This greater recoverability motivates a fixed ranking under the cue-based approach: Max(strid)/‖__C » Max(C)/‖__C. With the relevant *Effort constraint interleaved, we obtain the UNT pattern:

(12) Word-initial strident is maintained in pre-consonantal position, other C is not:

		Max(strid)/‖__C	*Effort(obstruent)	Max(C)/‖__C
☞	ʃkan ⌧ ʃkan		**	
	ʃkan ⌧ kan	*!	*	*
	pkan ⌧ pkan		**!	
☞	pkan ⌧ kan		*	*

S + C clusters (where S denotes any strident fricative) are thus permitted in initial position, while most other clusters are not.

The effect of tableau (12) must be qualified, however, by noting that strident fricatives are not permitted initially, if the following consonant is another fricative. Acoustically, a sequence of fricatives simply constitutes an interval of friction noise, with smooth changes to the spectrum, which might be perceived as mere transitions from a single fricative into a following vowel. The absence of clear discontinuity in the friction noise makes for poor manner cues to the presence of two distinct fricatives. This consideration gives rise to the Licensing-by-Cue ranking Max(strident fricative)/‖__non-fricative » Max(strident fric)/‖__C. And now that pre-nonfricative position has been split off from other contexts, the ranking of *Effort(fric) must be modified as follows, to capture the UNT ban on initial fricative clusters, while still permitting other strident + C clusters:

(13)

		Max(S)/‖__non-fricative	*Effort(S)	Max(S)/‖__
	ʃsan ⌧ ʃsan		**!	
☞	ʃsan ⌧ san		*	*
☞	ʃkan ⌧ ʃkan		*	
	ʃkan ⌧ kan	*!		*

A further issue is the absence of the ejective strident fricatives [s’,ʃ’,ɬ’] from initial clusters. In one sense, the explanation for this gap lies in the diachronic origin of the ejectives < S? < Sq (where "S" denotes any strident fricative). Because no word began with more than two consonants in Proto-Northern Totonacan (nor in modern UNT), no forms contained an initial SqC cluster which would have developed into a S’C cluster. However, there is also a plausible synchronic basis for the ban on such clusters, which might account for the failure of any S’C clusters to develop subsequently, e.g. via syncope (s’etiná 'red tick' > s’tiná). As Steriade 1995 has observed, the cues to ejection lie in the ejective's release, particularly VOT and creaky voicing at the beginning of the following vowel. Such cues would not be present in pre-obstruent position; before a nasal, the cues would be obscured by the oral closure; and before approximants, creaky voicing and long-lag VOT would obscure the approximant's formant cues. Consequently, ejectives typically are restricted to pre-vocalic position. We thus motivate the Licensing-

by-Cue fixed ranking Max(ejection)/__V » Max(ejection) (i.e. even /__C). The UNT ban on ejective clusters then follows from the ranking in (14).

(14) Ejective not permitted in word-initial pre-C position, but permitted before V:

		Max(eject.)/__V	*Effort(eject.)	Max(eject.)
	s'tiná ~ s'tiná		*!	
☞	s'tiná ~ stiná			*
☞	s'aná ~ s'aná		*	
	s'aná ~ saná	*!		*

4.2. Affricates

Recall that stop + fricative clusters are permitted in initial position, if the fricative is strident, and homorganic to the stop, i.e. if the cluster could be characterized as a strident affricate. First, why are non-strident affricates (e.g. [kx]) banned, in UNT and many other languages? We claim that the answer lies in the confusibility of [kx] (with a non-strident fricated release) and corresponding plain stop [k] (which also has friction noise, in the stop release itself, and in any lag between the release and the onset of voicing. (In this regard, note that UNT [p,t,k] are notably more aspirated than the equivalent stops in Mexican Spanish.) The substantially louder and longer friction in a strident affricate, on the other hand, is less likely to be misperceived as a plain stop. These considerations motivate the fixed ranking Max(S)/stop__V » Max(fricative)/stop__V, and the stridency requirement in UNT then follows from the ranking in (15).

(15)

		Max(S)/stop__V	*Effort(S)	Max(fric.)/stop__V
☞	tʃintáʃn̰á ~ tʃintáʃn̰á		*	
	tʃintáʃn̰á ~ tintáʃn̰á	*!		*
	kxintáʃn̰á ~ kxintáʃn̰á		*!	
☞	kxintáʃn̰á ~ kʰintáʃn̰á			*

We must also account for the homorganicity restriction on the preceding stop in these clusters. This can be attributed to the impoverished place cues to the stop when preceded by a pause and followed by a fricative: the stop enjoys no preceding nor following formant transitions, and the place cues in the release burst are obscured by the friction noise which immediately follows it. This motivates the fixed ranking Max(stop place)/__V or /V__ » Max(stop place) (i.e. even in the absence of formant transitions and audible release burst); and the UNT word-initial homorganicity restriction for stop + fricative clusters then follows from the ranking in (16).

(16) No stop but [t] in word-initial pre-fric. position, but other stops can occur after V:

		Max(stop place) /__V or /V__	*Effort (heterorganic cluster)	Max(stop place)
	kʃintáʃnạ́ ~ kʃintáʃnạ́		*!	
☞	kʃintáʃnạ́ ~ tʃintáʃnạ́			*
☞	tʃintáʃnạ́ ~ tʃintáʃnạ́			
	tʃintáʃnạ́ ~ kʃintáʃnạ́		*!	*
☞	akʃintáʃnạ́ ~ akʃintáʃnạ́		*	
	akʃintáʃnạ́ ~ aʃintáʃnạ́	*!		*

The *Effort(heterorganic cluster) reflects an assumption that a cluster involving constrictions with two different active articulators is more effortful than a cluster involving a single articulator. We thus derive the special phonotactic behaviour of t + strident fricative sequences from the perceptibility of their contrasts, rather than by stipulation that they count as a single segment.

We treat the absence of ejective affricates as an accidental gap in modern UNT, arising from the diachronic developments discussed in §2.1. There is no plausible set of constraints which could actively ban ejective affricates while permitting ejective fricatives.

4.3. Stop + approximant clusters

With the foregoing constraint ranking, we account for the word-initial clusters of UNT prior to contact with Spanish. The phonotactics of the modern language, including loanwords, can be captured, however, with minor modification of the analysis above, to permit stop + approximant clusters.

For purposes of perception of a preceding stop, approximants are superior to nasals or obstruents, but inferior to vowels. They are superior in that they contain clear formant structure, and thus are capable of providing formant transition cues to the stop's place of articulation. Moreover, because they have relatively open constriction, they do not obscure the stop's burst properties. Nasals have formant structure as well; but nasals show significant weakening in the upper formants due to the antiresonance (zero) and a low frequency resonance (pole) below 500 Hz. These nasal pole-zero patterns substantially obscure the formant transition cues to a preceding consonant. Obstruents have no formant structure, by definition, hence they can provide no formant transition cues to a preceding obstruent. Furthermore, because nasals and obstruents have close oral constriction, they may obscure the stop's burst properties. Approximants are, in turn, inferior to vowels, in that the approximants alter the formant transitions from the stop into the following vowel: [j] raises F2 and lowers F1; [w] raises F1 and lowers F2; [ɾ] lowers F3; and [l] weakens formants above (roughly) 1200 Hz. Moreover, approximants are themselves more vulnerable to misperception than vowels, in that the stop's release properties, including long-lag VOT, may obscure the formant structure of a significant portion of the

approximant. Vowels, which are generally substantially longer than approximants, are less vulnerable in this regard.

The foregoing acoustic considerations motivate the following fixed rankings: Max(stop place)/__V » Max(stop place)/__approximant » Max(stop place) (i.e. even when followed by a nasal or obstruent), and Max(approximant)/V__ » Max(approximant) (i.e. even after a stop). With {Max(stop pl.)/__V, *Effort(stop)} » Max(stop pl.)/__approx., or Max(approx.)/V__ » *Effort(approx.) » Max(approx.), we obtain the phonotactics of UNT prior to Spanish contact, as above. With demotion of *Effort(stop), or *Effort(approx.), as shown in (17), we obtain the phonotactics of modern UNT, permitting stop + approximant clusters word-initially.

(17) a.

	/kwé:nta/	Max(stop pl.)/__approx.	*Effort(stop)	Max(stop pl.)
☞	kwé:nta		*	
	wé:nta	*!		*

b.

	/kwé:nta/	Max(approx.)	*Effort(approx.)
☞	kwé:nta		*
	ké:nta	*!	

4.4. Absence of [ŋ]

A final issue is the ban on word-initial [ŋ]. The cues distinguishing a velar from an alveolar nasal lie principally in the formant transitions into the nasal, rather than the transitions out of the nasal. Unlike a stop, the nasal has no release burst to provide place cues. Furthermore, the pole-zero resonance patterns, which provide internal place cues to the nasal, are quite similar for [n] and [ŋ], as opposed to [m]. These considerations motivate the fixed ranking Max(nasal velar place)/V__ » Max(nasal velar place) (i.e. even in the absence of preceding formant transitions); and the UNT ban on initial [ŋ] then follows from the ranking in (18).

(18)

		Max(nasal velar place)/V__	*Effort(ŋ)	Max(nasal velar place)
	ŋikpuʃú ⧸ ŋikpuʃú		*!	
☞	ŋikpuʃú ⧸ nikpuʃu			*
☞	mo:ŋʃú̱ ⧸ mo:ŋʃú̱		*	
	mo:ŋʃú̱ ⧸ mo:nʃú̱	*!		*

5. Analysis: word-final position

5.1. Ban on word-final approximants

In final position, any single consonant, or any vowel, can occur, except for approximants. The vulnerability of an approximant in /V__‖ position is due to its poor manner cues. (In this discussion, we disregard [ɾ], whose manner cues are somewhat richer than the other approximants, but whose marginal status in UNT, and low type-frequency in word-final position in the source-language, Spanish,[11] adequately accounts for its absence in word-final position.) There is no clear discontinuity between the formant structure of the approximant and that of the vowel that precedes it. Indeed, the glides, [j] and [w], are merely excursions in F1 and F2 frequency, and can therefore readily be misattributed to the vowel itself, particularly where there is no vowel following the glide, to more clearly distinguish the glide from the flanking segments.

(19)

		Max(glide)/V__V	*Effort(glide)	Max(glide)/__V
	stáj ⌧ stáj		*!	
☞	stáj ⌧ stá			*
☞	stája̲ ⌧ stája̲		*	
	stáa̲ ⌧ stáa̲	*!		*

In contrast, the formant structure of nasals displays an abrupt discontinuity with adjacent vowels during the oral closure interval, with marked weakening of all formants, particularly in the F2 range.

(20)

		Max(nas)/V__	*Effort(nas) *Effort(glide)	Max(glide)/V__
	stáj ⌧ stáj		*!	
☞	stáj ⌧ stá			*
☞	stán ⌧ stán		*	
	stán ⌧ stá	*!		

Obstruents have no formant structure at all, and thus display clear discontinuity as well; therefore we can substitute “obs” for “nas” in the tableau above, with similar phonotactic results.

The lateral approximant has somewhat richer manner cues, particularly a weakening of the higher formants. Evidence from UNT alternations shows that word-final laterals are not banned, per se; rather, their manner cues must be enhanced with devoicing, which makes for a more abrupt discontinuity with the preceding vowel – resulting in neutralization of /l/ to the lateral fricative in word-final position:

[11] Infinitival forms of verbs do end in [ɾ] in Spanish; but Spanish verbal inflectional morphology has not been borrowed into UNT. Indeed, most of the Spanish loanwords in UNT are nouns, which rarely end in [ɾ].

(21) ikwíɬ ‘I am seated’ wiɬ ‘s/he is seated’
wílaˌ ‘you-sg. are seated’ wilaːnaːntít ‘you-pl. are seated’

The absence of word-final [l], as well as the l ~ ɬ alternations exemplified in (21), can be captured in terms of ranking of Max(lateral) and Max(approximant) relative to a perceptually based markedness constraint, *approximant/V__‖.

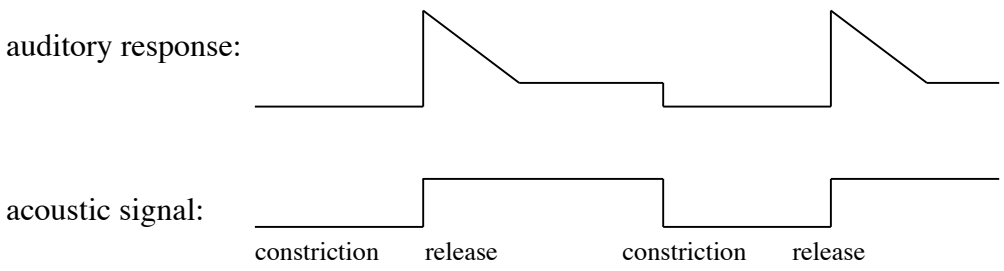
(22)

/wil/	Max(lateral)	*approximant/V__‖	Max(approximant)
wil ~ wil		*!	
☞ wil ~ wiɬ			*
wil ~ wi	*!		*

Since the alternation constitutes a fortition rather than a lenition, we must appeal to a perceptually based markedness constraint rather than a *Effort constraint.

The foregoing analysis, relying on approximants’ poverty of manner cues in /V__‖ position, raises the question of why approximants are not similarly banned in the mirror-image context, /‖__V. Our answer relies upon a possible asymmetry in the perception of cues in a stimulus onset vs. offset. Wright, Frisch, and Pisoni (1999) summarize evidence that the mammalian auditory system is significantly more sensitive to cues which occur in quiet to loud transitions (i.e. signal onset) than in loud to quiet transitions (signal offset), for the timescale and amplitude range characteristic of syllables of speech. If this auditory response asymmetry is indeed maintained at higher levels of perceptual processing, then cues occuring in a CV transition will be more perceptually salient than cues in a VC transition, given that vowels are, by definition, louder than the adjacent consonants, as schematized in (23) (after Silverman 1995).

(23)



Silverman 1995 hypothesizes that this auditory asymmetry, together with the aerodynamic asymmetry between obstruent constriction and release, lie behind the putative onset/coda asymmetry of Jakobsonian syllable typology (cf. Prince and Smolensky 1993, ch. 6).

We can now motivate the following rankings: for any consonant C, Max(C)/__V » Max(C)/V__ (modulo consonants containing particular place or phonation contrasts whose cues are located principally in the VC transition, such as [ŋ], as discussed in §4.5). And for any context-sensitive perceptually based markedness constraint, *C/V__ »

*C/__V. Applying these ranking schemas to the distribution of approximants in UNT, we can account for the phonotactic asymmetry between pre-vocalic and post-vocalic approximants simply by ranking Max(glide)/V__V » Max(glide)/__V » *Effort(glide) » Max(glide), and *approximant/V__ » Max(approximant) » *approximant:

(24)

	/ja:stá/	Max(glide)/__V	*Effort(glide)
☞	ja:st̰á		*
	a:st̰á	*!	

	/li:ʃkúli/	Max(approx.)	*approx.
☞	li:ʃkúli		*
	ɬi:ʃkúli	*!	

Finally, note that the UNT ban on final approximants poses serious problems for sonority-based approach to phonotactics, such as Zec 1988, which explicitly claims that the occurrence of a consonant in coda position in a given language implies the occurrence of coda consonants of higher sonority. In UNT, we see that final (coda) nasals, but not higher-sonority approximants, are permitted. This pattern is unproblematic, however, in the cue-based approach, wherein the ban on approximants in this position is attributable to the weakness of their manner cues.

5.2. Stop or nasal + strident fricative

For word-final {nasal or stop} + strident clusters, our account is simply the mirror-image of our account of initial strident + C clusters, combined with our analysis above of the ban on post-vocalic approximants. The strident energy of these fricatives, and the spectral properties of this energy, provides sufficient manner and place cues for recovery of the fricative, notwithstanding the absence of formant transitions from an adjacent vowel.

(25)

		Max(S)/non-fric.__‖	*Effort(obstruent)	Max(C)/C__‖
☞	lapɬ □ lapɬ		**	
	lapɬ □ lap	*!	*	*
	lapk □ lapk		**!	
☞	lapk □ lap		*	*
	lasɬ □ lasɬ		**!	
☞	lasɬ □ las		*	*

As for approximant + fricative clusters, the tableaux in §5.3 above, which account for the ban on approximants in post-vocalic, pre-pausal position, likewise apply to post-vocalic, pre-obstruent position. The perceptual vulnerability of approximants in both cases lies in the absence of following formant transitions. The only further wrinkle concerns /l/, which does not fortify in this context, but rather is banned tout court. As the [ɬ] is not word-final following a non-fricative, the high-ranked Max(S)/non-fric.__‖ in tableau (25) does not apply, and so either the [ɬ] or the following obstruent would have to drop, due to *Effort(obstruent) » Max(C)/C__‖: in either case, a final [ɬ] + obstruent cluster is ruled out.

6. Analysis: word-medial clusters

6.1. Ban on word-medial [ŋ]

Any single consonant can occur intervocalically except for the velar nasal [ŋ]. The absence of the intervocalic velar nasal can be diachronically accounted for from its development as a dorsal allophone of /n/ before velars and uvulars in Proto-Northern Totonac, with a subsequent q > ʔ sound change (see §4.4). Later, [ʔ] deleted in /C__C or /C__‖ position, resulting in ŋʔ > ŋ, thus giving rise to an [ŋ] phoneme. In pre-vocalic position, however, [ŋʔ] remained unchanged. The deletion of glottal stop in /C__C or /C__‖ position, but not /__V position, can be attributed to a high ranked constraint: Max(ʔ)/{__V,V__} (don't delete [ʔ] adjacent to a vowel) » *Effort(ʔ) » Max(ʔ).

(26)

		Max(ʔ)/{__V,V__}	*Effort(ʔ)	Max(ʔ)
☞	a̱ʔtsaŋʔáː ~ a̱ʔtsaŋʔáː		**	
	a̱ʔtsaŋʔáː ~ a̱ʔtsaŋáː	*!	*	*
☞	ʃáŋʔka ~ ʃáŋka			*
	ʃáŋʔka ~ ʃáŋʔka		*!	
☞	ɬamáŋʔ ~ ɬamáŋ			*
	ɬamáŋʔ ~ ɬamáŋʔ		*!	

We regard the synchronic absence of intervocalic [ŋ] as an accidental gap. From a cue-based perspective, any place contrast licensed in /__V position should, a fortiori, be licensed in /V__V position, because the latter provides a superset of the cues of the former. The absence of the word-initial [ŋ] is discussed in §4.4 above.

6.2. C + C clusters

The fact that most consonants can occur as either member of a C + C cluster follows from elements of our word-initial and word-final analysis. Specifically, the occurrence of all consonants (other than [ŋ] for diachronic reasons) in /__V position follows from the general ranking schema Max(C)/__V » *Effort(C). The occurrence of obstruents and nasals in /V__C position follows from tableau (20) and surrounding discussion, with the additional inference that their cues in this context are no weaker than in /V__‖ position. The absence of glides and [l] is similarly accounted for in tableaux (21-22) and surrounding text.

6.3. (ʔ +) C + C + C clusters

In word-medial position, an obstruent or a nasal can be followed by any cluster permitted in word-initial position. The occurrence of an obstruent in C_1 position follows

from §6.2.[12] As for the $C_2 + C_3$ members of these clusters, they are prevocalic; therefore, by the same reasoning that permits them word-initially (see §4), they are also licensed word-medially, since the latter context provides a superset of the cues in word-initial position.

The only instance of a quadruple cluster is [pa̱ʔɬtʃa̱] 'tomato'. There is good acoustic reason for [ʔ], but not other consonants, to be licensed in this position: for [ʔ] is transparent to the formant transitions from the preceding vowel into the following consonant. We can capture the licensing of [ʔ] by modifying tableau (20) as follows:

(27)

/ pa̱ʔɬtʃa̱/	Max(obstruent)/V(ʔ)__	*Effort(obstruent)
☞ pa̱ʔɬtʃa̱		****
pa̱ʔtʃa̱	*!	***

7. Conclusion

UNT has been shown to pose a problem for sonority-based approaches to phonotactics. Within sonority-based approaches, the occurrence of word-initial S + stop clusters, and word-final C + S clusters., necessitate further stipulations; however, Licensing by Cue accounts for these clusters in terms of the strident fricatives' salient internal cues, and thus the strident does not require a following approximant or vowel to provide transitional cues.

A further problem for sonority-based approaches which we identify concerns the absence of coda glides and [l] in UNT, while lower sonority consonants are permitted. According to most sonority-based theories of syllabification, high-sonority consonants are preferred in coda position. In our cue-based approach, however, their absence can be accounted for in terms of the weakness of the glides' manner cues post-vocalically, in the absence of a following glide.

Finally, the foregoing analysis demonstrates that it is indeed possible to provide a principled and elegant account of the phonotactics of a particular language, without reference to syllable divisions, or to sub-syllabic structure such as onset position, and mora assignment.

[12] Note that our analysis also permits [ɾ] + $C_2 + C_3$ clusters, though these are not attested in the database. It is unclear whether this poses a problem for our analysis, or whether this gap is accidental, due to the general marginal status of [ɾ] in UNT.

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