

Motivating Constraint Domains

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1 March 1996
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Background

In the ordered-rule approach to phonology which has until recently characterized most generative work in the field, there can be many **intermediate stages** in a derivation. A classic case from English (cf. Kiparsky 1982):

- (1) a. *basic form* protést_V
 b. *V → N conversion, new stress* prótèst_N
 c. *N → V conversion* prótèst_V

The intermediate stage (b) provides a simple account for the location of stress in the final form (c). In some cases, however, intermediate stages lead to complications in the analysis, such as requiring pseudo **'look-ahead'** devices.

For example, a standard assumption in derivational prosodic phonology is that lower-level constituents are created before higher ones: e.g. syllables, then feet, then the word. In metrical phonology, this **bottom-up** construction means feet are created before the word layer (by the End Rule, picking out the leftmost or rightmost foot). But Hayes (1995) and others have argued that sometimes there is motivation for **top-down** parsing: apply the End Rule, then construct feet so that the head of a foot is under the higher grid mark (in accordance with the Continuous Column Constraint).

We can contrast the treatment of **initial light-heavy** in two languages which both have quantity-sensitive trochees built from left to right: the difference follows from top-down versus bottom-up parsing.

- (2) a. Malayalam: bottom-up parsing
- i. Footing
- | | | |
|----|-------|-----|
| ~ | (-) | ~ |
| pa | f̄a: | t̄i |
- ii. End Rule
- | | | |
|-------|-------|-----------------|
| (x) | (-) | ~ |
| pa | f̄á: | t̄i 'complaint' |
- b. Cahuilla (v? rime is heavy): top-down parsing
- i. End Rule
- | | | |
|-------|-------|----|
| (x) | (-) | ~ |
| su | ka? | ti |
- ii. Footing
- | | | |
|-------|-------|---------------------|
| (x) | (-) | ~ |
| (~) | (-) | ~ |
| sú | kà? | ti 'the deer (OBJ)' |

In Cahuilla, the need to have a foot underneath the x placed by the End Rule forces creation of a degenerate (~) foot so that the initial syllable is stressed.

A **surface-oriented** approach such as Optimality Theory (Prince and Smolensky 1993) eliminates such inconsistencies, and that is one of its primary advantages. For example, the Malayalam/Cahuilla contrast can be analyzed using surface constraints only, such as the following.

- (3) a. FTBIN A foot must contain two moras or two syllables.
 b. ALIGNL The main stress must be at the left edge of the word.

The two logical **rankings** of these constraints give us the two languages.

- (4) a. FTBIN » ALIGNL Do not stress the initial syllable if that would require a degenerate foot.
 = Malayalam
 b. ALIGNL » FTBIN Create a degenerate foot in order to achieve initial-syllable stress.
 = Cahuilla

An important example of an intermediate stage is the **level** of lexical phonology, which captures a relationship between sets of phonological and morphological rules. I illustrate with data from Manam (Lichtenberk 1983), in which **stress clash is prohibited within a root but not elsewhere**. This leads to the stress pattern CVC.Cv.Cv internal to a root (5) but CVC.CVCv elsewhere (6).

- (5) a. émbeʔi 'sacred flute'
 b. óŋʔau 'Onkau' (*name*)
- (6) a. arò-n-túʔa (*aróntuʔa) 'right in front of you'
 b. sàgodè-n-tína (*sàgodéntina) 'you are really well-mannered'

In a **lexical phonology model** (e.g. Kiparsky 1982), the root pattern suggests application of footing to the root alone, which avoids clash; but later footing, after suffixation and in a different level, permits clash.

- (7) a. *Root stress* (émbe)ʔi (áro)
 b. *Suffixation* — (áro)-n-tuʔa
 c. *Refooting* — a(ròn)(túʔa)


While it is possible to incorporate levels directly into an OT approach (e.g. McCarthy and Prince 1993a), such a move **undermines the essential surface orientation** of the theory. The lack of levels in a strictly parallel version of OT might then be seen as a disadvantage of this approach. Buckley (1995a,b) proposes '**constraint domains**' which capture similar generalizations to levels by delimiting substrings of the surface representation which are subject to different constraint rankings. In Manam:

- (8) { root } { suffixes }


If **stress is assigned only once**, the otiose first stage of footing in (7) can be eliminated entirely. The root pattern is expressed as a **constraint on stress which holds only within the root domain**. A bit schematically (see Buckley 1995b for details):

- (9) *CLASH^{rt} Adjacent stressed syllables are not permitted. *Holds of the root only.*
 ALIGNR Align the right edge of the word with a foot.

(10)

{émbeʔi} _{rt}	*CLASH ^{rt}	ALIGNR
a.  (émbe)ʔi		*
b. (èm)(béʔi)	*!	

(11)

{áro} _{rt} {n-tuʔa} _{suf}	*CLASH ^{rt}	ALIGNR
a. a(róntu)ʔa		*!
b.  a(ròn)(túʔa)		

The clashing feet in (11b) are ignored because the clash (ròn)(túʔa) is not within the root {áro}.

Cyclic effects like the conversion in (1) are the subject of considerable current work in Correspondence Theory (e.g. McCarthy and Prince 1994, 1995; Orgun 1994, 1995; Benua 1995; McCarthy 1995; Kenstowicz 1995; cf. Burzio 1994). Essentially, *prótèst_V* has the stress it does because it is morphologically related to *prótèst_N*, not because it is derived from it.

I argue that domains are not only a **viable** reinterpretation of levels, but in fact are **superior** because they are able to capture generalizations which elude stepwise derivations. Specifically, the blocking of three processes in Kashaya, a Pomoan language of Northern California, which would alter vowel length in a particular set of suffixes can be captured in the domains account by a **single constraint**, but in lexical phonology the similarity must remain a coincidence. I also show that the formulation of the processes themselves is significantly more elegant and explanatory using constraints.

The three processes in question are those termed by Buckley (1994) **Iambic Lengthening, Foot Flipping** (and related issues), and **Final Shortening**; I discuss them in that order.

Iambic Lengthening

Kashaya builds iambs from left to right. No secondary stresses; iterativity is shown by **Iambic Lengthening** (=IL). The main (only) stress is normally on the first foot. The root is shown in bold; note the vowel length alternations in the suffixes.

- (12) a. **kel-aloq^w-iç--i** → (kelá:) (loqo:) çí 'look back up!'
 b. **kel-mul-ad-uced--u** → (kél) (mula:) (duce:) du 'keep peering around'
 c. **mo-mul-ad-uced--u** → (momú:) (ladu:) (cedu) 'keep running around'

A word-final vowel (12c) never undergoes IL; final long vowels are avoided, but more to the point every verb-final suffix, and potentially others preceding it, permit no IL of their vowels. **Non-lengthening suffixes** uniformly occur to the right of those which permit IL, so the domain of IL is a substring at the right side of the word. The double hyphen (--) indicates the beginning of the non-lengthening domain.

- (13) a. **śi--p^hila** → (śip^hī) la 'if [it] happens'
 b. **mo-mac-ed--ela** → (momá:) (cede) la 'I keep running in there'
 c. **hoṭ^h-ala--śuw-em** → (hoṭ^há:) (laśū) (wem) 'it would warm [us] up'
 d. **mo-mac--eti** → (momá:) (ceti) 'although he ran in there'

Buckley (1994) proposes five levels in a lexical phonology framework (e.g. Kiparsky 1982). In this approach, the derivation requires **several stages**: first the lengthening suffixes are added to the root; then IL applies; and then the non-lengthening suffixes are added. After the second round of morphology, IL does not reapply. Specifically, Lengthening applies to the output of level 3 morphology, but then turns off and does not apply in levels 4 and 5.

- (14) a. *MORPHOLOGY 1* mo + mac mo + mac + ed
 b. *Phonology (with IL)* (moma:) <c> (moma:) (ce) <d>
 c. *MORPHOLOGY 2* (moma:) c + eti (moma:) (ce) d + ela
 d. *Phonology (no IL)* (momá:) (ceti) (momá:) (cede) (la)

This crucially refers to an **intermediate representation**, but work in Optimality Theory has placed that approach in doubt; much to be gained if ordered rules are replaced with constraints on surface representations (cf. Prince and Smolensky 1991, 1993). An example is the need for provisional final-consonant extrametricality in (14b), to permit IL in intermediate *momac*; cf. Buckley (1995a,b).

In a **domains** analysis, the double hyphen can be seen as delimiting two constraint domains, call them 1 and 2. (A complete account of the phonology may require more subtle division into domains.) **Non-lengthening suffixes** uniformly occur to the right of those which permit IL, so the domain of IL is a substring at the left side of the word. Schematically, this can be thought of in either of the following two ways: more descriptively (a) or as a translation of the levels approach (b).

- (15) a. { root + lengthening suffixes }₁ { nonlengthening suffixes }₂
 b. { root + level 2 + level 3 }₁ { level 4 + level 5 }₂

More specifically, if we do not appeal to *momaced* as an **intermediate** representation, we must refer to it as a **substring** of the surface representation within which IL occurs (cf. also Inkelas 1989, Inkelas and Orgun 1995). Below, within {...}₁ IL occurs, within {...}₂ it does not.

- (16) a. *Input with domains shown* {momaced}₁{ela}₂
 b. *Output with feet* (momá:)(cede)(la)

I will show that this difference can be attributed to the interaction of constraints on (i) the weight of the strong branch of an iamb, and (ii) the maintenance of underlying vowel length.

First, we must generate the foot structure on which IL is based. In a surface analysis, there is no notion of directionality; instead, we must refer to the **alignment of feet** (McCarthy and Prince 1993). As Crowhurst and Hewitt (1995) show, the precise manner in which a directionally based generalization such as 'left-to-right foot construction' translates into the alignment framework depends on whether degenerate feet are permitted. Below in (42) I show that it is **right** alignment that must be used in Kashaya; this means that degenerate feet must be permitted, as supported by the existence of monomoraic words (e.g. *čá* 'stay!').


While I give here only single-word examples, Kashaya stress is assigned to the phrase (see Buckley 1995c for analysis). The following two constraints generate the **basic foot structure**.

- (17) ALIGNR Align(Ft, R; PhonPhr, R)

PARSESYL Every syllable must be parsed by a foot.

In order to get the effect of **iterative footing** it is necessary to rank PARSESYL over ALIGNR (McCarthy and Prince 1993). I assume the undominated constraint FTFORM(Iamb).

(18)


keladucedu	PARSESYL	ALIGNR
a.  (kelá:) (duce:) (du)		*, ***
b. ke (ladú:) (cedu)	*!	**
c. keladu (cedú)	*!***	

As mentioned, using ALIGNR to achieve the effect of left-to-right footing requires that we permit **degenerate feet**. In languages that avoid such feet, FTBIN is responsible (Prince and Smolensky 1993; cf. McCarthy and Prince 1993: 91). I assume that universally no foot is larger than two syllables.

(19) FTBIN A foot is binary under moraic or syllabic analysis.

Since, however, degenerate feet are **necessary** for ALIGNR in Kashaya, PARSESYL » FTBIN.

(20)


keladucedu	PARSESYL	FTBIN
a.  (kelá:) (duce:) (du)		*
b. (kelá:) (duce:) du	*!	

The basic **effect of IL** is to achieve a perfect or canonical iamb, which consists of a light (and unstressed) syllable followed by a heavy (and possibly stressed) syllable (cf. Hayes 1985, 1995).

(21) ASYM In a branching iamb, the strong branch must be heavy.

ASYM is ranked lower than ALIGNR; cf. (25b,d). Notice in (22) that the **location of feet** is determined by PARSESYL and ALIGNR, while ASYM secondarily determines the **internal composition** of those feet.

(22)

keladucedu	PARSESYL	ALIGNR	ASYM
a. (kelá) (duce) (du)		*, ***	*!*
b. (kelá:) (duce) (du)		*, ***	*!
c.  (kelá:) (duce:) (du)		*, ***	
d. (kelá:) (du) (cedu)		** , ***!	*
e. (kelá:) ducedu	*!***	***	

IL must be prevented in the non-lengthening domain (cf. Urbanczyk 1995: 512, McCarthy 1995: 43).


(23) Q-IDENT The quantity of each input segment must be identical to its output quantity.

The **difference between lengthening and non-lengthening suffixes** is quite simply a matter of which constraint wins: ASYM or Q-IDENT. Since the winner differs across the two domains, there must be a different constraint ranking in those domains. Q-IDENT^{1}, which evaluates only segments in the lengthening domain C1, is ranked below ASYM; while Q-IDENT^{2}, for the non-lengthening domain C2, dominates ASYM to prevent IL.

(24) Q-IDENT^{2} » ASYM » Q-IDENT^{1}

The UR, with domains labeled, is shown in the upper left corner of the tableau.

(25)

{kelala} ₁ {p ^h ila} ₂	Q-IDENT ^{2}	ALIGNR	ASYM	Q-IDENT ^{1}
a. (kelá) (lap ^h i) (la)		*, ***	**!	
b.  (kelá:) (lap ^h i) (la)		*, ***	*	*
c. (kelá:) (lap ^h i:) (la)	*!			*
d. (kelá:) (la) (p ^h i) (la)		*, **, ***!		

Although in (25c) iambic structure is perfectly satisfied, it happens at the expense of preservation of underlying vowel length in the suffix $-p^h i l a$, subject to high-ranking Q-IDENT^{2}. In (b), iambic structure is met only within the domain where low-ranked Q-IDENT^{1} is violated, making it optimal.

Not only is Q-IDENT^{1} low-ranked relative to ASYM, in fact it never plays any role in choosing candidates. Any form that Q-IDENT^{1} might favor is ruled out by an alignment constraints, which dominates ASYM and therefore necessarily Q-IDENT^{1}. (Every long vowel leads to a new foot and adds violations of ALIGN.) As noted by Buckley (1995a), an alternative to the view that a constraint such as Q-IDENT exists in two domain-specific forms is that there is only one constraint, but (in this case) it is ignored in C1. The important point is that violations within C1 never matter, whether this is treated as low ranking of a domain-particularized constraint, or by completely ignoring the violations. Thus I generally omit Q-IDENT^{1} from tableaux, as potential *CLASH^{suf} was omitted for Manam.

In sum, domains provide a rather straightforward reinterpretation of levels in a surface-oriented framework, avoiding complications of intermediate stages such as otiose footing and ad hoc extrasyllabicity (as in (14); see Buckley 1995a).

Excursus: Extrametricality

The **word-initial syllable** is regularly excluded from foot structure — is **extrametrical** — when the verb root is two or more syllables in length. (The roots seen so far, in (12) and (13), are one syllable long.)

- (26) a. **libut-ad--u**
 → (butá:)(du) ‘keep whistling’
 b. **šivey-ibic-ed--em**
 → <ši>(weyí:)(bice:)(dem) ‘when new growth starts’
 c. **bimucid-uced--u**
 → <bi>(mucí:)(duce:)(du) ‘used to eat’

Many verbs in Kashaya take a **monosyllabic prefix**; here extrametricality occurs regardless of root length.

- (27) a. **du-ḱil-ič--i**
 → <du>(ḱilí:)(či) ‘point at yourself!’
 b. **c^hi-ʔdic-mac-adad--u**
 → <c^hiʔ>(díč^h)(maca:)(dadu) ‘pick up while going in’
 c. **do-hqoṭol-ič-ed--a-em**
 → <doh>(qoṭó:)(liče:)(dam) ‘couldn’t get around’

To account for the lack of extrametricality in unprefixated monosyllabic roots, lexical phonology can apply a rule of Syllable Extrametricality **after prefixation but before suffixation**; the Non-Exhaustiveness Condition prevents an entire domain from being extrametrical, so only stems (root plus possible prefix) of at least two syllables will undergo the rule (Buckley 1994b).


(28)	<i>ROOT, PREFIX</i>	libut	du-ḱil	kel	
	<i>Extrametricality</i>	but	<du>ḱil	—	(*<kel>)
	<i>SUFFIXATION</i>	but-ad-u	<du>ḱil-ič-i	kel-ad-u	
	<i>Footing</i>	(butá:)(du)	<du>(ḱilí:)(či)	(kelá:)(du)	

Once again, the lexical phonology analysis relies crucially on an intermediate stage. In this case that stage is different from the one required for IL in (14), which does include many suffixes.

In OT, the equivalent of Syllable Extrametricality is a constraint which **prevents a syllable from being footed**. Below is one possible formulation. As shown in (30), NONINITIAL » PARSESYL.

- (29) NONINITIAL Align(Ft, L; Syl, R).

(30)


	{libutad} ₁ {u} ₂	NONINITIAL	PARSESYL	ALIGNR
a.	(libú:)(tadu)	*!		**
b. 	li(butá:)(du)		*	*
c.	li(bú)(tadu)		*	**!

Of course, NONINITIAL is **always violated in words with a root restricted to the first syllable**. Without intermediate representations, however, we cannot appeal to the Non-Exhaustiveness Condition. Rather, a constraint prevents the complete non-footing of the root.

(31) FT-ROOT The root must be dominated by a foot. (The root must overlap with a foot.)

Intuition: the **morphological head of the word** is too important to be excluded from higher prosodic structure (see Buckley 1995c for more discussion).


(32)

{ kelad } ₁ {u} ₂	FT-ROOT	NONINITIAL
a.  (kelá:) (du)		*
b. ke (ladú)	*!	

In the interpretation of this constraint, only a syllable which is **headed** by material in the root satisfies the requirement of inclusion in the next higher level of prosodic structure, the foot. For example, the presence of the root /l/ in the foot in (32b) is insufficient to permit non-footing of /ke/.

When the **root is at least disyllabic**, FT-ROOT and NONINITIAL can both be satisfied.

(33)

{ libutad } ₁ {u} ₂	FT-ROOT	NONINITIAL	PARSESYL	ALIGNR
a. (libú:) (tadu)		*!		**
b.  lí (butá:) (du)			*	*
c. lí (bú) (tadu)			*	**!
d. libu (tadú)	*!		**	

When a monosyllabic root is **preceded by a prefix**, the two constraints FT-ROOT and NONINITIAL are again both satisfied in the optimal candidate: it is the word-initial prefix which is excluded from foot structure, and the root itself is free to be footed. While the lexical phonology analysis illustrated in (28) makes use of the prefix and root as an intermediate constituent in accounting for when Syllable Extrametricality can apply, this fact must be stipulated. The constraint analysis refers directly to the root alone, in the form of the constraint FT-ROOT; the **role of the prefix simply falls out** from the nature of the constraints and the morphology.

Foot Flipping

A remarkable indication of the pressure in Kashaya for iambic rhythm is found in the process that Buckley (1994a,b) calls **Foot Flipping**. When the leftmost (visible) sequence of the word is C_vvC_v, the vowel lengths in the two syllables are ‘flipped’ or reversed, resulting in the perfect iamb C_vC_vv.

(34)

a. di:ć -aq ^w -ić--i	→	(dića:)(qoćí)	‘take a message out!’
b. qa -cid--u	→	(qaci:)(dú)	‘keep leaving’
c. miku:ṭ -ad--e:	→	<mi>(kuṭa:)(dé:)	‘keep humming’
d. mu-bo:k -ibic--?	→	<mo>(boki:)(bí?)	‘start to rise’

In addition to the flipping of vowel lengths, notice that the **stress falls on the second foot**, rather than on the first one as is normally the case in Kashaya.

C_vvC_vC — where the last consonant is in the coda — **does not undergo Flipping**. The reason: the maximal syllable in Kashaya is C_vC, and Flipping would result in *C_vvC.

(35)

a. di:ć --i?ba	→	(di:)(ćí?) (ba)	‘cause to bring a message out’
b. qa :-muć--ba	→	(qa:)(múć) (ba)	‘after leaving each other’
c. miku:ṭ --e:	→	<mi>(ku:)(ṭé:)	‘be humming’
d. kilu:ca :-qa-w	→	<ki>(lu:)(cá:)(qaw)	‘a lock’

In this case the stress also falls on the second foot in the word; essentially, it is analogy with these forms that lead to the **shifted stress** in (34) above and (36) below. See Buckley (1995c) for analysis.

A related phenomenon is found with **Closed-Syllable Shortening**. Notice in (36) that the first foot is again skipped for stress, even though on the surface it does not contain a long vowel.

- (36) a. **di:ć-wač--a-emu** → (d^íć) (wač^á) (mu) ‘what they say (is)’
 b. **da-li:t-qa--w** → <da> (li:t^h) (q^áw) ‘let wave with the hand’

What all three cases of stress shift have in common is a **long vowel** that seems to start out at the beginning of the foot that is skipped; only in (35) does it surface there. Buckley (1994a,b) proposes a serial analysis whereby a rule of Foot Extrametricality applies to any foot **beginning** with Cvv, thereby uniting Cvv and (underlying) CvvCv and CvvC. This requires temporary creation of the **ill-formed ‘anti-iamb’** CvvCv, which persists until Foot Extrametricality applies, after which a literal rule of Foot Flipping simply reverses the vowel lengths to create a true iamb. Henceforth I use « » for an extrametrical foot.

- (37) i. *Foot Construction* (d^í:) (ćah) (qaw) (d^í: ća) (qo ći)
 ii. *Foot Extrametricality* «di:» (ćáh) (qaw) «di: ća» (qo ćí)
 iii. *Foot Flipping* — «di ća:» (qo ćí)

Similarly, the **ill-formed superheavy** CvvC must be temporarily permitted until Foot Extrametricality applies, after which it undergoes Shortening (cf. Buckley 1991).

- (38) i. *Foot Construction* (di:ć) (wača) (mu) <da> (li:t^h) (qaw)
 ii. *Foot Extrametricality* «di:ć» (wača) (mu) <da> «li:t^h» (qaw)
 iii. *Shortening* «dić» (wač^á) (mu) <da> «lit^h» (q^áw)

In addition to the ad hoc nature of Foot Flipping and the temporary creation of ill-formed structures, Foot Extrametricality also requires the **dubious generalization** “begins with Cvv”, to cover Cvv (35), CvvCv (34), and CvvC (36).

A more principled analysis is possible using constraints, by separating the formal treatment of vowel length and stress shift. The change in vowel length does not need to be analyzed as ‘flipping’ per se, whereby the mora moves from one syllable to another. Rather, it can be seen as **underlying indeterminacy** in the association of the mora, which is resolved by metrical and syllabic well-formedness; that is, one mora’s **association is underspecified** (cf. Kiparsky 1991).

- (39) a. *root morpheme* b. *with suffixes*
- $$\begin{array}{c} \mu \quad \mu \\ | \quad | \\ d \quad i \quad \acute{c} \end{array} \qquad \begin{array}{c} \mu \quad \mu \quad \mu \quad \mu \quad \mu \\ | \quad | \quad | \quad | \quad | \\ d \quad i \quad \acute{c} \quad a \quad q \quad o \quad \acute{c} \quad i \end{array}$$

There are two basic **surface realizations possible**: leftward or rightward linking to a vowel.

- (40) a.
$$\begin{array}{c} \mu \quad \mu \quad \mu \quad \mu \quad \mu \\ | \quad / \quad | \quad | \quad | \\ d \quad i \quad \acute{c} \quad a \quad q \quad o \quad \acute{c} \quad i \end{array} \qquad \text{b.} \qquad \begin{array}{c} \mu \quad \mu \quad \mu \quad \mu \quad \mu \\ | \quad \backslash \quad | \quad | \quad | \\ d \quad i \quad \acute{c} \quad a \quad q \quad o \quad \acute{c} \quad i \end{array}$$

The choice between these forms is made by ALIGNR, which **prefers branching feet at the left edge**. (A raised period [·] indicates a floating mora in the UR; a colon [:] indicates a linked mora.)

(41)

	{di·ća qoć} ₁ {i} ₂	Q-IDENT ^{2}	ALIGNR	ASYM
a.	(di:) (ća qo:) (ći)		*, **!	
b.	(dića:) (qoći)		**	*
c.	(dića:) (qoći:)	*!	**	

The next example shows clearly that **rightward alignment** is necessary in Kashaya, since (42a,b) are identical in all respects except for the location of vowel length and foot boundaries.

(42)

	{miku·ɬad} ₁ {e:} ₂	NONINITIAL	PARSESYL	ALIGNR
a.	mi (ku:) (ɬadé:)		*	**!
b.	mi (kuɬa:) (dé:)		*	*
c.	(miku:) (ɬadé:)	*!		**

The major success of the constraint-based analysis is that the **same constraint** needed to determine foot structure in simple cases — namely, ALIGNR — serves as the motivation for Foot Flipping. The fact that the lexical phonology analysis requires the ad hoc rule of Foot Flipping to accomplish the same task constitutes a strong argument in favor of the constraint-based approach.

Morphologically blocked Flipping

In addition to its ad hoc nature, the serial lexical phonology analysis in (37) treats IL and Foot Flipping as independent rules, and it is a complete coincidence that the **domains of the two rules are identical**. For example, notice that the suffix *-mela* resists IL (43a) as well as Foot Flipping (b).

(43)

a.	baɬi --mela	→	<ba>(ɬimé)(la)	'[we] camped'
			*<ba>(ɬimé:)(la)	
b.	ɬa --mela	→	«ɬa:»(melá)	'I left'
			*«ɬame:»(lá)	

Formally, this shared restriction on IL and Foot Flipping is simple enough to state, by assigning both rules to the same lexical level (cf. Buckley 1994a). But this move provides no explanation as to **why** this correlation should obtain, and it is predicted that a similar language might have the same rules in different levels. This prediction is dubious, since both processes result in the same perfect iamb.

The similarity is further obscured by the fact that the rule of Foot Flipping cannot, in fact, turn off after level 3. Rather, it has to be active throughout the lexical phonology, to avoid a true look-ahead device: this is necessary because whether or not Foot Flipping actually occurs depends on the overall syllable structure of the word, and this depends on suffixes added in levels 4 and 5. Therefore it is only the rule of “CV Adjunction”, which feeds Foot Flipping by creating an anti-iamb (CV:CV) from nonbranching (CV:), that is inactive after level 3. See Buckley (1994a, 1995c) for discussion.

In the OT analysis, the **high-ranking status of Q-IDENT^{2}** accounts for both facts: IL and Foot Flipping both introduce a long vowel, and Q-IDENT^{2} ensures that this not occur in C2.

(44)

	{ɬa·} ₁ {mela} ₂	Q-IDENT ^{2}	ALIGNR	ASYM
a.	(ɬa:) (melá)		**	*
b.	(ɬame:) (lá)	*!	*	

The explanation of the correlation is transparent in the constraint-based analysis: in both cases, creation of a long vowel in C2 is blocked by Q-IDENT. The special status of C2 is stipulated for a **single constraint**, which by itself accounts for the lack of **both processes**. Such an explanation is not possible in the ordered-rule approach, and this fact constitutes a powerful argument against it.

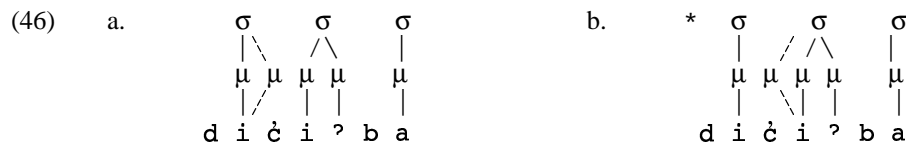
Phonologically blocked Flipping

As seen in (35), vowel length surfaces in the root, i.e. there is **no Flipping**, when the rightward potential docking site of the floating mora is a **heavy syllable**. Below is a relevant input representation.

(45)

	μ	μ	μ	μ
	d	i	ɬ	i
			?	b
				a

The first of these consonants /?b/ must syllabify as a coda, where it must bear a mora itself. That makes a total of two moras in the syllable, with **no room for the floating mora**.



(47) BIMORA A maximum of two moras is permitted in a syllable.

To avoid a bimoraic syllable, but maintain the long vowel, the coda would have to be eliminated from the syllable, either by **deleting the consonant** (*dič̣i:ba*) or by **inserting a vowel** so the consonant can syllabify as an onset (*dič̣i:ʔiba*). Neither of these candidates wins, due to the following constraints.

- (48) MAX Every input segment must correspond to an output segment. (Do not delete.)
 DEP Every output segment must correspond to an input segment. (Do not insert.)

MAX and DEP are fundamental faithfulness constraints on segments, which resist changes to the basic underlying string; see McCarthy and Prince (1995).

(49)

$\{di \cdot \acute{c}i\}_1 \{ba\}_2$	BIMORA	MAX	DEP	ALIGNR
a. $\leftarrow (di:) (\acute{c}i?) (ba)$				*,**
b. $(di\acute{c}i:?) (ba)$	*!			*
c. $(di\acute{c}i:) (ba)$		*!		*
d. $(di\acute{c}i:) (?iba)$			*!	**

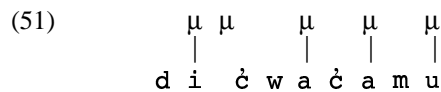
Reshuffling of mora–segment linkings (e.g. vocalic mora links to coda) is prevented as follows.

- (50) MORA-IDENT The features linked to a mora in the input are identical to those in the output.

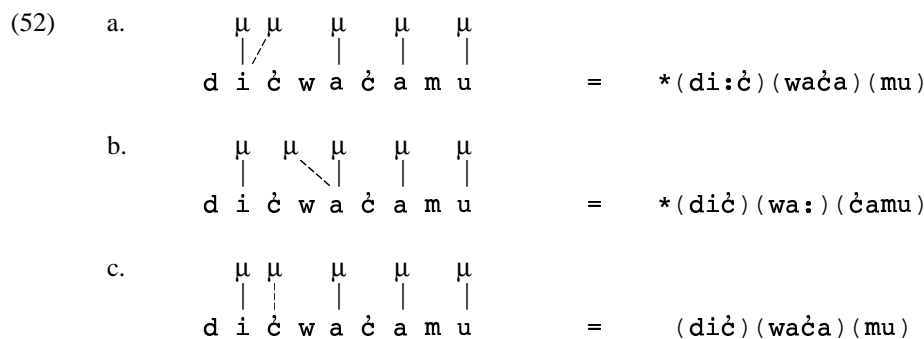
See Buckley (1995c) for discussion of further constraints which prevent other rearrangements of the moraic structure, e.g. MAX(μ) and LINEARITY.

Closed-Syllable Shortening


The analysis developed so far also accounts quite easily for Closed-Syllable Shortening (36). The following input has a **cluster of two consonants**, /čw/, following the root vowel.



In this context, the floating mora has not just two places to link, in the ways seen above, but it can also, as shown in (52c), **serve as the mora for the coda consonant /č/**.



The form in (52a) is ruled out by BIMORA, just as illustrated in (49b). The linking to the following vowel in (52b), by contrast, is well-formed syllabically. But it is **not as well aligned** as (52c), where the floating mora links to the coda consonant and pre-emptly Weight-by-Position.

(53)	{di·čwač}_1{amu}_2	BIMORA	ALIGNR	ASYM
a.	(di:č) (wača) (mu)	*!	*,***	*
b.	(dič) (wa:) (čamu)		**,**!	*
c. 	(dič) (wača) (mu)		*,***	*

This derivation captures a reasonable intuitive interpretation of Closed-Syllable Shortening, that the coda consonant ‘steals’ the second mora of a long vowel. The only quirk in Kashaya is that the mora in question was never actually linked to the vowel.

Elision

Within C1, adjacent vowels /V_iV_j/ become long [V_i:] by **Elision** (in C2 the result is short [V_i], by Q-IDENT; cf. (36a)). This occurs where Flipping is not possible, whether phonologically (54) or morphologically (55).

- (54) a. **mo-ibic--?** → «mo:» (bí?) ‘run away’
 b. **ca-ad--u?ba** → «ca:» (dú?) (ba) ‘could fly’
 c. **puhṭi-aqac--?** → <puh>«ṭi:» (qá?) ‘go up alone’
- (55) a. **mo-aq--ela** → «mo:» (qalá) ‘I’m running’
 b. **mo-ad--eti** → «mo:» (detí) ‘even though [it] was running’
 c. **c^hi-de-ad--u** → <c^hi>«de:» (dú) ‘carry along’

The two adjacent vowels are, however, a common **source of Foot Flipping**.

- (56) a. **mo-aloq^w-iç--i**
 → «molo:» (qočí) ‘run up out here!’
 b. **do-ibic--i**
 → «dobi:» (cí) ‘raise your hand!’
 c. **yehe-ala-meç--t^hu-?**
 → <ye>«hela:» (mé?) (t^hu?) ‘don’t drag yourself down!’

Using an ordered-rule framework, Buckley (1994a,b) has to assume that even in cases of Flipping, the **intermediate step** exists in which the two vowels are syllabified together, and then the length is flipped.

- (57) *Underlying form* moaloqočí cahnoaduči
 i. *Elision and Footing* (mo:lo) (qočí) <cah> (no:du) (čí)
 ii. *Foot Extrametricality* «mo:lo» (qočí) <cah>«no:du» (čí)
 iii. *Foot Flipping* «molo:» (qočí) <cah>«nodu:» (čí)

This **intermediate CvvCv foot is necessary to trigger** both Foot Extrametricality and Foot Flipping. Similarly, **intermediate superheavy CvvC** is required for forms with Closed-Syllable Shortening (cf. (36)), though in this case the only need is to trigger Foot Extrametricality.


- (58) a. **mo-aq--mela**
 → «mo:h» (melá)
 → «moh» (melá) ‘I ran through there’
- b. **p^hila-aç--me-?**
 → <p^hi>«la:ç» (mé?)
 → <p^hi>«laç» (mé?) ‘come here! (pl)’

The **floating-mora analysis** extends easily to these cases, and **obviates the intermediate steps**. Assume that loss of the second vowel is accomplished by constraints dominating MORA-IDENT (50), including ONSET (e.g. Prince and Smolensky 1993) and NODIPH (e.g. Rosenthal 1994).

- (59) μ μ μ μ μ
 | † | | |
 m o a l o q o č i

The second mora is prohibited from remaining linked to its own features, and **behaves identically to an underlyingly floating mora**, as in (39b). The two output possibilities are precisely those outlined in (40).

(60)

{moala} ₁ {qoči} ₂	ALIGNR	ASYM
a. (mo:) (laqo:) (či)	*,**!*	
b.  (mola:) (qoči)	**	*

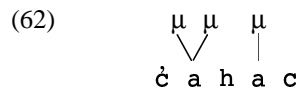
In a sense, it is a root like *di·č-* which is like *mo-ag-*, rather than vice versa: there is no long vowel in the underlying form of *di·č-*, simply a short vowel and a floating mora, just as in *ca-ad-* there is a short root vowel plus a mora provided by the suffix. Once again the constraint-based analysis makes possible a simpler and more elegant account of the alternations.

True Long Vowels

While it appears to be a fact about Kashaya that verb roots normally do not have underlying long vowels — i.e. vowel features linked to two moras — there are nevertheless a few cases of apparent **underlying long vowels**, and these are non-alternating and fail to undergo Foot Flipping.


- (61)
- | | | | |
|---------------------------|---|------------------------|--------------------------------|
| ča:hac-id--em | → | «ča:»(hací:)(dem) | ‘when he marries’ |
| ma:ku-c-ibic--? | → | «ma:»(kucí:)(bi?) | ‘start to grow deaf’ |
| ?aca:č-am-at-ad--u | → | <?a>«ca:»(čamá:)(tadu) | ‘embryo start to develop (pl)’ |

I treat these roots as **prespecified in the underlying representation** with long vowels (cf. Kiparsky 1991), and use the colon [:] in the inputs in (61) as an indication of this analysis.



This underlying linking is all that is necessary to account for the lack of Flipping. MORA-IDENT (50) prevents movement of the second mora of the long vowel into the following syllable.

(63)

{ča:hacid} ₁ {em} ₂	MORA-IDENT	ALIGNR	ASYM
a.  (ča:) (hací:)(dem)		*,***	
b. (čaha:)(cidém)	*!	**	

MORA-IDENT must look not at whether the **content** of the features linked to the mora is the same, but whether the same **linkings** to the mora token are maintained. This means that movement from one /a/ to another is prohibited.

The **empirical contrast** between prelinked and variable long vowels supports the floating mora approach.

Final Shortening

So far we have seen two processes which are subject to Q-IDENT^{2}, and for which the constraint domain provides a unified explanation: **Iambic Lengthening** and **Foot Flipping**. The third process is Final Shortening. When a long vowel belonging to a verb root ends up in word-final position, as **when a vocalic suffix is elided, the root vowel becomes short**.

- (64)
- | | | | |
|-----------------------|---|------|------------------------------------|
| a. du- k i:--i | → | duki | ‘scratch it with your fingernail!’ |
| b. hi- š a:--i | → | hiša | ‘break!’ |
| c. č a:--i | → | ča | ‘leave!’ |

There is a late verbal suffix *-e:*, however, which **surfaces with its length intact**.


- (65)
- | | | | |
|---|---|--|-------------------------|
| a. miku:ɬ-ad--e: | → | mikuɬa:de: | ‘keep humming’ |
| b. nohp^ho--t^hi-mi-mi-ya-e: | → | nohp ^h ot ^h imimiye: | ‘did not live long ago’ |
| c. do-ht-ibic--t^he: | → | dohtibi ^h t ^h e: | ‘didn’t raise hand’ |

In a lexical phonology approach, Buckley (1994) proposed that this level 5 suffix has a special prosodic status such that it is **outside the prosodic word**, and thus does not undergo **word-final shortening**.

(66) [[mikuṭa:d]_we:]_φ


In the **domains** approach, however, nothing special needs to be said. The suffix *-e:* is independently known to be **located in domain 2** — it occurs to the right of all other domain 2 suffixes — so its underlying length is automatically protected by Q-IDENT^{2}.

(67)

	{miku:ṭad} ₁ {e:} ₂	Q-IDENT ^{2}	* V:] _w
a. 	mikuṭa:de:		*
b.	mikuṭa:de	*!	

Elision is effected by a set of constraints, most importantly ONSET. Of course, since a root vowel is located in domain 1, it is unprotected by Q-IDENT^{2}, and is shortened.

(68)

	{ḡa:} ₁ {i} ₂	ONSET	Q-IDENT ^{2}	* V:] _w	Q-IDENT ^{1}
a.	ḡa:i	*!			
b.	ḡa:			*!	
c. 	ḡa				*

The deletion of the final /i/ is not a violation of Q-IDENT^{2}, since identity constraints hold only when the relevant segment is actually present in both the input and output (McCarthy and Prince 1995). What (68b,c) do violate is MAX, which normally prevents deletion of segments but in Kashaya is ranked below ONSET (as well as below DEP, which prevents insertion of a default onset consonant).

Conclusion

The constraint-domains approach offers a completely unified account for these **three cases of blocking** — a single high-ranking constraint, Q-IDENT, that holds strongly only within C-domain 2. A levels-based approach, on the other hand, must give quite distinct analyses of the three cases. Further, the constraint-based approach to Foot Flipping provides a much simpler and **more principled account of the vowel length alternations**. There has already been considerable evidence adduced in favor of a phonology organized around constraints rather than rules. The contrast presented here shows that even though constraints can logically be fit into a level-ordered framework, a better framework is one which **takes seriously the surface orientation** of Optimality Theory and replaces levels with constraint domains.

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