Positionally Abstract Underlying Representations in Klamath[*]

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1 Introduction

Phonology, at its essence, is a transformation between underlying representations (URs) of morphemes and surface forms (Heinz 2015). However, the identity of the UR is not always immediately apparent from the surface forms. An abstract UR is any UR such that some feature or component of the UR never appears in any of its surface exponents (following Kentstowicz & Kisseberth (1979); Baković (2009)). In contrast, a concrete UR is a UR such that all features in the UR surface in some surface exponent. Abstract URs can be used to elegantly represent morphemes, when the concrete URs fail.

In Klamath, a Plains Penutian language once spoken in central Oregon, certain verb stems show an [i] in certain forms that deletes elsewhere, for example [ʔeːw̥itkʰ]-[ʔeːw̥a]. Previous work on the language, (Barker 1964) analyzes these forms using fully abstract segments in the UR, for the previous example, /ʔeːw̥i/. In this paper, I argue that this [i]-[∅] alternation cannot be represented by any single concrete UR. Rather I claim, due to its distribution, the alternation is best represented by /e/, which is an abstract UR in these forms, even though /e/ can be a part of concrete URs elsewhere in Klamath.

In section 2, I show the specific alternation and show that no concrete option can serve as the UR. In section 3, I present the distribution of [e] in Klamath and show that /e/ has the ability to represent this alternation. In section 4, I show how this analysis can be modeled in Optimality Theory, using positional faithfulness constraints (Beckman 1998). Finally, in section 5, I compare /e/ with other possible abstract analyses, showing that /e/ is superior to any other potential UR.

2 The Klamath Alternation

Verb stems in Klamath can appear with a large variety of suffixes. I will focus specifically on two of the most productive verb suffixes seen in Barker (1963), /-a/ 'indicative', and /-tkʰ/ 'in a state of having been ...-ed'. A set of verb stems transcribed with /i̠/ by Barker, show an [i] before the /-tkʰ/ suffix (and similar suffixes) that does not appear before /-a/ or other suffixes that would create less complex phonotactic clusters.

(1) *Verb stems exhibiting [∅] ∼ [i̠] alternation*[1]

/ʔeːw̥i̠/	[ʔeːw̥a] 'is deep'	[ʔeːw̥itkʰ] 'deep'
/q'eːl'i̠/	[q'eːl'a] 'acts silly'	[q'eːl'**i**tkʰ] 'one acting silly'
/nupuːsi̠/	[nupuːsa] 'burns a little'	[nupuːs**i**tkʰ] 'charred'
/quːj'i̠/	[quːj'a] 'feels passionate'	[quːj'**i**tkʰ] 'passionate'

The use of /i̠/ is descriptive, and does not have explanatory weight (nor does Barker (1964) mean for it to, as one small aspect of his grammar of Klamath). /i̠/ appears only in the last syllable of verb stems, where the [i]-[∅] alternation appears, and no argument is made as for why it does not appear elsewhere, or how it would behave in those positions. In a modern phonological analysis, we must define this segment featurally. Currently /i̠/ stands totally as an abstraction of a segment, it is a variable rather than a number, a pronoun rather than a name. Therefore, we must identify a possible identity of /i̠/.

For a verb like [ʔeːw̥a]-[ʔeːw̥itkʰ], two possible concrete UR analyses exist.

- /ʔeːw̥i̠/ could serve as the UR, with /i/-deletion deriving [ʔeːw̥a]
- /ʔeːw̥/ could serve as the UR, with [i]-epenthesis deriving [ʔeːw̥itkʰ]

Assume that the final /i/ is deleted in these circumstances, then the UR for these verb stems must be /i/ final. There must be some phonological process that leads to deletion of /i/ when paired with the /-a/ suffix. However, another set of verb stems show an [i] that never deletes, even in all those circumstances where the alternating stems appear to show deletion.

(2) *Verb stems with non-alternating stem-final /i/*

[stupw̥**i**] 'has first menstruation'	[stupw̥itkʰ] 'one who reached womanhood'
[slaːm'**i**] 'is a widower'	[slaːm'itkʰ] 'widower'
[sn'ew̥l**i**] 'has a cold'	[sn'ew̥litkʰ] 'one having a cold'

The first column of verb stems are paired with the indicative /-a/ suffix, thus, /stupw̥i-a/ surfaces as [stupw̥i]. To resolve hiatus here, the suffix vowel is deleting rather than the stem /i/. In order for /ʔeːw̥i/ to serve as the UR for [ʔeːw̥a]-[ʔeːw̥itkʰ], the /i/ must delete here, but this context is near identical to the one in /stupw̥i-a/→[stupw̥i]. There is no reason to motivate both deletion of /i/ in /ʔeːw̥i-a/ and deletion of /a/ in /stupw̥i-a/. Therefore, it is impossible to obtain both /ʔeːw̥i-a/→[ʔeːw̥a] and /stupw̥i-a/→[stupw̥i], so /i/ can be ruled out as the UR for the alternation.

If /ʔeːw̥-tkʰ/ represents [ʔeːw̥itkʰ] underlyingly, the [i] must appear through epenthesis. However, other evidence shows that [a] is the default epenthetic vowel for breaking up these sorts of clusters. A number of verb forms exist with final consonants, that would create illicit clusters when paired with the /-tkʰ/ suffix.

(3) *Verb stems showing [a] as the default epenthetic vowel*

[sk'aːw̥-a] 'is cold'	[sk'aːw̥-**a**-tkʰ] 'cold'	[sk'aːw̥-tki] 'turns cold'
[kuw̥-a] 'swells up'	[kuw̥-**a**-tkʰ] 'swollen'	[kuw̥-y'asqs] 'venereal disease'
[q'aqneːk-a] 'is dirty'	[q'aqneːk-**a**-tkʰ] 'dirty'	[q'aqneːk-wal] 'is dirty on top'

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[1] All Klamath data comes from (Barker 1963; Barker 1964). Following (Blevins 1993), I transcribe Barker's voiceless stops as aspirated and voiced stops as plain voiceless, and Barker's [o] as [u].

These forms must truly be consonant final. If they had an underlying /a/ finally, i.e. /sk'aːwa/, we would expect that /a/ to always surface, so we would see [sk'aːwatki]. Since we see [sk'aːwtki], the /a/ must either delete, or not be present in the UR. There is little motivation for /a/'s deletion here, so URs like /sk'aːw̥/ represent these morphemes, with [a]-epenthesis between morphemes.

2.1 Deglottalization

Further evidence against an epenthesis account for the [i]-[∅] alternation comes from its interaction with glottalization. Many alternating stems show glottalization of the preceding consonant when [i] does not appear, and no glottalization when it does. Here I will show that this glottal alternation can only appear if the [i]-[∅] alternation is represented underlyingly with some segment, which precedes the glottal segment in the UR.

In Klamath, all consonants have a contrastive glottal counterpart. This includes the sonorants [m' n' j' w' l'], and the ejectives [p' t' ʧ' k' q']. This laryngeal contrast is lost before stops, (Blevins 1993). However, a set of stems with the [i]-[∅] alternation, also show a glottal alternation on the stem final consonant.

(4)   [ntʰeːw'a] 'breaks surface with round instrument'   [ntʰeːwitkʰ] 'broken'

Note the glottalization on the bold consonant. When [i] appears, glottalization does not, and when glottalization appears, [i] does not. This cannot caused by some complementary distribution, where some underlying segment alternates between glottalizing the previous consonant and surfacing as [i] in other circumstances, because we have seen above in (1) that not all stems with the [i]-[∅] alternation show this glottalization alternation (compare [ʔeːwa]-[ʔeːwitkʰ] with [ntʰeːw'a]-[ntʰeːwitkʰ]); and [i] and a closed glottis feature ([cg]) have little phonetic similarity.

The glottalization must delete in [ntʰeːwitkʰ]. However, there is no surface-apparent motivation for the deletion of a [cg] feature. Deglottalization occurs before stops, but in both forms in (4), the consonant is prevocalic. [i] epenthesis here counterbleeds deglottalization, since the context motivating deglottalization is destroyed by [i] epenthesis:

(5)   *Deglottaliztion before [i] Epenthesis*
       /ntʰeːw'-tkʰ/ $\overrightarrow{Deglottalization}$ ntʰeːwtkʰ $\overrightarrow{[i] - Epenthesis}$ [ntʰeːwitkʰ]

(6)   *[i]-Epenthesis before Deglottalization*
       /ntʰeːw'-tkʰ/ $\overrightarrow{[i] - Epenthesis}$ ntʰeːw'itkʰ $\overrightarrow{Deglottalization}$ [ntʰeːw'itkʰ]

In classic OT, and other parallel frameworks, this becomes problematic, since the deglottalization no longer has any surface motivation. We can see that the faithfulness constraint that preserves glottalization, (here MAX-[CG]) must outrank any constraint that marks glottalized consonants, in order to preserve them throughout Klamath, (7).

(7)   *[CG] contrast is normally preserved in Klamath*

	/taq'-a/	DEPV	MAX-[CG]	*[CG]
☞	taq'a			*!
	taqa		*!	

Klamath has a widespread process of glottal coalescence prevocalically, i.e. /CʔV/→[C'V]. If a vowel appears between the consonant and the glottal stop, coalescence will not occur. By analyzing the [i] as a vowel that is at some point between the consonant and the glottalization, we can explain why [i] and [∅] appear with [C] and [C'] respectively.

However, epenthesis cannot separate these segments in a parallel framework like OT. There is no way to rank our constraints so that the deglottalizing candidate [ntʰeːwitkʰ] defeats [ntʰeːw'itkʰ], since the latter candidate is more faithful than the first, and cannot be more marked (we cannot mark [w'], even before front vowels (c.f. [ʔit'aːw'i] 'put pl. objs. in the sunshine')). Therefore the hypothetical /ntʰeːwʔ/ UR always fails.

(8) *Loss of [CG] contrast has no surface apparent motivation*

/ntʰeːwʔ-tkʰ/	DEPV	MAX-[CG]	*[CG]
✗ ntʰeːwitkʰ	*	*!	
ntʰeːw'itkʰ	*		*!

On the other hand, with a UR like /ntʰeːwVʔ/ for the morpheme, where V represents some underlying vowel that surfaces as [i] or deletes, we would only expect to see glottal coalescence if /V/ deletes. When the vowel does surface, glottalization is stuck in an illicit position and must delete, because it cannot move before the vowel. Thus the [i]-[∅] alternation cannot be caused by epenthesis.

(9) *An underlying vowel must intervene before ʔ.*

/ntʰeːwVʔ-tkʰ/	LINEARITY	MAX-[CG]	*[CG]
☞ ntʰeːwitkʰ		*!	
ntʰeːw'itkʰ	*		*!

We have found that no single concrete UR can serve for an alternating verb stem. Thus, some form of abstract analysis is necessary to model this alternation. Some segment must underlyingly separate the final consonant from the glottalization in stems with the glottal alternation, and that segment must surface as [i] sometimes, but cannot underlyingly be /i/.

3   Distributions

I argue that the [i]-[∅] alternation is most elegantly represented by underlying /e/. In order to understand why this works, we need to analyze the surface distribution of the short mid front vowel in Klamath and the distribution of the [i]-[∅] alternation. Barker's /i̱/ only appears in final syllables of multisyllabic verb stems. My investigation of all forms in Barker (1963) shows that all [i]-[∅] alternations must be either stem final, or followed just by /ʔ/. In this section, I will show that [e] surfaces in many positions throughout Klamath, but never appears in noninitial syllables of verbs; the alternation and [e] are in complementary distribution.

3.1   Distribution of [e]

Klamath has a four way vowel place distinction, with long and short variants for each vowel. The [i]-[∅] alternation surfaces only in final syllables of multisyllabic

verb stems, so if the surface distribution of some Klamath vowel has a gap in that position, it is possible that the vowel could represent the alternation. I compiled a digital corpus based on all the surface forms in Barker's Klamath Dictionary (1963), and analyzed the surface distributions of each vowel (10). I found that [e] had the smallest distribution of all short vowels, and favors initial syllables strongly, with 92.4% of [e]s (and 94.9% of [e]s in verbs) appearing in initial syllables.

(10) *Vowel Distributions of Klamath*

Vowel	Overall			Verb		
	Total	σ_1	%	Total	σ_1	%
[a]	11147	2261	20.3	9059	1909	21.0
[aː]	1242	326	26.2	630	159	25.2
[e]	1744	1611	92.4	1392	1321	94.9
[eː]	952	289	30.4	746	205	27.5
[i]	3637	1915	52.7	2839	1860	65.5
[iː]	1228	132	10.7	924	97	10.5
[u]	2354	2080	88.4	2001	1796	89.8
[uː]	1301	398	30.6	1094	325	29.7
Total	23605	9012	38.4	18416	10672	57.9
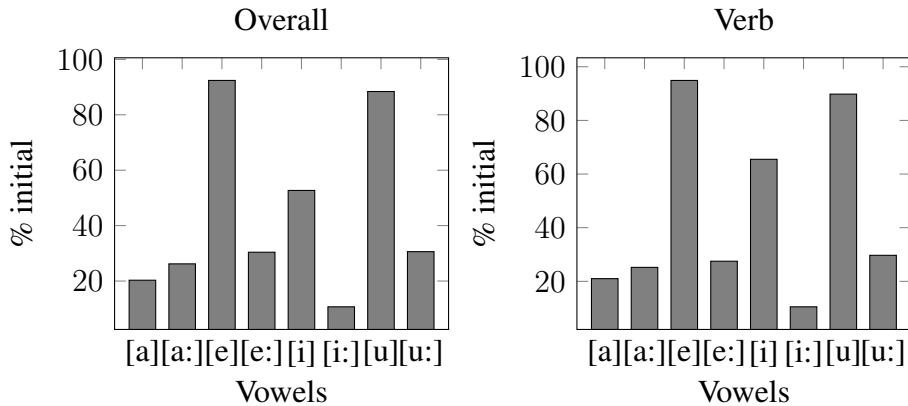
Since 38.4 percent of syllables in Barker's dictionary are initial syllables, we would expect most vowels to appear more often in non-initial syllables than initial syllables. However, we see a large preference for short [e] to appear in just initial syllables. This preference becomes even more stark when looking just at verbs. Out of 1392 [e] that surface in verbs, only 71 are not in word initial syllables. In fact, I argue that other than several exceptional stems, [e] never surfaces in noninitial syllables of verbs.

Of all 71 [e] found in noninitial syllables of verbs, only 18 are not preceded by a reduplication of an initial [e]. Then only six morphemes are responsible for all [e]s found in non-initial syllables of verbs. Of these, four are highly specific (and unproductive or irregular) terms with ritual or athletic connotations, leading me to believe they may be loanwords of some sort.[2]

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[2]These are 'hang (as a swing)', [sqinwett'a], 'roll in snow (as part of a power quest)' [w'illpʰeʔa], 'hop on one foot' [tʃ'iw̥tʃ'iw̥teneːʔa], and 'play catch' an irregular reciprocal form of throw,

The remaining two morphemes are more productive but both can be analyzed as having /e/ as the initial syllable of the stem. One, is the hortatory suffix /-ek^h/ which appears with a variety of verb stems, surfacing faithfully often, but Barker notes that it has an allomorph [-ik]. With the data given in Barker's work, I am unable to determine what would motivate one or the other, and suggest perhaps the contrast between these forms had been lost.[3]

The only remaining case of non-initial [e], /wetk/ (Barker's /uwetk/), can likely be accounted for within a broader analysis that takes copy epenthesis into account. Therefore, we are left with no productive morphemes that have [e] surfacing in non-stem initial positions.

One might note that [u] favors initial syllables to an only slightly smaller degree to [e], and wonder if [u] may be also thought to be in complementary distribution to the [i]-[∅] alternation. However, noninitial [u] appears in at least 90 nonreduplicative noninitial syllables of verbs in Barker's dictionary, with forms coming from at least 22 different morphemes, most of which showing wide productivity. Therefore, the distribution of [u] is likely unprincipled and accidental.

We can claim that [e] never surfaces in noninitial syllables of verbs (with few exceptions), which means that [e] never surfaces in the same position as our [i]-[∅] alternation, unlike say nonalternating [i] which we saw above surfaces contrastively with the alternation. In the next section, I will show that /e/ underlies the [i]-[∅] alternation. To truly make this argument, I will show that /e/ becoming [i] and deleting are phonologically well motivated repairs.

3.2 Why do we see this distribution?

Cross-linguistically, certain *privileged* positions maintain contrasts more often than unprivileged positions (Beckman 1998). Specifically for our purposes, vowel height contrasts are often lost in unprivileged positions. Recall, short mid vowels only surface in nouns and initial syllables.

Positional privilege is offered to positions for both psycholinguistic and phonetic reasons. Psycholinguistically, segments in roots are privileged over segments in affixes (Casali 1996; Casali 1997; Beckman 1998; Walker 2011) and stem-initial syllables are privileged over other syllables (Walker 2011; Steriade 1995; Trubetzkoy 1969; Beckman 1998). Barnes (2002) notes that many of the initial syllable effects are tied in with phonetic properties, say initial stress or some other phonetic prominence on these syllables like lengthening or peripheralization.

Smith (1997) argues that nouns show privilege over verbs, and evidence from child language backs up this argument (Gentner & Boroditsky 2001; Adam & Bat-El 2008; Jesney & Tessier 2011).

Since initial syllables and nouns are both privileged to some degree, those syllables that fall in neither category, non-initial syllables of verbs, are least privileged. Therefore, a loss of height contrasts is motivated in those positions.

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[saqʼweh?a] ('Throw' has a less marked Klamath form, [qʼawa], which we would expect to pattern with [saqʼwa].)

[3]Compare [punwik^h]'let me drink', with [kawliːjek^h] 'let me find it for you', or [snikuːʧnʼik^h] 'let me send' with [huʧʧnʼek] 'let me run'.

Many languages show restricted vowel inventories in unprivileged positions. Especially in vowel inventories like Klamath's, it is likely for the height contrast between mid vowels and high or low vowels to be lost. Crosswhite (1999) notes that it is so typologically common for mid-vowels to be allowed only in stressed syllables that false generalizations have been made claiming that mid vowels are always more vulnerable to reduction. This misunderstanding is fed by how typologically common it is for mid vowels to be permitted in stressed syllables but not unstressed syllables (Barnes 2002; Crosswhite 1999; Crosswhite 2004).

Phonetically, this is driven by a preference for the the corner vowels, [i a u], since those vowels are maximally acoustically distinct and are quantal sounds, i.e. their acoustic quality is consistent across a range of articulations (Crosswhite 2004). While the inventory shift between stressed and unstressed syllables is largely uniform, the mappings between them are not.

3.3 /e/ alternates between [i] and [∅]

The mappings between /e/ and [i]-[∅] are very similar to the "yer"-pattern seen in Russian. Since these mappings are found in another language totally unrelated to Klamath, we gain evidence that this mapping is a natural phenomenon in language that could perhaps be learnable.

In Russian, mid vowels only appear in stressed syllables (i.e. [arlʲˈets]), and /e/ in particular either raises to [i] ([ˈsosʲin]) or deletes based on syllable structure constraints ([sasnˈa]) (Gouskova 2012; Gouskova & Becker 2013).

(11)   *Russian [i]-[∅] Alternation*
       /sosʲen/   [ˈsosʲin]   [sasn-ˈa]   'pine (gen pl/nom sg)'
       /arl-ʲets/   [arlʲˈets]   [arlʲits ˈa] 'rhodonite (gen pl/nom sg)'

The Klamath phenomenon presented here differs from the Russian one in a few key areas. First, and of least concern, the specific phonotactic restrictions preventing deletion in some circumstances differ, as we would expect from two completely unrelated languages with different syllable structures.

Second, Russian mid-vowels are preserved in stressed syllables, rather than nouns or initial syllables. The Klamath case is just a different sort of positional privilege effect, as stressed syllables are privileged over unstressed ones, (Steriade 1995; Beckman 1998). If one sort of privilege can drive a certain phenomenon, we would expect to see similar phenomenon with other types of privilege. While loss of vowel contrast has been most investigated between stressed and unstressed syllables, this restriction of mid-vowels to privileged positions is not solely stress-conditioned; in Tamil (Beckman 1998; Bosch & Wiltshire 1992) mid-vowels are licit in initial syllables but not elsewhere.

3.4 Long [eː]

So far, I have ignored the long mid vowel. Long [eː] does not share short [e]'s gap in noninitial syllables of verbs. However, this is not a surprising result, long vowels are known to be more privileged than short vowels, (Walker 2011; Crosswhite 2004; Barnes 2002; Beckman 1998). Yet, a careful investigation of long [eː] in these unprivileged positions uncovers more evidence for our /e/→[i]-[∅] hypothesis.

Barker notes several verb stems with alternations involving [eː]. Each of these has [eː] surfacing at the right edge of a verb stem with suffixes like /-tkʰ/, but deleting elsewhere.

(12) *Long [eː] alternation*
    [nt'useːtkʰ]   'swelled up'   [nt'usʔa]   'swells up'
    [tʃujeːtkʰ]   'hatted'   [tʃujʔa]   'puts on a hat'

In fact, any noninitial syllable /eː/ that surfaces in a verb (i.e. all noninitial verbal [eː]s) must appear in a context that would cause /e/ to reduce to [i] rather than deleting. /nt'useːʔ-tkʰ/ surfaces as [nt'useːtkʰ] whereas, /nt'useʔ-tkʰ/ would surface as [nt'usitkʰ], but both stems would surface as [nt'usʔa] with /-a/ or [nt'ustki] with /-tki/. Therefore I argue that long vowels are privileged enough to be protected from the reduction process, but not as privileged as nouns or initial syllables which are also protected from deletion.

Since the deletion process occurs in all non-initial mid vowels in verbs, learners are given extra scaffolding that the UR of the [i]-[∅] alternation is short /e/, rather than an exceptional /i/, or something else. If the [i]-[∅] alternation was represented with an exceptional /i/ for example, the similarity between the [i]-[∅] alternation and the [eː]-[∅] alternation–which can concretely be represented with /eː/– would be mostly lost. However, if both are underlyingly represented with mid vowels, differing just by length, we can explain both of these phenomena simply.

In conclusion, there is substantial evidence that suggests that /e/ underlies the [i]-[∅] alternation in Klamath. Above, in subsection 3.1, we saw that [e] seems more marked than the other vowels in Klamath, since it never appears in noninitial syllables of verbs. In 3.2 we saw that [e] being marked is crosslinguistically expected. In section 3.3 I presented evidence from Russian that languages can repair these marked mid vowels using a conspiracy between reduction to [i] and deletion. Finally, we saw that similarities between the [i]-[∅] and [eː]-[∅] alternations suggest that both are represented with mid vowels. These facts can all be easily derived in OT, using familiar constraints.

4   Deriving the Alternations

In this analysis, two types of faithfulness constraints will be critical, IDENT(HI) and MAX-V, which militate against reduction of /e/ to [i], and deletion respectively. In order to make mid vowels marked, I use the *MID constraint, proposed by Beckman (1997).

(13)   a. ID(HIGH)- Assign a violation mark for each segment in the input i_x with an output correspondent o_x, if o_x and i_x do not have the same [±high] feature.
      b. MAX-V- Assign a violation mark for each vowel in the input i_x with no output correspondent.
      c. *MID- Assign a violation mark for each mid vowel in the output (*[e]).

In order to reflect positional privilege, we will use positional faithfulness constraints (Beckman 1998), which are violated only if the faithfulness constraint is violated

in a privileged position. When using positional variants of MAX-V, it is critical that the relevant positions are defined upon the input rather than the output. This requires a somewhat strange wording of initial syllabicity, since typically inputs are considered unsyllabified. However evidence exists from child phonology that positions like syllable onset are available on the input (Jesney 2015).

(14) a. ID(HIGH)/NOUN- Assign a violation mark for each segment in the input i_x with an output correspondent o_x, if o_x and i_x do not have the same [±high] feature, and i_x is in a NOUN stem.

b. ID(HIGH)/σ_1- Assign a violation mark for each segment in the input i_x with an output correspondent o_x, if o_x and i_x do not have the same [±high] feature, and i_x is in the first vowel of the stem.

c. ID(HIGH)/Vː- Assign a violation mark for each segment in the input i_x with an output correspondent o_x, if o_x and i_x do not have the same [±high] feature, and i_x is a long vowel.

(15) a. MAX-V/NOUN- Assign a violation mark for each vowel in the input i_x with no output correspondent, where i_x is in a NOUN stem.

b. MAX-V/σ_1- Assign a violation mark for each vowel in the input i_x with no output correspondent, where i_x is in the first vowel of its stem.

c. MAX-V/Vː- Assign a violation mark for each vowel in the input i_x with no output correspondent, where i_x is a long vowel.

4.1 Capturing the distribution of [e]

Since there are principled gaps in the distribution of short mid vowels in Klamath, *MID must be at least somewhat active, that is it must be ranked over the general faithfulness constraint militating against some repair for mid vowels. Due to the principle of Richness of the Base, any input with an [e] in a non-initial syllable of a verb stem must map to some licit Klamath form, without the [e] in that position. In (16), [taq'epka] cannot surface, because it has an [e] in a fully unprivileged position. For our purposes it doesn't matter which of the other candidates wins, just that one of them does, so it is necessary that *MIDV cannot be ranked below both ID(HI) or MAX-V.

(16) *Richness of the Base example showing gap in distribution of [e]*

/taqepk-a/	ID(HI)	MAX-V	*MIDV
✗ taqepka			*
taqipka	*		
taqpka		*	

Now, we must find the rankings that protect mid-vowels when they are in privileged positions.

First consider a short mid vowel in a non-initial syllable of a noun stem, here [sqʰul'e] 'meadowlark'. In (17), [sqʰul'e] violates none of the faithfulness constraints, as it is fully faithful, and violates *MIDV once, for the final [e]. Compare this to the other two candidates, which each satisfy *MIDV but violate one of the positional faithfulness constraints, since the input is a NOUN stem. Both ID(HI)/NOUN and MAX-V/NOUN must be ranked above *MIDV.

(17) *Protecting [e] in nouns*

/sqʰul'e/ NOUN	ID(HI)/NOUN	MAX-V/NOUN	*MIDV
☞ sqʰul'e			*
sqʰul'		*W!	L
sqʰul'i	*W!		L

Protecting [e] in initial syllables works completely analogously with protecting [e] in nouns. The tableau in (18) shows that the [e] in [tejuːwa] 'dares someone to do' is protected by ranking ID(HI)/σ_1 and MAX-V/σ_1 over *MIDV.

(18) *Protecting [e] in initial syllables*

/tejuːw-a/	ID(HI)/σ_1	MAX-V/σ_1	*MIDV
☞ te.juː.wa			*
tjuː.wa		*W!	L
ti.juː.wa	*W!		L

Importantly, these positional faithfulness constraints are not violated by repairs to /e/ that were in unprivileged positions, so the /e/ in /taqepka/ is not protected by them.

(19) *Unprivileged /e/ does not violate positional faithfulness*

/taqepk-a/	ID(HI)/NOUN	ID(HI)/σ_1	*MIDV	ID(HI)
taqepka			*W!	L
☞ taqipka				*!

By ranking the positional faithfulness constraints above *MIDV and the general ones below, we obtain a language where [e] never surfaces in noninitial syllables of verbs, which is the distribution seen in Klamath.

4.2 Modeling the [i]-[∅] alternation.

We've shown that unprivileged /e/ cannot surface. Now it is necessary to show how unprivileged /e/ alternates between [i] and [∅]. Deletion is the preferred repair for mid vowels, because when /e/ raises only when deletion would create a phonotactically illicit cluster, and deletes in all other contexts.

MAX-V must be dominated by ID(HI) as seen in (20). The first [e] in each of these is protected by ID(HI)/σ_1 and MAX-V/σ_1 being ranked above *MIDV. However, the second [e] in [ntʰeweʔa] is not protected by any faithfulness constraints ranked above *MIDV. By ranking ID(HI) above MAX-V, the second /e/ deletes, as in [ntʰew'a] rather than raise it to [i], like in [ntʰewiʔa].

(20) */e/ deletes by default*[4]

/ntʰeweʔ-a/	*MIDV	ID(HI)	MAX-V
☞ ntʰe.w'a	*		*
ntʰe.wi.ʔa	*	*W!	L
ntʰe.we.ʔa	**W!		L

---

[4]The rankings necessary to drive glottal coalescence and deletion are irrelevant to the discussion here, so I ignore all candidates that would show non-Klamath-like glottalization.

In order to prevent /e/ from deleting and prefer raising in the appropriate contexts, there must be some syllable structure constraints militating against illicit clusters. The actual details of Klamath phonotactics are highly complex so for the purposes of this paper, I will simplify the system. Word final [Ctk^h] clusters do not appear for the majority of consonants, and [e] reduction occurs rather than deletion when it would create a [Ctk^h#] cluster. By no means are these the only clusters that would prevent /e/ from deleting–many other examples exist in Barker (1963)

(21) *Other contexts where /e/ cannot delete.*

[samp'al**i**ttan?a]	'keeps making mistakes'	[samp'alta]	'makes a mistake'
[kak'iːm**i**bli]	'goes back arnd. the edge'	[kak'iːm'a]	'goes arnd. the edge'
[waqs**i**k^{h}anka]	'gallops around'	[waqs?a]	'gallops'

Here I will use a cover constraint PHTAC, defined to model this system specifically, but know that this constraint is just a simplification of the interactions of many more rigorously defined constraints.

(22) PHTAC- Assign a violation mark for any consonant cluster that is phonotactically illicit in Klamath, i.e. [Ctk^h#]

With PHTAC ranked above ID(HI), the preference for deletion over reduction of /e/ reverses. In (23), the deletion candidate, which would win with just the ranking seen in (20), now violates PHTAC, because it has a word final [wtk^h] cluster. Since *MIDV dominates ID(HI), however, /e/ raises rather than surfacing faithfully.

(23) PHTAC *drives raising of /e/ to [i]*

	/nt^{h}ewe?-tk^h/	PHTAC	*MIDV	ID(HI)	MAX-V
☞	nt^{h}ewitk^h			*	
	nt^{h}ewetk^h		*W!	L	
	nt^{h}ewtk^h	*W!		L	*W

Due to the details of Klamath syllable structure, which are only hinted at here, PHTAC is not violated by all consonant clusters. In (24), because [wl̥] is a perfectly licit cluster in Klamath, [nt^{h}ewl̥i] ends up beating the raising candidate [nt^{h}ewil̥i].

(24) *Not all clusters are illicit*

	/nt^{h}ewe?-l̥i/	PHTAC	*MIDV	ID(HI)	MAX-V
	nt^{h}ewil̥i			*W!	L
	nt^{h}ewel̥i		*W!		L
☞	nt^{h}ewl̥i				*

By ranking ID(HI) above MAX-V and PHTAC and *MIDV over ID(HI) non-privileged /e/'s show the [i]-[∅] alternation as seen in Klamath.

4.2.1 The long vowel alternation

Long /eː/ deletion can be motivated by *MIDV as well. Since long mid vowels are not safe from deletion, MAX-V/Vː must be ranked below *MID, as seen in (25). [nt'us?a] beats [nt'useː?a] because *MIDV favors it, and is ranked above MAX-V/Vː. ID(HI)/Vː must dominate MAX-V/Vː as well, because that constraint is the only one that favors the winner to the reduction candidate, [nt'usiː?a].

(25) *Long /eː/ deletes when it can*

/nt'useːʔ-a/	PHTAC	ID(HI)/Vː	*MIDV	MAX-V/Vː
☞ *nt'usʔa*				*
nt'useːʔa			*W!	L
nt'usiːʔa		*W!		L

On the other hand, when PHTAC would be violated by a deleting candidate, the long /eː/ remains faithful. Therefore, PHTAC must dominate *MIDV, so [nt'useːtkʰ] beats [nt'ustkʰ]. Since long /eː/ never reduces, ID(HI)/Vː must dominate *MIDV so that a candidate with a raising long /eː/ always loses to the faithful candidate.

(26) *Long /eː/ never raises to [iː]*

/nt'useːʔ-tkʰ/	PHTAC	ID(HI)/Vː	*MIDV	MAX-V/Vː
☞ *nt'useːtkʰ*			*	
nt'usiːtkʰ		*W!	L	
nt'ustkʰ	*W!		L	*W

Long /eː/ is protected in otherwise privileged positions, say if a long /eː/ is in an initial syllable, by the same positional faithfulness constraints we used in 4.1, since those constraints apply regardless of the length of the vowel. Those rankings found above also explain why /eː/ deletion is only seen in noninitial syllables of verb stems, and not any other privileged positions.

By ranking the markedness constraint between the two positional faithfulness constraints, only the lower ranked repair is available, which allows for a less abstract alternation. Since long mid vowels show this sort of alternation, we have greater evidence that short mid vowels in these positions would not surface faithfully. The gap in the surface distribution [e] is principled rather than accidental.

4.3   Summary of Constraint Rankings

In order to model this Klamath alternation, we needed three sets of rankings. First, the rankings in (27) drive the surface distribution of [e]. Second, to allow /e/ to alternate between [i] and [∅] we need the rankings in (28). Finally, the rankings in (29) allow /eː/ to show the [eː]-[∅] alternation.

(27) a. ID(HI)/NOUN, MAX-V/NOUN ≫ *MIDV

    b. ID(HI)/σ_1, MAX-V/σ_1 ≫ *MIDV

    c. *MIDV ≫ Some repair for [e] (ID(HI), MAX-V, etc.)

(28) a. ID(HI) ≫ MAX-V

    b. PHTAC, *MIDV ≫ ID(HI)

(29) a. *MIDV ≫ MAX-V/Vː

    b. PHTAC, ID(HI)/Vː ≫ *MIDV

Critically, the rankings in (27) and (29) are uncontroversially necessary for Klamath. Neither of these sets of rankings use abstract URs, rather (27) is necessary to find the correct distribution of [e] from richness of the base inputs, and long /eː/ deletion, represented in (29) is not an abstract alternation, because the long /eː/ does surface somewhere. The only two additional rankings needed to find Klamath

if /e/ underlies the [i]-[∅] alternation are those in (28). Since PHTAC must dominate *MIDV, truthfully only two rankings are necessary to use /e/ as the abstract UR for this alternation, ID(HI) ≫ MAX-V and *MIDV ≫ ID(HI).

5 Abstract URs

Barker (1964) uses an abstract morphophoneme, /i̱/ as the UR for the [i]-[∅] alternation. This UR was defined specifically to represent this alternation, and only appeared in lexical items that showed the alternation. In a featural theory of phonology, however, this abstract UR must be featurally distinct from /i/. We have two requirements for the abstract UR that represents the [i]-[∅] alternation. First, the UR should be minimally featurally distinct from [i], or else becoming [i] would incur a great number of faithfulness violations. Second, the UR cannot surface faithfully in the same positions as the [i]-[∅] alternation.

/e/ is distinct from /i/ in just one feature, /e/ is [-hi] to /i/'s [+hi], and we saw above that the UR cannot have no features distinct from /i/, because [i] surfaces faithfully in the same environments as the alternation. We've shown that /e/ does not surface in these positions, so it is able to serve as the UR by these two criteria.

However, /e/ is not the only segment that fits these two criteria this well. Many features exist so that one could change /i/'s value for that feature and the resulting segment would not contrast with the alternation. We could use [±ATR] ([ɪ]), [±round] ([y]), [±nasal] ([ĩ]) or many other features, phonetically based or not. A simple constraint ranking could be found for each of these to drive the alternation, PHTAC ≫ M ≫ ID(F) ≫ MAX-V, where M represents some markedness constraint that marks the abstract segment. Such a markedness constraint must exist and be relatively high ranked, because the segment never appears on the surface in Klamath normally. Yet, there remain a few reasons we would prefer /e/ to any of these URs.

None of these other segments would ever surface anywhere in Klamath, whereas /e/ surfaces freely in nouns, initial syllables, and sometimes when long. The gap in the surface distribution of [e] explains the distribution of [i]-[∅]. If we used a different UR to represent the alternation, we could expect to see the [i]-[∅] alternation in initial syllables of verb stems or in nouns, but we do not. Further, if we claimed /y/ (or some other form) underlied the [i]-[∅], we may posit that the UR /yː/ could underlie a non-observed [iː]-[∅] alternation, since all other vowels have a length contrast.

It is possible to devise of OT grammars where /y/ would show the [i]-[∅] alternation only in noninitial syllables of verbs, and always neutralize to [i] or something else in any more privileged position and have /e/ surfacing faithfully in privileged positions, but neutralizing without alternations in noninitial syllables of verbs. But these grammars require an unnecessary and unwanted level of complexity; none of these other potential URs is closer to [i] than /e/, but the grammar must now include an additional feature to create the additional contrast with /i/.

From a learning perspective, it seems likely that learners would prefer to represent contrasts in their lexicon with features that are already being used to create contrasts is similar environments. Since [±hi] is already used to differentiate be-

tween front vowels in privileged positions to distinguish [i] and [e], it is intuitive for a learner to continue to use [±hi] to distinguish between [i] and [i]-[∅]. In some substance-free phonological theories, features are not inherent, but are learned when needed (See Blaho (2008) (Ch. 1) for a survey of such works). In such a theory, the learner would be unable to use a feature like [±round] or [±ATR] if an already necessary feature like [±hi] would work as well. For more non-substance free arguments why a learner would prefer to get the most out of one feature before using another for abstract URs, see O'Hara (2015).

No issues remain to prevent us from claiming that /e/ represents the [i]-[∅] alternation. All other abstract URs have the same issues as /e/, with less benefits. By getting the most utility out of each of the contrasts extant in the grammar, we can find the best grammar.

6 Conclusions

In this paper I have shown /e/ to be the best abstract UR for the [i]-[∅] alternation in Klamath. /e/ fulfills several criteria for evaluating potential abstract URs: URs should be proximal to their alternants, URs should never surface contrastively with an abstract alternation, URs should not have large accidental gaps where they do not appear lexically, and URs should make the most use of already contrastive features. Each of these criteria is in principle violable, but when comparing two potential abstract URs we select the one that performs best on these criteria.

Some of these criteria are trivially a part of phonological theory, i.e. a UR should not contrast with its surface exponents in the same context. For a phonological grammar to act as a function, it must not allow the same input to contrastively surface as two outputs. Upcoming work (O'Hara 2015) shows that all of these criteria are emergent features of current phonological learning theories. Each of these criteria exists as a mathematical property of a phonological learner based on those already found in the literature (Jarosz 2006; Tesar 2014; Hayes & Wilson 2008).

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