Constraints on onsets and codas of words and phrases[1]

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Abstract
For any phonotactic restriction on syllable onsets and codas, it can be shown that parallel restrictions are attested at edges of each higher prosodic domain. Onsets can be required at the beginnings of syllables, words, or utterances; codas can be banned at the ends of any of these constituents; and so on. This paper argues that these restrictions follow from constraint schemata: any markedness constraint on syllable onsets or codas (M_{Ons} or M_{Coda}) is part of a family of constraints (M_{Ons}(Onset/PCat) or M_{Coda}(Coda/PCat)) imposing parallel restrictions on initial onsets or final codas of each prosodic domain. These prosodic domain-edge markedness constraints can induce epenthesis, deletion, or other segmental changes at domain edges; they can also shape words' prosodic structures.

1. Phonotactic restrictions on prosodic domain edges

The set of segments occurring in word-initial onsets or word-final codas is often different from those occurring in medial onsets and codas. Some languages allow more segments and structures in intial onsets or final codas than in word-internal ones. Word-initial syllables in Axininca Campa may either have onsets or be onsetless, but onsets are required in all non-initial syllables (McCarthy and Prince, 1993b, Payne, 1981). Similarly in Kamaiurá, codas are permitted only in word-final syllables (Everett and Seki, 1985, McCarthy and Prince, 1986/1996). The opposite pattern, where a word-edge inventory is a subset of the medial inventory, is also attested. Initial syllables in Madi must have onsets while medial syllables may have onsets or be onsetless (Tucker, 1967); in Chamicuro, codas are banned in word-final syllables but may occur nonfinally (Parker, 2001: 365-6).

Instances of the first sort of restrictions – superset inventories at word edges – are often discussed in the literature; analyses of these patterns typically involve either extraprosodicity or

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positional faithfulness. This paper will focus on cases of the second sort, where the inventory of segments or structures in the initial onsets or final codas of a word or larger prosodic domain is a subset of those in domain-medial onsets or codas.

The typology of these subset-at-edge restrictions leads to the central descriptive claim of this paper: any markedness restriction which can be imposed on syllable onsets or codas can also be imposed on initial onsets or final codas of any larger prosodic domain as well. All prosodic domains can be subject to the same edge restrictions. Onsets, for example, can be required at the left edge of any prosodic domain. In Klamath, all syllables must have onsets (Blevins, 1995). Onsets are required only word-initially in Madi (Tucker, 1967), and in Selayarese, only utterance-initial syllables must have onsets: hiatus is tolerated within words, and words may begin with vowels, but glottal stops are epenthesized before word-initial vowels when they fall in utterance-initial position (Mithun and Basri, 1986: 242). The set of possible utterance-initial onsets in Selayarese is thus a subset of the possible utterance-medial onsets.

Domain-edge inventories can be restricted to subsets of medial inventories in other ways as well. Marked onsets like [ŋ] can be banned from all syllables (Mongolian; Poppe, 1970), from only word-initial syllables (Yamphu; Rutgers, 1998: 33), or from only utterance-initial syllables (Kunwinjku; Evans, 2003: 94-5). Similarly, Mascaró and Wetzels (2001) demonstrate that voiced obstruents can devoice at the ends of syllables, words, or other domains; codas can also be banned in all syllables, or in word-final, phrase-final, or utterance-final syllables.

In order to show that an Optimality Theoretic grammar (Prince and Smolensky, 1993/2004) can capture these parallel restrictions, two questions must be addressed. First, which constraints must be present in the universal constraint inventory CON in order to account for the restrictions? Positional markedness provides a ready answer, allowing markedness constraints to be relativized to positions where particularly strict restrictions apply. ONSET, which requires

onsets of all syllables, can in this way target specifically word-initial syllables (ONSET/Word), utterance-initial syllables (ONSET/Utterance), and so on.

Positional markedness alone, however, offers no explanation for the parallels among domain-edge markedness restrictions. It imposes no inherent requirement that parallel position-specific versions of ONSET, for example, must target initial onsets of each prosodic domain. In order to account for this parallelism, this paper argues that CON must contain domain-edge markedness constraint schemata in which each onset or coda requirement targets the initial onset or final coda of each prosodic domain: ONSET is necessarily part of a family of constraints which penalize initial onsetless syllables in each prosodic domain (ONSET/σ, ONSET/Word, ONSET/Utterance, etc.).

The paper is structured as follows. Section two describes the proposed constraint schemata and outlines the predictions of this theory. Section three presents typological evidence demonstrating that the markedness parallels among domain edges predicted by these constraint schemata are attested. Section four turns to the factorial typology predicted by these constraints, focusing on cases where edge inventories are not subsets of medial inventories. In one case, an attested class of superset-at-edge patterns is predicted by the interaction of domain-edge markedness constraints with positional faithfulness. Prosodic strict layering may also be violated; this also correctly predicts exceptions to the subset-at-edge generalization.

2. Domain-edge markedness constraints

If markedness restrictions on syllable onsets and codas are paralleled by corresponding restrictions on initial onsets and final codas of larger prosodic domains, the universal OT constraint inventory CON should contain structure of the following kind: any markedness constraint on syllable onsets or codas is part of a family of constraints, defined by constraint schemata, which impose the same restriction on the initial onsets or final codas of each prosodic

domain. This proposal builds on the insights of Selkirk (1995) and Truckenbrodt (1999), among others, who have observed that the edges of prosodic domains behave in fundamentally similar ways and who have thus proposed constraint schemata which refer to these domain edges in unified ways.

This section will propose domain-edge markedness constraint schemata of this type. The generalized form of the schemata is described in section 2.1, along with a discussion of the domain-edge positions targeted by these constraints. The specific families of constraints predicted by the schemata are then explored in section 2.2.

2.1 Schemata for domain-edge markedness constraints

The constraint schemata in (1) define constraints of the general form M_{Onset}(Onset/PCat) and M_{Coda}(Coda/PCat). These schemata generate families of constraints on prosodic domain-initial onsets and domain-final codas which, together, impose parallel markedness restrictions (M_{Onset} and M_{Coda}) on the edges of each prosodic domain (PCat) as in (2). The ranking among constraints in these schemata is free, rather than fixed, as will be shown in section 4.3.1.

(1) Domain-edge markedness constraint schemata

a. M_{Onset}(Onset/PCat) Where M_{Onset} is some markedness constraint which targets onsets, and PCat is some prosodic domain, assign one violation for each instance of PCat whose leftmost onset violates M_{Onset}.

b. M_{Coda}(Coda/PCat) Where M_{Coda} is some markedness constraint which targets codas, and PCat is some prosodic domain, assign one violation for each instance of PCat whose rightmost coda violates M_{Coda}.

(2) Constraint types generated by domain-edge markedness schemata

a. M_{Ons}(Onset/Utt) M_{Ons}(Onset/Phr) M_{Ons}(Onset/Word) M_{Ons}(Onset/σ)

b. M_{Coda}(Coda/Utt) M_{Coda}(Coda/Phr) M_{Coda}(Coda/Word) M_{Coda}(Coda/σ)

This paper will focus on the prosodic domains syllable, word, phrase, and utterance. The proposal, however, claims that the edge restrictions discussed here hold at the edges of all domains, including feet and the various phrasal domains between word and utterance (e.g. clitic groups, major and minor phrases, intonational phrases). This discussion sets feet aside, as purely foot-oriented phonotactic restrictions are extremely difficult to distinguish from stress-based phonotactic restrictions (see Smith 2002: 97-115 for discussion). The phrase-edge restrictions discussed here could presumably be more accurately characterized as holding at edges of major phrases, intonational phrases, etc. However, as phonotactic descriptions typically don't provide sufficient evidence to make these distinctions, this discussion makes no such specific claims. The constraint schemata by definition include constraints on the edges of each existing prosodic level; additional descriptive work is predicted to reveal these phonotactic distinctions.

If parallel markedness restrictions can hold on initial onsets or final codas of any prosodic domain, the constraint schemata responsible for these restrictions must refer to domain-initial onsets and domain-final codas. The schemata above use 'Onset/PCat' and 'Coda/PCat' to refer to these classes of positions; these terms are explicitly defined in (3). 'Onset of a prosodic domain' (Onset/PCat) is defined with respect to the initial (leftmost) syllable in that domain. In this sense, the onset of a prosodic word is the onset, if any, of the prosodic word-initial syllable, (assuming that this onset is not extrametrical, but falls within the prosodic word). Examples of the onsets of various domains are given in (4). Similarly, the coda of a word is the (prosodic word-internal) coda, if any, of the word-final syllable.

(3) a. Onset/PCat The onset of the leftmost syllable of PCat.

Where PCat is some prosodic domain, all consonants in PCat which belong to the leftmost syllable of PCat and which precede that syllable's head.

b. Coda/PCat The coda of the rightmost syllable of PCat.

Where PCat is some prosodic domain, all consonants in PCat which belong to the rightmost syllable of PCat and which follow that syllable's head.

(4) a. Onset/σ All consonants in a syllable which (belong to the leftmost syllable of the syllable and) precede the syllable's head.[2]

b. Onset/Word All consonants in a word which belong to the leftmost syllable of the word and precede that (leftmost) syllable's head.

c. Onset/Utterance All consonants in a utterance which belong to the leftmost syllable of the utterance and precede that (leftmost) syllable's head.

The constraint schemata proposed here refer to onsets and codas of prosodic domains in imposing parallel restrictions on domain-initial onsets and domain-final codas. The suggestion that constraints treat these positions similarly should not, however, be taken as an argument that these positions have any sort of novel representational structure. This discussion assumes standard prosodic structures in which onset segments are dominated by syllables, syllables are dominated by prosodic words, and so on.[3] Because domain-edge markedness constraints refer to domain-initial onsets and domain-final codas, these categories emerge from traditional structures.

2.2 Predicted constraints

By definition, domain-edge markedness constraint schemata impose all attested syllable onset and coda restrictions on the initial onsets and final codas of all other prosodic domains as well. Thus this section will survey a variety of restrictions on syllable onsets and codas in order to identify predicted sets of domain-edge markedness constraints.

[2] The "leftmost syllable of a syllable" is the syllable itself, given proper containment. Thus the initial onset of a syllable (Onset/σ) is simply the familiar syllable onset.

[3] Prosodic structures violating prosodic strict layering are considered in section 4.3.

Considering first familiar restrictions on syllable onsets, languages often require all syllables to have onsets; this ban on onsetless syllables holds in Cairene Arabic, Sedang, and Klamath, among others (Blevins, 1995). This requirement is enforced by the markedness constraint ONSET: 'Each syllable must have an onset.' The M_{Onset}(Onset/PCat) schema in (5) predicts parallel constraints requiring initial onsets in all prosodic domains, as in (6).

(5) ONSET/PCat (EXIST(Onset/PCat)) — Where PCat is some prosodic domain, assign one violation for each instance of PCat which lacks an onset.

'PCat must have an (initial) onset.'

(6) ONSET/Utterance ONSET/Phrase ONSET/Word ONSET/σ

Languages may also block particular segments from occurring in onset position; these marked onsets include [h], [ʔ], and [ŋ].[4] In Macushi (Abbott, 1991), for example, the restriction on syllable onset [h] can induce metathesis. As shown in (7), [h] metathesizes with [i] or [u] where [h] would otherwise be syllabified as an onset in a morphologically complex word. Syllable onset [h] is also banned in Chamicuro (Parker, 2001) and Wiyot (Teeter, 1964). Similarly, [ʔ] and [ŋ] are banned in all syllable onsets in the languages listed in (8) and (9).

(7) Macushi

/koneka-sah-i-ja/ → [ko.ne.ka.sa.ih.ja] 'he made it'
*[ko.ne.ka.sa.hi.ja]

/kuh-toh-u-ja/ → [kuh.to.uh.ja] 'what I did'
*[kuh.to.hu.ja]

(8) [ʔ] in codas; *[ʔ] in onsets
Balantak (Broselow, 2003: 187, Busenitz and Busenitz, 1991)
Chamicuro, Tiriyó (Parker, 2001: 362)
Finnish (Branch, 1987: 597)
Many Northern Australian languages: Gamu, Gunwinjgu, Jawoyn, Manggarrayi, Ngalakan, Ngandi, Rembarrnga, Wagiman, Warray, Yolngu (Harvey, 1991: 224)

[4] Throughout this paper, languages are described as lacking some segment *x* in a particular prosodic position if *x* is completely absent from the position; or if *x* appears in that position only in non-native words, or only in interjections, ideophones, or function words; or if there is a productive process of dropping *x* from that position.

(9) [ŋ] in codas; *[ŋ] in onsets
Doyayo (Wiering and Wiering, 1986)
Lower Grand Valley Dani (Bromley, 1961)
Mixe (Van Haitsma and Van Haitsma, 1976: 16)
Mongolian (Poppe, 1970)
Mundang (Elders, 2000)

These restrictions on marked syllable onsets can be captured by constraints of the general form *X(Onset/σ); again, the M_{Onset}(Onset/PCat) schema predicts that each such constraint should belong to a family of parallel constraints banning that marked onset initially in all prosodic domains. The general form of *X(Onset/PCat) constraints is given in (10), and the predicted constraints of this form are given in (11).

(10) *X(Onset/PCat) Where X is some segment or (set of) segment(s) and PCat is some prosodic domain, assign one violation for each instance of X in an onset of PCat.

'X cannot be the (leftmost) onset of PCat.'

(11) *h(Onset/Utterance) *h(Onset/Phrase) *h(Onset/Word) *h(Onset/σ)
*ʔ(Onset/Utterance) *ʔ(Onset/Phrase) *ʔ(Onset/Word) *ʔ(Onset/σ)
*ŋ(Onset/Utterance) *ŋ(Onset/Phrase) *ŋ(Onset/Word) *ŋ(Onset/σ)

Turning to syllable codas, languages like Mazateco (Pike and Pike, 1947) and Cayuvava (Blevins, 1995), among others, ban codas in all syllables (NoCoda), and languages like Italian restrict the size of codas to only a single segment (*ComplexCoda). Particular segments may also be marked in coda position: voiced obstruent codas are consistently devoiced in German (*VoiObsCoda). Japanese severely restricts the place and manner of coda segments, allowing only geminates and nasals homorganic with following onsets; this is frequently accounted for within OT under the cover constraint CodaCond (Ito and Mester, 1994). The domain-edge markedness constraint schemata associated with these restrictions are defined in (12) and (14). Each schema gives rise to a set of constraints imposing the restriction on the final coda of each prosodic domain, as in the NoCoda example in (13).

(12) NoCoda/PCat (No(Coda/PCat)) Where PCat is some prosodic domain, assign one violation for each instance of PCat which has a coda.

'PCat cannot have a (final) coda.'

(13) NoCoda/Utterance NoCoda/Phrase NoCoda/Word NoCoda/σ

(14) *X(Coda/PCat) Where X is some segment or (set of) feature(s) and PCat is some prosodic domain, assign one violation for each instance of X in a coda of PCat.

'X cannot be the (final) coda of PCat.'

➔ *Complex(Coda/PCat)
*VoiObs(Coda/PCat)
CodaCond(Coda/PCat)

3. Phonotactic parallels across prosodic domains

Each of the syllable onset and coda restrictions mentioned in section 2.2 can also target initial onsets or final codas of any larger prosodic domain. That is, each restriction which can be imposed on all of a language's onsets can be imposed on only word-initial onsets in another language, only phrase-initial onsets in a third, and only utterance-initial onsets in a fourth. Similar cross-linguistic, cross-domain parallels are found for coda restrictions. Crucially, as long as strict layering is obeyed, the positions targeted by e.g. word-edge restrictions are a subset of those targeted by syllable-edge restrictions: if onsets are required in all Klamath syllables, then of course initial syllables in Klamath words, phrases, and utterances will be among those which must have onsets. In languages where a phonotactic restriction targets only word edges, however, medial syllables may either have onsets or be onsetless, creating a subset-at-edge phonotactic pattern. This section will present data illustrating restrictions on the onsets and codas of words, phrases, and utterances which parallel each syllable-edge restriction described above. Section 4 will then explore the factorial typology of these constraints, demonstrating that constraints in

each schema are freely rankable, and that we can correctly predict their effects in languages where strict layering is violated or where positional faithfulness is highly ranked.

3.1 Prosodic word edge restrictions

As Bell (1971), McCarthy (1998), and Smith (2002: 126-31), among others, have observed, languages can tolerate onsetless syllables in word-medial position (that is, they can allow medial hiatus) while requiring all word-initial syllables to have onsets. Examples of languages requiring word-initial onsets are listed in (15); this pattern is predicted by, and so provides evidence for, the domain-edge markedness constraint ONSET/Word.

(15) Onsets are required of (all and only) word-initial syllables[5]
Bininj Gun-Wok (Evans, 2003: 94-5)
Guaranî (Gregores and Suarez, 1967)
Guhang Ifugao (Newell, 1956: 536)
Hausa (Greenberg, 1941)
Leti (Engelenhoven, 2004)
Madi (Tucker, 1967)
Northwest River Montagnais (Clarke, 1982)
Wiyot (Teeter, 1964)
Woleaian (Sohn, 1975)
See also many examples in Bell (1971: 36)

Given an underlyingly vowel-initial word, the languages in (15) prevent words from surfacing with onsetless initial syllables in various ways. While most languages epenthesize [ʔ] before word-initial vowels, other processes are also attested. In Madi (Tucker, 1967: 107), underlyingly vowel-initial words can surface with initial epenthetic [h], as in [ini] ~ [hini] 'black'.[6] Glides are epenthesized before underlying initial vowels in Woleaian (Sohn, 1975: 33-4), and initial short vowels in Northwest River Montagnais (Clarke, 1982) are deleted.

[5] Conversely, there are a number of languages in which marked onsets or onsetless syllables are tolerated only word-initially (see e.g. Beckman, 1999), or in which codas are tolerated only word-finally (see e.g. Broselow, 2003). These patterns are predicted given positional faithfulness to word edges, as discussed in section 4.2.

[6] Those consonants epenthesized at the beginning of vowel-initial words are also sometimes banned word-initially. See Gouskova (2003: 191) for a similar observation about schwa: it is both marked and prone to deletion and also unmarked and optimal for epenthesis.

The marked onset segments [ŋ], [h], and [ʔ] may also be banned in strictly word-initial onsets while surfacing in medial onsets (and often in codas as well). These word-initial marked onset restrictions, described below, motivate the constraints *ŋ(Onset/Word), *ʔ(Onset/Word), and *h(Onset/Word). First, languages in which word-initial [ŋ] is banned are listed in (16).

(16) [ŋ] in codas, medial onsets; *[ŋ] in word-initial onsets
Gumbaiŋgar (Smythe, 1948: 7)
Ijo (Williamson, 1969)
Koɳḍa (Krishnamurti and Benham, 1998: 243)
Sri Lankan Portuguese Creole (Hume and Tserdanelis, 2002: 445)
Tümpisa Shoshone (Dayley, 1989: 388)
Wori (Hagège, 1967: 25)
Yamphu (Rutgers, 1998: 33)

In a number of these languages, underlying word-initial /ŋ/ can surface as [n]. In Yamphu, "[t]he velar nasal /ŋ/ occurs in word-initial position only in a small number of words, especially in the speech of elderly people. In word-initial position, the velar nasal may always be replaced with the apico-alveolar nasal /n/." (Rutgers, 1998: 33) Words with this variation between underlying initial [ŋ] and [n] in (17a) contrast with the invariant underlyingly /n/-initial words in (17b); [ŋ] does not alternate with [n] when it occurs in non-word-initial position, as in (17c).

(17) Yamphu

a.	ŋa	~	na	'fish'	c.	nindaŋa	*nindana	'head'
	ŋa:kma	~	na:kma	'to request'		parleŋ	*parlen	'tale'
						cwæŋdoʔ	*cwændoʔ	'sizzling'
b.	neʔma		*ŋeʔma	'to count'				
	nitci		*ŋitci	'two'				

Like [ŋ], [ʔ] and [h] can be permitted in medial onsets (and often in codas as well) but banned in word-initial onsets, as shown in (18).

(18) a. [ʔ] in medial onsets; *[ʔ] in word-initial onsets
Barua (Lloyd and Healey, 1970: 11)
Djinang and Djinba (Waters, 1989)
Feʔfeʔ Bamileke (Hyman, 1978)
Koɳɖa (Krishnamurti and Benham, 1998: 243)
Nahuatl (Sullivan, 1988)
Timugon Murut (Prentice, 1971)
Western Shoshoni (Crum and Dayley, 1993: 233)

b. [h] in medial onsets, codas; *[h] in word-initial onsets
Carib (Peasgood, 1972: 36)
Sierra Nahuat (Key and Key, 1953: 54)
Ura (Crowley, 1998: 4)

To demonstrate conclusively that languages can allow [ŋ], [ʔ], and [h] in medial onsets while banning them word-initially, these segments must occur in medial positions which are unambiguously onsets, such as the final position of an intervocalic consonant cluster. Evidence for the prosodic position of medial glottal stop is found in Koɳɖa, where [ʔ] is banned word-initially. Medial [ʔ] can occur at the end of an intervocalic sequence of consonants as in (19a); this is canonically an onset, rather than coda or ambisyllabic, position. Similarly in Gumbaiŋgar, [ŋ] occurs freely word-medially but can be dropped from word-initial onsets. As in Koɳɖa, medial [ŋ] can be the second of two non-homorganic intervocalic consonants as in (19b), indicating that it too is an onset rather than ambisyllabic.

(19) a. Koɳɖa

ɖi̯g.ʔa	‘get off’
do̰ṛk.ʔi.ŋa	‘is found’
panz.ʔiŋ	‘because’

b. Gumbaiŋgar

bal.ŋan	‘gristle, sinew, cartilage’
djil.ŋu:jn.ga	‘Australian cedar’
mu.ɭu:r.ŋa.ɾin	‘bloodshot’

Coda restrictions can also exclusively target word-final codas. Broselow (2003) discusses a number of languages which allow medial codas to surface freely, licensing their own place and voicing features, but ban codas in word-final syllables. This occurs in Chamicuro (Parker, 2001: 365-6), Italian and Telugu (Harris and Gussmann, 1998), and many Australian languages (Dixon, 2002: 644-8, Hamilton, 1996: 228), providing evidence for NoCoda/Word. Marked coda

segments may also be banned exclusively word-finally. Word-final obstruents are devoiced in languages including Russian, Polish, Walloon, and Mideastern (Polish) Yiddish. This restriction is discussed in detail by Mascaró and Wetzels (2001), and can be enforced by the constraint *VOIOBS(Coda/Word).

Further restrictions on the place and manner of word-final codas similar to the restrictions on syllable codas in Japanese motivate the constraint CODACOND/Word. In Garawa (Furby, 1974, Hamilton, 1996: 257) [ʈ c n ɳ ɲ l ɭ ɾ] may occur in medial codas as the first members of heterorganic clusters like [ʈ.c], [c.p], [n.k], [ɳ.m], [ɲ.p] [l.w], [ɭ.w], and [ɾ.ŋ]. Word-finally, however, only [n l ɭ ɾ] may occur. Word-final codas thus ban low-sonority stops (*[ʈ], *[c]) and also restrict the place of nasals ([n], *[ɳ], *[ɲ]).

Finally, languages can allow complex medial codas while limiting the size of final codas to only a single consonant, providing evidence for the predicted constraint *COMPLEX(Coda/Word). In Dongolese Nubian (Armbruster, 1960: 43, 48-9), complex medial codas are attested as in (20a), while underlying word-final codas are simplified via [ɪ] epenthesis as in (20b).

(20) Dongolese Nubian

a.	mat.bahn.tu:r	'inside the kitchen'	b.	/ɟins/	→ [ɟin.sɪ] ~ [ɟi.nɪs]	'sort, kind'
	diɟm.ba:.dɪr	'after five'		/bɛr-k/	→ [bɛr.kɪ]	'(the) wood (obj.)'
	wɛln.di	'canine'		/to:g-n/	→ [to:.gɪn]	'she strikes'

3.2 Phrase edge restrictions

The preceding discussion has demonstrated a number of parallels between markedness restrictions targeting syllable onsets and codas and those targeting word-initial onsets and word-final codas. These parallel restrictions offer support for the theory proposed here – that every markedness constraint on syllable onsets or codas belongs to a domain-edge markedness constraint schema imposing the same restriction on initial onsets or final codas of all prosodic

domains. As this hypothesis is argued to hold for all prosodic domains, the following sections examine evidence for additional parallels among prosodic domain edges above the word level.

The typology of these larger prosodic domains is more difficult to examine, primarily because most language descriptions are concerned with word phonology. As a result, there are very few reports of phonotactic restrictions in domains larger than the word. This section and the next examine some of the reported restrictions on phrase and utterance edges, demonstrating that these parallel the attested restrictions on syllable and word edges.

Wiltshire (2003: 258-60) observes that a ban on phrase-final codas in Leti is similar to more common bans on word-final and syllable-final codas. Leti codas are banned only phrase-finally (Engelenhoven, 2004, Hume, 1998), motivating the constraint NoCoda/Phrase. Consonants at the ends of phonological phrases (described by Hume as being roughly equivalent to major syntactic XPs) metathesize with preceding vowels. Syllables and words may thus end in consonants, but phrases may not; examples of this are shown in (21).

(21)	Leti				
		/…urun mɔa]$_{Phr}$ /	→	[…urun mɔa]$_{Phr}$]	‘Moanese breadfruit’
		/…urun]$_{Phr}$ /	→	[…urnu]$_{Phr}$]	‘beautiful’
		/…mɛsar lavna]$_{Phr}$ /	→	[…mɛsar lavna]$_{Phr}$]	‘teacher, big’
		/…mɛsar]$_{Phr}$ /	→	[…mɛsra]$_{Phr}$]	‘teacher’

Marked coda segments may also be banned only phrase-finally. In the variety of Yiddish described by Birnbaum (1979: 211), voiced obstruents are devoiced phrase-finally, when they are “followed by a break in speaking, even a short one, and, of course, at the end of a sentence” (p. 211); (22) illustrates. Note that underlyingly voiced obstruents which are word-final but not phrase-final, like the [z] in [er iz miit, bin ex…], remain voiced. This pattern provides evidence for *VoiObs(Coda/Phrase).

(22)	Yiddish				
		/my meig, ober…/	→	[my meik, ober]	‘one may – but…’
		/zaan vaab, demlt…/	→	[zaan vaap, demlt…]	‘his wife, at that time…’
		/er iz miid, bin ex…/	→	[er iz miit, bin ex…]	‘he is tired, so I…’
		/di maaz, er vet…/	→	[di maas, er vet…]	‘the mice, he will…’

Finally, Koromfe restricts the place and manner of phrase-final coda segments. "Phrase-medially, word-final consonants can occur freely; in phrase-final position only the consonants [m,n,ŋ,l] are permitted; after all other consonants an 'epenthetic' vowel must be 'inserted'." (Rennison, 1997: 422) These place and manner restrictions support the proposed constraint CODACOND/Phrase.

These correspondences between phrase edges, word edges, and syllable edges lend support to the claim that all prosodic domain edges are subject to parallel restrictions. While only a subset of the attested syllable-edge restrictions have phrase-edge parallels (notably, there are no known reports of restrictions on phrase-initial onsets), this is most likely a consequence of the fact that such restrictions are simply rarely observed or described.

3.3 Utterance edge restrictions

Finally, languages can impose onset and coda restrictions on only utterance-initial or utterance-final syllables. A number of languages, including those in (23), require only utterance-initial syllables to have onsets, tolerating hiatus within words and across word and phrase boundaries.

(23) <u>All utterance-initial syllables have onsets</u>
Anejom̃ (Lynch, 2000)
Hawaiian (Elbert and Pukui, 1979: 10)
Koya (Tyler, 1969)
Kunjen (Sommer, 1969: 28)
Lango (Noonan, 1992)
Menomini (Bloomfield, 1962: 3)
Sanuma (Borgman, 1990: 223)
Selayarese (Mithun and Basri, 1986: 242)
Tuvalu (Milner, 1958: 370)

This requirement for utterance-initial onsets (ONSET/Utterance), like the requirement for word-initial onsets, can be satisfied in a variety of ways. In Selayarese, [ʔ] is epenthesized before vowel-initial words only when they occur in isolation or otherwise in utterance-initial position, as in (24) (Mithun and Basri, 1986: 242). The requirement that utterances have initial onsets can

also be satisfied via initial epenthesis of [h], as in Menomini, or of a homorganic glide, as in Koya. In Kunjen, utterance-initial vowels are deleted.

(24)	Selayarese	[$_{Utt}$ ʔa:pa]	‘what?’
		[$_{Utt}$ ʔinn̄]	‘this’
		[$_{Utt}$ ʔa:pa inn̄] *[$_{Utt}$ ʔa:pa ʔinn̄]	‘what is this?’

Like these restrictions on onsetless syllables, restrictions on marked onsets can also hold in only utterance-initial position; these patterns are predicted by, and so motivate, the constraints *ʔ(Onset/Utterance), *h(Onset/Utterance), *ŋ(Onset/Utterance). In Kaiwa, for example, [ʔ] is reportedly licensed word-medially and initially, but banned in strictly utterance-initial position (Bridgeman, 1961: 332). West and Welch (1967: 14) similarly describe the distribution of [h] in Tucano as failing to appear only utterance-initially.

Onset [ŋ] is dispreferred utterance-initially in the Kunwinjku dialect of Bininj Gun-Wok. Evans (2003: 94-5) observes that word-initial [ŋ] is optionally deleted in Kunwinjku, and that this deletion occurs most frequently in utterance-initial position: there are “[a] large number of words which freely drop the initial *ŋ* found in their cognates in other dialects, *particularly when coming at the beginning of a breath group*” (p. 94; emphasis added). This appears to be a case of [ŋ] deletion, rather than epenthesis, as the [ŋ]-initial pronunciations are generally preferred: “I have heard Kunwinjku speakers also make this vowel-initial pronunciation, but then correct my repetitions by restoring the *ŋ*-. They also standardise toward the *ŋ*-initial spelling when writing in Kunwinjku.” (p. 94)

(25)	Kunwinjku	ŋanabbaru	~	anabbaru	‘buffalo’
		ŋokko	~	okko	‘already’
		ŋuniwam	~	uniwam	‘you two went’

Turning to the ends of utterances, codas may be banned in only utterance-final syllables (NoCoda/Utterance). Utterance-final consonants are deleted in Western Shoshoni (Crum and Dayley, 1993: 235, 248); they are followed by epenthetic vowels in Arrernte (Tabain et al., 2004:

178) and Sardinian (Ferrer, 1994: 43). Examples of utterance-final pronunciations of otherwise consonant-final Sardinian words are given in (26).

(26) Sardinian *medas* [mɛðaza] *sun* [suni]
fit [fiði] *fut* [fuði]

3.4 Summary

This section has shown that any markedness restriction which can target syllable onsets or codas can also target strictly the initial onsets or final codas of any larger prosodic domain. That is, any restriction which one language can impose on all syllable onsets can be imposed on all and only word-initial onsets in another, on all and only phrase-initial onsets in a third, and on all and only utterance-initial onsets in a fourth; coda restrictions are similarly parallel across prosodic domains. These correspondences are summarized in the table in (27).

(27) Attested phonotactic restrictions on prosodic domains

RESTRICTION	Syllable	Word	Phrase	Utterance
ONSET(PCat)	Klamath	Madi		Selayarese
*ŋ(Onset/PCat)	Mongolian	Yamphu		Kunwinjku
*ʔ(Onset/PCat)	Balantak	Koɳḍa		Kaiwa
*h(Onset/PCat)	Macushi	Carib		Tucano
NOCODA(PCat)	Mazateco	Chamicuro	Leti	Sardinian
*COMPLEX(Coda/PCat)	Italian	Dongolese Nubian		
*VOIOBS(Coda/PCat)	German	Russian	Yiddish	
CODACOND(PCat)	Japanese	Garawa	Koromfe	

The parallels among these domain-edge markedness restrictions suggest that they are general prosodic domain phenomena, rather than strictly syllable phenomena: onset restrictions can apply to initial onsets in any domain, and coda restrictions can apply to final codas in any domain. These parallels are formally captured in the M_{Onset}(Onset/PCat) and M_{Coda}(Coda/PCat) constraint schemata, defined in section 2. The schemata generate sets of parallel constraints

imposing each onset or coda restrictions on the initial onset or final coda, respectively, of each prosodic domain (PCat). Despite relatively scarce reports of phonotactic restrictions on the edges of prosodic domains above the word, (27) shows that the parallel restrictions predicted by these schemata are attested.

The discovery of these constraint schemata enriches our understanding of the structure of prosodic domains and of OT's universal constraint inventory CON. Specifically, this shows that CON is highly structured: CON cannot contain arbitrarily different sets of constraints targeting the edges of different prosodic domains; instead, these positions are subject to parallel sets of markedness constraints.

4. Factorial typology

Because domain-edge markedness constraints assess violations based on the location of prosodic domain edges, they also interact with the constraints determining the location of those edges. There are two possible ways to avoid violating a positional markedness constraint: either the marked structure itself may change, as in the languages described so far, or else the marked element may surface in a position not targeted by the constraint. Sections 4.1 and 4.2 address situations where violations are avoided by changing the marked structures themselves; this happens when constraints demanding prosodic strict layering (Selkirk, 1995, Truckenbrodt, 1999) dominate faithfulness constraints. Section 4.1 looks at basic faithfulness constraints, and section 4.2 adds positional faithfulness constraints like FAITH/σ_1. Section 4.3 then examines cases in Banawá and Tzutujil where strict layering constraints are crucially dominated by faithfulness and ONSET/Word, allowing initial onsetless syllables to surface outside prosodic words. As a result, these are cases where morphological (though not prosodic) words avoid phonotactic subset-at-edge patterns, despite the activity of domain-edge markedness constraints. Violations of strict layering also allow Banawá to thwart the typical within-language

implicational relationship among prosodic domain edges: while words must have onsets, this restriction does not extend to utterances, as utterances may surface without initial onsets. This pattern further shows that domain-edge markedness constraints must be freely rankable. Section 4.4 finally presents a comprehensive factorial typology.

4.1 Subset-at-edge patterns: Basic faithfulness

In an OT grammar, interactions among faithfulness constraints and domain-edge markedness constraints give rise to phonotactic restrictions at various prosodic domain edges. This section illustrates these rankings using examples where the marked onset [ʔ] is banned initially in syllables, words, and utterances. Other domain-edge restrictions follow from similar rankings of the appropriate markedness and faithfulness constraints.

First, when all of the relevant faithfulness constraints (here, simply IDENT) are ranked below *ʔ(Onset/σ), the Chamicuro pattern of total avoidance of all onset [ʔ] emerges.[7]

(28) Chamicuro: No syllable onset [ʔ][8]

ʔaʔaʔ	*ʔ(Onset/Utt)	*ʔ(Onset/Wd)	*ʔ(Onset/σ)	IDENT
a. ʔa.ʔaʔ		*!	**	
b. ➔ ta.taʔ				**

Tableaux in this section follow the convention of arranging domain-edge markedness constraints such that those on larger domains dominate those on smaller domains – here, *ʔ(Onset/Utterance) » *ʔ(Onset/Word) » *ʔ(Onset/σ). This ranking, however, is not crucial. When prosodic strict layering holds, as is assumed here (that is, when the constraint

[7] Unless otherwise indicated by [ ]$_{Phrase}$ or [ ]$_{Utt}$ edges, inputs and candidates in tableaux throughout this paper are assumed to be medial in phrases and utterances.

[8] In this and other hypothetical tableaux I assume the familiar OT idea of Richness of the Base (Prince and Smolensky, 1993/2004), under which there are no restrictions on inputs; any imaginable input will have some winning output form in each language. Additionally, in these tableaux illustrating phonotactic restrictions, the winning unfaithful mappings are themselves hypothetical. That is, in (28), the crucial point is simply that onset [ʔ] does not surface faithfully; the /ʔ/ ➔ [t] mapping is hypothetical.

STRICTLAYER is ranked highly enough to be consistently obeyed; see section 4.3 for discussion), all word-initial onsets are also syllable-initial onsets. In this sort of implicational prosodic structure, *ʔ(Onset/σ) bans syllable-initial [ʔ], and also bans initial [ʔ] in words and larger domains. Generally, given strict layering, a marked onset or coda is banned at the edge of the smallest prosodic domain targeted by a domain-edge markedness constraint which dominates relevant faithfulness constraints, and also at edges of all larger prosodic domains. Here, [ʔ] onsets are banned initially in all syllables because *ʔ(Onset/σ) is the most specific domain-edge markedness constraint dominating IDENT. They are also banned initially in words and utterances, regardless of the ranking of *ʔ(Onset/Word) and *ʔ(Onset/Utterance), due to the implicational nature of a typical prosodic structure.

When faithfulness constraints are ranked below *ʔ(Onset/Word) but above *ʔ(Onset/σ) as in (29), the Nahuatl pattern emerges: [ʔ] can surface in medial but not word-initial or utterance-initial onsets. Again, the ranking of *ʔ(Onset/Utterance) is not crucial: utterance-initial [ʔ] will be banned by the ranking *ʔ(Onset/Word) » IDENT as long as strict layering is obeyed. IDENT must dominate *ʔ(Onset/σ), however, in order for medial onset [ʔ] to surface.

(29) Nahuatl: No word onset [ʔ]

ʔaʔaʔ	*ʔ(Onset/Utt)	*ʔ(Onset/Wd)	IDENT	*ʔ(Onset/σ)
a. ʔa.ʔaʔ		*!		**
b. ➔ ta.ʔaʔ			*	*
c. ta.taʔ			**!	

Utterance-initial [ʔ] is banned when faithfulness is ranked below *ʔ(Onset/Utterance) but above *ʔ(Onset/Word) and *ʔ(Onset/σ) – that is, when *ʔ(Onset/Utterance) is the most specific domain-edge markedness constraint dominating IDENT. This occurs in Kaiwa.

(30) Kaiwa: No utterance onset [ʔ]

a. Utterance-medial

[$_{Utt}$ … ʔaʔaʔ	*ʔ(Onset/Utt)	IDENT	*ʔ(Onset/Wd)	*ʔ(Onset/σ)
a. ➔ [$_{Utt}$ … ʔa.ʔaʔ			*	**
b. [$_{Utt}$ … ta.ʔaʔ		*!		*
c. [$_{Utt}$ … ta.taʔ		**!		

b. Utterance-initial

[$_{Utt}$ ʔaʔaʔ	*ʔ(Onset/Utt)	IDENT	*ʔ(Onset/Wd)	*ʔ(Onset/σ)
a. [$_{Utt}$ ʔa.ʔaʔ	*!		*!	**
b. ➔ [$_{Utt}$ ta.ʔaʔ		*		*
c. [$_{Utt}$ ta.taʔ		**!		

Finally, when faithfulness constraints dominate all of the constraints against domain-initial glottal stop onsets, a language (like Arabic, among others) allows glottal stop in all onsets.

(31) Arabic: No restrictions on onset [ʔ]

ʔaʔaʔ	IDENT	*ʔ(Onset/Utt)	*ʔ(Onset/Wd)	*ʔ(Onset/σ)
a. ➔ ʔa.ʔaʔ			*	**
b. ta.ʔaʔ	*!			*
c. ta.taʔ	**!			

4.2 Superset-at-edge patterns: Positional faithfulness

Languages may also license a wider variety of onsets and codas at the edges of prosodic domains. In these superset-at-edge languages, marked onsets and codas may be licensed only at domain edges. This occurs in Lango, where [ŋ] can be an onset word-initially as in (32a), but not medially (Noonan, 1992: 10, 16-7). When a morphologically complex word would be expected to have a medial onset [ŋ], as in (32b) where an [ŋ]-final word is followed by a vowel-initial

suffix, [ŋ] deletes and the flanking vowels are nasalized. The languages in (33) similarly license the marked onset [h] only in word-initial position.

(32) Lango

a.			b.		
ŋèc	'back'		/cíŋ-ê/	[c̋ĩ̂ẽ̂]	'hands'
ŋwé	'smelly'		/cɔ̀ŋ-ê/	[cɔ̃̀ẽ̂]	'knees'
ŋwɛ̀ccɔ̀	'to run from'		/ɲə̀ŋ-ê/	[ɲə̃̀ẽ̂]	'crocodiles'
ŋù:	'beast of prey'		/tjàŋ-ê/	[tjã̀ẽ̂]	'durra stalks'

(33) Marked onset [h] in word-initial, not medial onsets
Lamani (Trail, 1970)
Lele (Frajzyngier, 2001)
Mbay (Keegan, 1997)
Songhay (Prost, 1956)
Tsisaath Nootka (Stonham, 1999)
Wiyot (Teeter, 1964)
Yana (Sapir and Swadesh, 1960)

These superset-at-edge phonotactic patterns, which reverse the distribution of marked onset and coda segments seen in earlier sections of this paper, occur when positional faithfulness constraints dominate domain-edge markedness constraints. While domain-edge markedness constraints penalize marked segments or structures at the edges of prosodic domains, positional faithfulness constraints penalize unfaithful mappings in positions including word-initial syllables (Beckman, 1999). In OT terms, there can be a direct conflict between a domain-edge markedness constraint like *ŋ(Onset/Word) and a positional faithfulness constraint like IDENT/σ_1.

The distribution of [ŋ] in Lango can be accounted for by the ranking IDENT/σ_1 » *ŋ(Onset/Word), *ŋ(Onset/σ) » IDENT in (34). The result of this ranking is a superset-at-edge pattern where the marked onset [ŋ] is banned in medial onsets due to *ŋ(Onset/σ) » IDENT, but permitted in word-initial onsets because of IDENT/σ_1 » *ŋ(Onset/Word).

(34) Lango: Marked onsets are only licensed word-initially

ŋaŋa	IDENT/σ_1	*ŋ(Onset/Word)	*ŋ(Onset/σ)	IDENT
a. ŋa.ŋa		*	**!	
b. ga.ŋa	*!		*	*
c. ➔ ŋa.ga		*	*	*
d. ga.ga	*!			**

Other superset-at-edge patterns involving marked onsets and codas emerge from similar rankings. In Axininca Campa, onsetless syllables are licensed only word-initially (McCarthy and Prince, 1993b, Payne, 1981). This follows from a ranking similar to (34): IDENT/σ_1 » ONSET/Word, ONSET/σ » IDENT. Similarly, IDENT/σ_1 » NOCODA/Word, NOCODA/σ » IDENT predicts that codas are licensed only in word-final syllables as in Kamaiurá (Everett and Seki, 1985, McCarthy and Prince, 1986/1996). Beckman (1999) and Broselow (2003) discuss additional patterns of this type.

4.3 Strict layering violations

This discussion has focused so far on cases where prosodic strict layering holds: all segments are syllabified, all syllables are in prosodic words, all prosodic words are in prosodic phrases, etc. (Nespor and Vogel, 1986, Selkirk, 1981, 1984). In these structures, an utterance-initial segment is also always phrase-initial, word-initial, and syllable-initial. Considering only prosodic structures of this sort has allowed us to assume the within-language implication that any language which bans a marked onset word-initially also bans it utterance-initially, as is typical.

Strict layering is not, however, always obeyed. Syllables can be attached directly to prosodic words rather than to feet, and clitics and function words can be attached directly to phrases rather than to prosodic words (Ito and Mester, 2003, Selkirk, 1995). Domain-edge markedness constraints are crucially sensitive to details of prosodic structure: the assessment of ONSET/Word violations incurred by a form depends on the precise location of prosodic word

edges in that form. Thus in a language where strict layering can be violated, restrictions are no longer necessarily implicational: a restriction which holds on a smaller domain does not necessarily hold on a larger domain as well.

This section will explore two ways in which domain-edge markedness constraints can interact with constraints governing the positions of prosodic domain edges (Selkirk, 1995, Truckenbrodt, 1999). First, faithful realization of marked onsets can result in prosodic structures which violate strict layering. In Banawá, underlyingly word-initial onsetless syllables surface outside prosodic words. Second, structures which are banned at domain edges can be tolerated when they are extraprosodic for other reasons, as in Tzutujil where extraprosodic proclitics may lack initial onsets despite the fact that lexical (and prosodic) words must have initial onsets.

4.3.1 Banawá: Marked structures become extraprosodic

Constraint rankings like the one in the hypothetical tableau in (35), where ONSET/Word and faithfulness constraints dominate the constraint enforcing prosodic strict layering, predict that violations of ONSET/Word could be avoided by allowing initial onsetless syllables to surface outside prosodic words.[9]

(35)

V.CV.CV	FAITH	ONSET/Word	STRICTLAYER
a. ➔ V [$_{Wd}$ CV.CV]			*
b. [$_{Wd}$ V.CV.CV]		*!	
c. [$_{Wd}$ CV.CV.CV]	*!		
d. [$_{Wd}$ CV.CV]	*!		

The winning structure in (35), with an extraprosodic initial vowel, is very similar to structures proposed by Spring (1990) to account for the fact that onsetless initial syllables in

[9] Here, a cover constraint simply called STRICTLAYER is used; see e.g. Selkirk (1995) for specific constraints that have been proposed to enforce strict layering.

Axininca Campa do not participate in reduplication. Downing (1998) also proposes similar structures for a number of languages in which onsetless word-initial syllables fail to bear stress or high tone, or do not participate in reduplication.

The present analysis builds on the central insight of Spring's and Downing's proposals: initial onsetless syllables can be extraprosodic and thus exceptional.[10] In Banawá, prosodic words must have initial onsets; structures where onsetless (underlyingly) word-initial syllables surface outside prosodic words follow from a desire to avoid violating high-ranking ONSET/Word.

The extraprosodic position of initial onsetless syllables is indicated by the fact that they cannot be stressed, unlike other initial syllables (Buller et al., 1993, Downing, 1998, Everett, 1990). The default Banawá stress pattern is illustrated in (36). Initial syllables, and every second syllable thereafter, are stressed; feet are trochaic and start at the left edge of the word. Main stress is typically (though not consistently) on the penultimate foot; for the purposes of the present discussion, the distinction between primary and secondary stress is irrelevant.

(36)

té.me	'foot'
má.ka.rì	'cloth'
tá.ti.kù.ne	'hair'
tì.na.rí.fa.bù.ne	'you are going to work'

Banawá syllables are either CV or V. Medial onsetless syllables may be either unstressed (as in 37a) or stressed (as in 37b). Postvocalic word-final [i] is extraprosodic and is never stressed.

(37)

a.		b.	
fú.a	'lose'	bá.du.è	'species of deer'
fú.a.nà	'lost'	sá.ji.è.i	'sound out'
já.u.mà.i	'pig'	kè.re.wé.du.à.ma	'turn end over end'
tì.a.sí.a.nì	'acquire'		

[10] See Downing (1998) for arguments against Spring's derivational analysis, and Smith (2002: 104-5) for arguments against Downing's constraint-conjunction approach.

The only initial syllables which are not stressed are those which are onsetless, as in (38). When a word has an initial onsetless syllable, its second syllable and every second syllable thereafter is stressed. That is, these words are stressed according to the normal pattern, but the first stress occurs on the second syllable.

(38)

u.wá.re.i	*ú.wa.rè.i	'make noise'
u.fá.bu.nè	*ú.fa.bù.ne	'I drink'
a.tì.ke.í.ja.rì.ne	*à.ti.kè.i.já.ri.nè	'happy'

The avoidance of stress on initial onsetless syllables can be accounted for by the constraint ranking in (39), which forces such syllables to fall outside the prosodic word.[11] Winning candidate (39a) is a word in which the initial [u] is attached directly to some larger prosodic constituent, e.g. a phonological phrase, in order to avoid violating ONSET/Word, though at the cost of violating the lower-ranked STRICTLAYER. Losing candidates (39b-c) surface with initial onsetless syllables, thus violating ONSET/Word; (39b) also violates ALIGN-L(Word, Foot) because the initial [u] is unfooted. Finally, (39d) has an epenthetic initial onset [ʔ], violating high-ranking FAITH. ONSET/Word can therefore account for Banawá's avoidance of prosodic word-initial onsetless syllables.

(39)

ufabune	ALIGN-L(Wd,Ft)	FAITH	ONSET/Word	STRICTLAYER
a. ➔ u [$_{Wd}$ (fá.bu)(nè)]				*
b. [$_{Wd}$ u (fá.bu)(nè)]	*!		*!	
c. [$_{Wd}$ (ú.fa)(bù.ne)]			*!	
d. [$_{Wd}$ (ʔú.fa)(bù.ne)]		*!		

An alternative explanation for languages' avoidance of stressed onsetless syllables is proposed by Smith (2002: 97ff.) and de Lacy (2001). They suggest that these patterns are due to a constraint penalizing stressed syllables without onsets: ONSET/σ́. Given the ranking in (40),

[11] I assume that TROCHEE rules out iambic candidates, e.g. *[$_{Wd}$ (u.fá)(bù.ne)], *[$_{Wd}$ (u.fá)(bu.nè)].

undominated ONSET/σ́ and STRICTLAYER cause feet to be displaced from the left edge of the prosodic word, leaving the initial onsetless syllable inside the prosodic word but unfooted and thus unstressed. Under this analysis, ONSET/σ́ must penalize onsetless syllables with either primary or secondary stress in order to explain both the avoidance of *[ú.fa.bù.ne] in favor of [u.fá.bu.nè] and also the avoidance of *[à.ti.kè.i.já.ri.ne] in favor of [a.tì.ke.í.ja.rì.ne] 'happy'.

(40)

ufabune	STRICTLAYER	FAITH	ONSET/σ́	ALIGN-L(Wd,Ft)
a. u [$_{Wd}$ (fá.bu)(nè)]	*!			
b. ➔ [$_{Wd}$ u (fá.bu)(nè)]				*
c. [$_{Wd}$ (ú.fa)(bù.ne)]			*!	
d. [$_{Wd}$ (ʔú.fa)(bù.ne)]		*!		

In Banawá, however, only initial onsetless syllables avoid stress; medial onsetless syllables may be stressed, as in [bá.du.è] 'species of deer' and [a.tì.ke.í.ja.rì.ne] 'happy'. As ONSET/σ́ does not distinguish between initial and medial onsetless syllables, the ranking from (41) incorrectly leaves initial CV syllables unfooted (and thus unstressed) when doing so prevents stress from appearing on medial onsetless syllables. This is illustrated in (41), where candidate (41b) is incorrectly chosen as the winner; the actual winner is (41c), where the final onsetless syllable is stressed.[12]

(41)

badue	STRICTLAYER	FAITH	ONSET/σ́	ALIGN-L(Wd,Ft)
a. ba [$_{Wd}$ (dú.e)]	*!			
b. ➔ *[$_{Wd}$ ba (dú.e)]				*
c. ✓[$_{Wd}$ (bá.du)(è)]			*!	
d. [$_{Wd}$ (bá.du)(ʔè)]		*!		

[12] It would be possible to account for the Banawá data using the locally conjoined constraint [ONSET/σ́ & ONSET/σ_1] (Smolensky, 1995, 1997); however, see McCarthy (1999: 365-6) and Padgett (2002) for arguments against local conjunction.

Because of its direct reference to word-initial onsets, ONSET/Word straightforwardly explains the difference between initial and medial onsetless syllables in Banawá. As shown in (42), a medial stressed onsetless syllable does not incur a violation of ONSET/Word, and thus does not disrupt the normal pattern of stress assignment. The repair chosen in Banawá, where onsetless initial syllables are removed from prosodic words and stress is therefore shifted away from these initial syllables, is a consequence of this domain-edge markedness constraint's ranking, with faithfulness, above STRICTLAYER.

(42)

badue	ALIGN-L(Wd,Ft)	FAITH	ONSET/Word	STRICTLAYER
a. ba [$_{Wd}$ (dú.e)]				*!
b. [$_{Wd}$ ba (dú.e)]	*!			
c. ➔ [$_{Wd}$ (bá.du)(è)]				
d. [$_{Wd}$ (bá.du)(ʔè)]		*!		

Finally, because strict layering is not consistently observed in Banawá, the relationship among phonotactic restrictions at different prosodic levels is atypical. When a form like *ufabune* occurs utterance-initially, the initial [u] is utterance-initial but not word-initial. The word is pronounced as it is utterance-medially, without an initial onset, in the prosodic structure [$_{Utt}$ u [$_{Wd}$ fá.bu.nè]]. Utterances are therefore unlike words in that they license initial onsetless syllables, indicating that the typical within-language implication regarding the distribution of marked domain-edge structures does not hold: onsetless syllables are banned word-initially but tolerated syllable-initially and utterance-initially.

This reveals that domain-edge markedness constraints must be freely rankable, as follows. The general discussion of Banawá stress shows that FAITH and ONSET/Word must dominate STRICTLAYER. For the correct utterance-initial surface form in (43) to win, STRICTLAYER must dominate ONSET/Utterance. By transitivity, ONSET/Word dominates

ONSET/Utterance in Banawá. Section 4.1 showed that the typical case, where a marked onset is banned utterance-initially but licensed word-initially, follows from a ranking like *X(Onset/Utterance) » FAITH » *X(Onset/Word). Thus in order for both *X(Onset/Utterance) » *X(Onset/Word) and *X(Onset/Word) » *X(Onset/Utterance) to be possible, constraints in the M_{Ons}(Onset/PCat) schema must be freely rankable.

(43)

ufabune	FAITH	ONSET/Word	STRICTLAYER	ONSET/Utt
a. ➔ [Utt u [Wd (fá.bu)(nè)]]			*	*
b. [Utt ʔu [Wd (fá.bu)(nè)]]	*!		*	
c. [Utt [Wd (ú.fa)(bù.ne)]]		*!		*
d. u [Utt [Wd (fá.bu)(nè)]]			**!	

4.3.2 Tolerance of marked 'initial' structures: Tzutujil clitics

When phonological material surfaces outside prosodic words for independent reasons, as can be true of clitics, it is not evaluated by domain-edge markedness constraints. In these cases, clitics can begin with structures which are never initial in lexical words, as the left edge of a lexical word always aligns with the left edge of a prosodic word and thus lexical word edges are subject to domain-edge markedness constraints. This occurs in Tzutujil (Dayley, 1985), where prosodic words (and thus all roots) must have initial onsets while proclitics may be onsetless.

Underlyingly vowel-initial Tzutujil roots receive epenthetic [ʔ] onsets, satisfying ONSET/Word.[13]

(44)

/ak'/	[ʔak']	'chicken'	/axq'i:x/	[ʔaxq'i:x]	'diviner'
/o:x/	[ʔo:x]	'avocado'	/oxqat/	[ʔoxqat]	'deerhunter'
/utz/	[ʔutz]	'good'	/utzi:l/	[ʔutzi:l]	'goodness'

[13] Epenthetic onset [ʔ] is obligatory on monosyllabic words and optional on longer forms; the crucial point here is that all vowel-initial words can take epenthetic initial [ʔ], unlike the clitics discussed below which never receive initial [ʔ].

The only Tzutujil words which regularly surface without initial onsets are the vowel-initial absolutive and ergative proclitics given in (45). As shown in (46), [ʔ] is never epenthesized before these clitics.

(45) a. Absolutive proclitics

1SG	in–	1PL	oq–
2SG	at–	2PL	ix–
3SG	∅	3PL	e:–/eʔ–[14]

b. Ergative proclitics

1SG	nu:–/w–	1PL	qa:–/q–
2SG	a:–/a:w–	2PL	e:–/e:w–
3SG	ru:–/r–	3PL	ke:–/k–

(46)

in=winak	*ʔin=winak	'I am a person'
oq=winak	*ʔoq=winak	'we are people'
a:=tz'i:ʔ	*ʔa:=tz'i:ʔ	'your dog'
a:w=ak'	*ʔa:w=ak	'your chicken'

This difference between roots and clitics emerges if, following Selkirk (1995), Tzutujil clitics surface outside of prosodic words, attaching directly to phonological phrases or higher prosodic constituents. ONSET/Word requires all and only prosodic words to have initial onsets and so is indifferent to the presence of onsets in extraprosodic clitics in candidates (47a) and (47b) below. ONSET/Word thus rules out only candidate (47c), where the clitic is fully incorporated into an onsetless prosodic word. DEP prefers candidates without epenthesis, eliminating candidates (47b) and (47d) and allowing the STRICTLAYER-violating candidate (47a) to win. Thus Tzutujil clitics, unlike roots, may surface with initial onsetless syllables.

(47)

a:w=ak'	ONSET/Word	DEP	STRICTLAYER
a. ➔ a: [$_{Wd}$ wak']			*
b. ʔa: [$_{Wd}$ wak']		*!	*
c. [$_{Wd}$ a:wak']	*!		
d. [$_{Wd}$ ʔa:wak']		*!	

In the winning candidate (47a), the final consonant of the clitic resyllabifies, providing an onset to the root. Allowing this, while preventing other unattested misalignments of root and

[14] When two forms occur, the first is for consonant-initial stems and the second for vowel-initial stems.

prosodic word edges, is crucial to a full analysis of Tzutujil clitics. Two types of undesirable outputs must be avoided: those in which onsetless root-initial syllables surface outside the prosodic word (as in Banawá), e.g. *a[xq'i:x] rather than [ʔaxq'i:x] 'diviner', and those in which clitics fully incorporate into prosodic words (thus satisfying STRICTLAYER), e.g. *[a:w=ak'], *[ʔa:w=ak'] instead of a:[w=ak'] 'your chicken'. A traditional alignment constraint like ALIGN-L(Root, PrWd) (McCarthy and Prince, 1993a), which demands that the left edge of each root cooccur with the left edge of a prosodic word, would prevent both of these undesirable results. Problematically, however, it would also rule out surface structures in which clitic-final consonants resyllabify to satisfy ONSET/Word as in (48), where the actual output is (48a); bare roots with epenthetic word-initial onset [ʔ] would also be wrongly eliminated.

(48)

a:w=ak'	ALIGN-L(Root, PrWd)	ONSET/Word	DEP	STRICTLAYER
a. ✓a: [$_{Wd}$ wak']	*!			*
b. ➔ *a:w [$_{Wd}$ ak']		*		*
c. a:w [$_{Wd}$ ʔak']	*!		*	*

Something weaker than ALIGN-L(Root, PrWd) must therefore mediate the relationship between Tzutujil root and word edges. The necessary constraint must force the beginning of the root to fall inside the prosodic word, and must allow epenthetic or clitic consonants but not clitic vowels to intervene between root and word edges. A constraint which aligns the edges of root-headed syllables with edges of prosodic words, ROOTHEADL, can account for this pattern.[15]

(49) ROOTHEADL The left edge of the leftmost syllable whose morphological domain is the root must be aligned with the left edge of a prosodic word.

This constraint crucially refers to the notion of 'morphological domain' introduced by van Oostendorp (2004) in a discussion of differences in the syllabification of Dutch prefix and

[15] This constraint is violated in Banawá words with onsetless initial syllables, as the 'leftmost syllable whose morphological domain is the root' in such a word surfaces outside the prosodic word.

suffix segments. A segment's morphological domain is the smallest word containing the segment, and a syllable inherits its morphological domain from its head; in Tzutujil, the morphological domain of a syllable is that of its vowel.

If alignment constraints can refer to morphological domains, ROOTHEADL can therefore require the leftmost vowel in a root to surface in the leftmost syllable of a prosodic word, while failing to penalize non-head material in that leftmost syllable with non-root morphological affiliations. Clitic and epenthetic consonants can thus appropriately appear before root-initial vowels inside Tzutujil prosodic words in order to satisfy ONSET/Word, while clitic vowels must remain outside prosodic words and root vowels must remain inside them. These results are shown in (50) and (51).

(50)

a:w=ak'	ROOTHEADL	ONSET/Word	DEP	STRICTLAYER
a. ➔ a: [$_{Wd}$ wak']				*
b. a:w [$_{Wd}$ ak']		*!		*
c. [$_{Wd}$ a:.wak']	*!	*!		
d. [$_{Wd}$ ʔa:.wak']	*!		*	

(51)

axq'i:x	ROOTHEADL	ONSET/Word	DEP	STRICTLAYER
a. a [$_{Wd}$ xq'i:x]	*!			*
b. [$_{Wd}$ ax.q'i:x]		*!		
c. ➔ [$_{Wd}$ ʔax.q'i:x]			*	

Without reference to segments' morphological affiliation, it is impossible to force all clitic vowels (but not all clitic consonants) to surface outside prosodic words and thus allow these clitic-initial vowels to escape from prosodic requirements on prosodic word-initial onsets. In general, morphologically-mediated alignment constraints like ROOTHEADL firmly link edgemost vowels to prosodic domain edges, while allowing consonants to enter or leave prosodic

domains without penalty. ROOTHEADL thus captures consonants' tendency to be freer than vowels in terms of prosodic alignment and resyllabification across word boundaries. de Lacy (2002) argues that in Maori, a single prosodic word must contain all vocalic elements of a root, but not necessarily all consonantal elements; final consonants surface in a distinct prosodic word when suffixes are added (and are otherwise deleted). Similarly, Cairene Arabic allows the initial consonant of a complex onset to resyllabify and become a coda to a preceding word, though vowels can never change their prosodic affiliations.

Given the formal parallels among domain-edge markedness constraints, all such constraints are predicted to interact in similar ways with candidates' prosodic structures. For example, *X(Onset/PCat) constraints should be able to license marked onsets only in extraprosodic clitics, or force root-initial marked onsets into extraprosodic positions. Coda constraints should also be sensitive to prosodic structure, licensing (marked or all) codas only in clitics or forcing them to surface outside the prosodic word. More specifically, a ranking like FAITH, NOCODA/Word » STRICTLAYER should force underlying word-final consonants to surface faithfully but in a position outside of prosodic words, rather than as word-final codas. In other words, this ranking accurately predicts that languages may require final consonants to be extrametrical.

4.4 General factorial typology

This paper has discussed cases where the onset or coda inventory at a prosodic domain edge is a subset of the comparable domain-medial inventory. In most cases, languages enforce these restrictions by epenthesizing, deleting, or changing the features of initial onsets or final codas. The constraint rankings under which these restrictions typically emerge are of the general type in (52a). When FAITH dominates STRICTLAYER as in (52b), on the other hand, prosodic structure rather than segmental content is modified in order to avoid marked onsets in word-initial

syllables. In Banawá and Tzutujil, prosodic (though not morphological) words must have onsets while utterances may be onsetless, thwarting the typical implicational relationship among prosodic domain edges within a particular language. Finally, in a language where both FAITH and STRICTLAYER dominate a domain-edge markedness constraint as in (52c), the restriction is not imposed on the language's surface forms.

(52) a. *X(Onset/PCat), STRICTLAYER » FAITH Segmental repair: *X* maps unfaithfully to *Y*

b. *X(Onset/PCat), FAITH » STRICTLAYER Prosodic repair: *X* surfaces outside *PCat*

c. FAITH, STRICTLAYER » *X(Onset/PCat) No repair: *X* surfaces in *PCat*-initial onsets

The schematic rankings in (52a-b) illustrate the two basic ways that languages can achieve the subset-at-edge patterns discussed throughout this paper. However, as discussed in section 4.2 and elsewhere, other patterns are also attested. The table in (53) gives each logically possible within-language combination of restricted and unrestricted initial onsets in the domains syllable, word, and utterance, with '$\not\forall$' denoting a restriction on initial onsetless syllables. These are illustrated using ONSET/PCat constraints, but comparable patterns of within-language restrictions are predicted for all marked onsets and codas. Phrases are ignored here because there is so little data on attested phrase-initial restrictions.

(53) Possible patterns of onset requirements across prosodic domains

	σ	Word	Utter-ance	Language	Ranking[16]
a.	CV V	CV V	CV V	English	FAITH/σ_1 » ONSET/σ FAITH ONSET/Word, STRICTLAYER ONSET/Utt
b.	CV ~~V~~	CV ~~V~~	CV ~~V~~	Klamath	ONSET/σ » FAITH/σ_1 ONSET/Word FAITH ONSET/Utt STRICTLAYER
c.	CV V	CV ~~V~~	CV ~~V~~	Madi	ONSET/Word » FAITH » ONSET/σ ONSET/Utt FAITH/σ_1 STRICTLAYER
d.	CV V	CV V	CV ~~V~~	Selayarese	ONSET/Utt » FAITH » ONSET/σ STRICTLAYER ONSET/Word FAITH/σ_1
e.	CV ~~V~~	CV V	CV V	Axininca Campa	FAITH/σ_1 » ONSET/σ » FAITH STRICTLAYER ONSET/Word ONSET/Utt
f.	CV V	CV ~~V~~	CV V	Banawá	FAITH » STRICTLAYER » ONSET/σ ONSET/Word ONSET/Utt FAITH/σ_1
g.	CV ~~V~~	CV V	CV ~~V~~	*Unattested*	ONSET/Utt » FAITH/σ_1 » ONSET/σ » FAITH STRICTLAYER RNSET/Word
h.	CV ~~V~~	CV ~~V~~	CV V	*Unattested*	*Impossible*

Most of these predicted languages are attested. An English-type language, in which faithfulness constraints and STRICTLAYER dominate all domain-edge markedness constraints, never requires onsets in any domain. Klamath, Madi, and Selayarese were discussed at length in section 3, and the corresponding rankings (with STRICTLAYER and some or all domain-edge markedness constraints dominating faithfulness) were illustrated in section 4.1. Axininca Campa is an example of the positional faithfulness pattern discussed in 4.2, where FAITH/σ_1 licenses

[16] As the goal of this table is to illustrate which languages are possible under some ranking of constraints, this column gives one possible ranking, or schematic for a set of similar rankings, which can produce each pattern of restrictions. Other rankings not listed here may also give rise to these languages.

marked onsets only word-initially and high-ranking STRICTLAYER ensures that they surface utterance-initially as well. Finally, as shown in 4.3.1, Banawá requires onsets only prosodic word-initially, and violates STRICTLAYER in order to satisfy ONSET/Word via a prosodic repair; onsetless syllables may occur medially and utterance-initially.

The final two patterns appear to be unattested. First, the ranking in (53g) predicts a second type of positional faithfulness pattern where onsets would be required of all but word-initial syllables. This ranking is illustrated in (54); the pattern is not, to my knowledge, attested.

(54) a. Syllables which are both utterance-initial and word-medial must have onsets

[Utt [Wd VV	STRICT LAYER	ONSET /Utt	FAITH/ σ_1	ONSET/ Word	ONSET/ σ	FAITH
a. [Utt [Wd V.V		*!		*	**	
b. [Utt [Wd CV.V			*		*!	*
c. [Utt [Wd V.CV		*!		*	*	*
d. ➔ [Utt [Wd CV.CV			*			**

b. Word-initial but utterance-medial syllables may surface without onsets

[Utt … [Wd VV	STRICT LAYER	ONSET /Utt	FAITH/ σ_1	ONSET/ Word	ONSET/ σ	FAITH
a. [Utt … [Wd V.V				*	**!	
b. [Utt … [Wd CV.V			*!		*	*
c. ➔ [Utt … [Wd V.CV				*	*	*
d. [Utt … [Wd CV.CV			*!			**

Finally, the language in (53h) requires onsets in all syllables except those occurring utterance-initially, where underlyingly onsetless vowels may surface. This is predicted to be unattested, as the comparative tableau in (55) shows that it is not possible under any constraint ranking.[17] In a language where all medial and word-initial syllables have onsets, onsetless

[17] A comparative tableau (Prince, 2002) shows constraints' favoring relations among candidates. For each constraint, and each candidate other than the winner, the tableau shows whether the constraint favors the winner over the loser ("W"), the loser over the winner ("L"), or neither (empty cell). While these tableaux do not indicate constraint ranking by left-to-right ordering, as do traditional violation tableaux, they can be used to determine necessary ranking conditions: for a ranking to map the input to the desired output, each constraint which favors some loser over the desired winner must be dominated by a constraint that favors the winner over that loser; that is,

utterance-initial syllables can surface only if they are extrametrical, in structures like [$_{Utt}$ V [$_{Wd}$ CV.CV]], the desired winner in (55). For this candidate to win, the constraints must be ranked such that it is more harmonic than both candidate (55a), where no onsets are epenthesized, and also (55b), where onsets are epenthesized to both medial and utterance-initial syllables. Candidate (55a) loses to the desired winner only if FAITH » ONSET/σ, while the reverse ranking ONSET/σ » FAITH must hold in order for (55b) to lose. As no constraint ranking can give rise to this language, it is appropriately predicted to be unattested.

(55) No constraint ranking requires onsets everywhere except utterance-initial

[$_{Utt}$ VCVV	ONSET /Wd	ONSET/ σ	FAITH/ σ_1	FAITH	STRICT LAYER	ONSET /Utt
W ➔ [$_{Utt}$ V [$_{Wd}$ CV.CV]]		*		*	*	*
a. [$_{Utt}$ V [$_{Wd}$ CV.V]]		** W		L	*	*
b. [$_{Utt}$ CV [$_{Wd}$ CV.CV]]		L		** W	*	L

Overall, while a diverse set of languages is predicted by the interactions of domain-edge markedness constraints and faithfulness constraints (both general and position-specific), this section has shown that this typology is more restricted than the set of all logically possible phonotactic patterns, and further, that nearly all of the predicted patterns are attested.

5. Conclusion

This paper has argued that the universal inventory of OT constraints must include domain-edge markedness constraint schemata of the form M_{Onset}(Onset/PCat) or M_{Coda}(Coda/PCat). These schemata give rise to families of parallel markedness constraints on the initial onsets or final codas of each prosodic domain, such as ONSET/σ, ONSET/Word, ONSET/Phrase, ONSET/Utterance and *VOIOBS(Coda/σ), *VOIOBS(Coda/Word), *VOIOBS(Coda/Phrase),

when constraints are ordered with respect to their ranking, each L in a row must be dominated by a W in the same row.

*VOIOBS(Coda/Utterance). While the familiar positional markedness framework allows each markedness constraint on onsets or codas to be relativized to each such domain-edge position, the inclusion of these schemata in CON accounts for the observation that restrictions on prosodic domain edges may not be arbitrarily different; rather, each attested restriction on syllable onsets and codas is also attested at the edges of words, phrases, and utterances.

Domain-edge markedness constraint violations are most frequently avoided via epenthesis, deletion, or some other featural change, resulting in an inventory of domain-edge onsets or codas which is a subset of the medial onset or coda inventory. These constraints may also interact with constraints demanding prosodic strict layering or positional faithfulness, accurately predicting languages where marked onsets surface only extrametrically, or even where marked onsets or codas are licensed only at domain edges. As the factorial typology of domain-edge markedness constraints accurately predicts a wide range of attested languages while generally not predicting unattested languages, these constraint schemata appear to be included in the universal OT constraint inventory CON; the findings presented here thus further our understanding of both the structure of prosodic domains and also of the internal structure of CON.

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