Never Surfacing Underlying Representations in Klamath

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Introduction

- In Klamath (Barker, 1963, 1964) an alternation is seen between [i] and [∅].
- This alternation cannot be caused by i-deletion or i-epenthesis.
- However, this alternation is in complementary distribution with /e/.
- This alternation can be represented underlyingly with /e/.
- Though /e/ is an abstract UR for such alternations, these forms are learnable due to emergent properties of MaxEnt learners.

Phonemic Inventory of Klamath

- Klamath was a Plateau Penutian language spoken in south-central Oregon.
- There are no living native speakers.
- My data comes from my digital transcription of Barker's Klamath Dictionary (1963).
- This searchable representation is available on my website. (https://dornsife.usc.edu/ohara/klamathdictionary/)

Vowels of Klamath (Adapted from Blevins (1993))

Vowels	+front		+long	+front	
+hi	i	u	+hi	i:	u:
	e	a		e:	a:

[i]∼[∅] Alternation

- Around 50 stems show [i] before the /-tk^{h}/ morpheme, but appear consonant final before the indicative /-a/ suffix.

a)	[ʔeːw̥a]	‘is deep’	(D: 31)
b)	[ʔeːw̥**i**tk^{h}]	‘deep’	

- Suffixes like that in (c) show that this is not (just) a hiatus resolution effect.

a)	[nt^{h}eːw’a]	‘breaks with a round instrument’	(D: 403)
b)	[nt^{h}eːw**i**tk^{h}]	‘broken’	
c)	[nt^{h}ewl̥i]	‘breaks into’	

Possible Concrete URs

- The two possible concrete URs for a form like [ʔeːw̥a]-[ʔeːw̥itkʰ] are /ʔeːw̥/ and /ʔeːw̥i/.
- If /ʔeːw̥/ was the underlying form, we would need to see [i]-epenthesis to break up the word-final [w̥tkʰ] cluster.
- If /ʔeːw̥i/ was the underlying form, we would need to see stem final /i/ deletion when not phonotactically necessary.

Epenthesis

[a] is the default epenthetic vowel in Klamath.

/snak'l-a/	[snak'la]	'has spots on the face'	(D: 379)
/snak'l-s/	[snak'als]	'pregnancy spots'	
/p^{h}ip^{h}iːk'-tk^h/	[p^{h}ip^{h}iːk'atk^h]	'wearing a bracelet'	(D: 301)
/p^{h}ip^{h}iːk'-s/	[p^{h}ip^{h}iːks]	'bracelet'	
/taq'-ni/	[taqni]	'Sharp One'	(D: 109)
/taq'-tk^h/	[taq'atk^h]	'sharp-edged	

- /ʔeːw̥/ should show [a]-epenthesis, contrary to the observed forms.
  - /ʔeːw̥-a/-[ʔeːw̥a]
  - */ʔeːw̥-tk^h/-[ʔeːw̥atk^h]

Non-Alternating [i]

Underlying /i/ drives deletion of /a/ in hiatus resolution.

/stupw̥i-a/	[stupw̥i]	'has first menstruation'	(D: 358)
/stupw̥i-tkʰ/	[stupw̥itkʰ]	'woman'	
/slaːm'i-a/	[slaːm'i]	'becomes a widower'	(D:373)
/slaːm'i-tkʰ/	[slaːm'itkʰ]	'widower'	
/sn'eːwl̥i-a/	[sn'eːwl̥i]	'gets a cold'	(D: 381)
/sn'eːwl̥i-tkʰ/	[sn'ewl̥itkʰ]	'one having a cold'	

- /ʔeːw̥i/ should not show /i/-deletion, contrary to the observed forms.
  - */ʔeːw̥i-a/-[ʔeːw̥i]
  - /ʔeːw̥i-tkʰ/-[ʔeːw̥itkʰ]

Distribution of [e]

- While all other vowels have a thorough distribution, [e] is relatively restricted in Klamath.
- Short [e] only appears in initial syllables of verb stems.

/tejuːw-a/ [tejuːwa] ‘dares someone to do’ (D: 113)

- Short [e] appears in any syllable of nouns.

/sq^{h}ul’e/ [sq^{h}ul’e] ‘meadowlark’ (D: 390)

- Long [eː] appears in any syllable, but only if its deletion would create an illicit cluster.

/nt’useː-tk^{h}/ [nt’useːtk^{h}] ‘swollen’ (D: 272)

Complementary Distribution

- The distribution of [e],
  - (nouns, initial syllables, or long vowels)

  is complementary with the distribution of the [i]-[∅] alternation
  - (final syllables of verb stems).
- /ʔeːw̥e/ can represent [ʔeːw̥a]-[ʔeːw̥itkʰ]
  - If phonotactically allowed, /e/ deletes.
  - If not, it raises.

Grounding

- Phonological contrasts are more likely to be maintained in privileged positions. (Beckman, 1998)
    - Long vowels are privileged over short vowels. (Steriade, 1995; Beckman, 1998)
    - Stem-initial syllables are privileged over other syllables. (ibid, Walker 2011; Trubetzkoy 1969)
    - Nouns show privilege over verbs. (Smith, 1997; Jesney & Tessier, 2011)
- Mid-vowels ([e]) are more marked than the corner vowels ([i a u]), and many languages show /e/-[i] raising in unprivileged positions. (Crosswhite, 2004)

Harmonic Grammar

- Following work in the phonological learning literature[1], I use weighted rather than ranked constraints, as in Harmonic Grammar (Legendre *et al.* , 1990, 2006).
- Here, I use Positional Faithfulness constraints.
- Marked structures are only allowed in privileged positions with the constraint ranking:
  - Positional Faithfulness ≫ Markedness ≫ General Faithfulness
- In HG, multiple low-weighted constraints can cumulatively interact to outweigh a higher-weighted constraint.
  - PosFaith+GenFaith > Markedness > GenFaith

[1] Goldwater & Johnson (2003); Wilson (2006); Hayes & Wilson (2008); Hayes *et al.* (2009); Potts *et al.* (2010); Jesney & Tessier (2011) among others.

Distribution of [e]

- In order to find that [e] is protected in initial syllables, w(F)+w(F/σ_1)> w(*MidV)

	$w = 3$	$w = 2$	$w = 2$	
/tejuːwa/	*MidV	Id[hi]	Id[hi]/σ_1	H
☞ a. te.juː.wa	-1			-3
b. ti.juː.wa		-1	-1	-4
	$w = 3$	$w = 2$	$w = 2$	
/tejuːwa/	*MidV	Max-V	Max-V/σ_1	H
☞ c. te.juː.wa	-1			-3
d. tjuː.wa		-1	-1	-4

Distribution of [e] II

- In order to find that [e] is protected in nouns, $w(F) + w(F_{\text{NOUN}}) > w(\text{*MIDV})$

	$w = 3$	$w = 2$	$w = 2$	
/sq^{h}ul'e$_{Noun}$/	*MIDV	ID[HI]	ID[HI]$_{\text{NOUN}}$	H
☞ a. sq^{h}u.l'e	-1			-3
b. sq^{h}u.l'i		-1	-1	-4
	$w = 3$	$w = 2$	$w = 2$	
/sq^{h}ul'e$_{Noun}$/	*MIDV	MAX-V	MAX-V$_{\text{NOUN}}$	H
☞ c. sq^{h}u.l'e	-1			-3
d. sq^{h}ul'		-1	-1	-4

Distribution of [e] III

- Since long [eː] does surface in noninitial syllables of verbs, $w(\text{Id[hi]}) + w(\text{Id[hi]/V:}) > w(\text{*MidV})$.

	$w = 3$	$w = 2$	$w = 2$	
/nt'useːtkʰ/	*MidV	Id[hi]	Id[hi]/Vː	H
☞ a. nt'useːtkʰ	-1			-3
b. nt'usiːtkʰ		-1	-1	-4

Driving the [i]-[∅] Alternation

- In order to get [e] deleting by default,
  $w(\text{*MidV}), w(\text{Id[hi]}) > w(\text{Max-V})$

	$w = 3$	$w = 2$	$w = 1$	
/ʔeːw̥e-ta/	*MidV	Id[hi]	Max-V	H
☞ a. ʔeːw̥ta	-1		-1	-4
b. ʔeːw̥ita	-1	-1		-5
c. ʔeːw̥eta	-2			-6

- So that [e] raises when it cannot delete,
  $w(\text{PhTac}) + w(\text{Max-V}), w(\text{*MidV}) > w(\text{Id[hi]})$

	$w = 3$	$w = 2$	$w = 2$	$w = 1$	
/ʔeːw̥e-tkʰ/	*MidV	Id[hi]	PhTac	Max-V	H
a. ʔeːw̥tkʰ	-1		-1	-1	-6
☞ b. ʔeːw̥itkʰ	-1	-1			-5
c. ʔeːw̥etkʰ	-2				-6

Summary of Analysis

- By using /e/ in the underlying forms for verbs with the [i]∼[∅], we gain several theoretical benefits:
  - The same constraints needed to restrict [e]'s surface distribution can be used to drive this alternation.
  - A large class of verb stems do not need to be marked overtly as exceptional.
  - There is additional evidence from the behavior of long /eː/ and the interaction with glottalization to back this up.
- However, a UR with a segment that does not occur on the surface anywhere is abstract, and some question the learnability of abstract URs.

Abstractness

- 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 Klamath, /ʔeːw̥e/ is an abstract UR, because the /e/ does not surface in any of the surface exponents of the morpheme.

Questions

- Are abstract URs learnable?
- And if so, why do we prefer /ʔeːw̥e/ to any other abstract UR.
    - The original morphophonemic account given in Barker (1964) uses an abstract UR similar to /ʔeːw̥ɪ/, where /ɪ/ only appears in the words showing the [i]-[∅] alternation.

CLAIM

Using a set of assumptions common in the phonological learning literature, not only are abstract URs learnable, but /ʔeːw̥e/ is preferred to /ʔeːw̥ɪ/

MaxLex

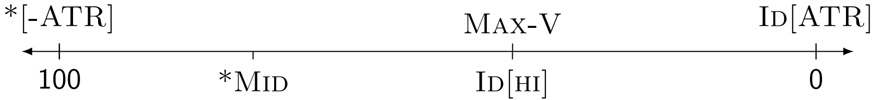
- My learning algorithm, MaxLex (A Maximum Entropy learner of Lexicons and Grammars), is based on several assumptions made by many different phonological learners.
  - MaxLex uses a Maximum Entropy grammar
    - following Goldwater & Johnson (2003); Wilson (2006); Hayes & Wilson (2008); Jäger & Rosenbach (2006); Jäger (2007); Hayes *et al.* (2009) and many others.
  - MaxLex first learns a phonotactic grammar at one stage and then becomes morphologically aware,
    - (Hayes, 2004; Jarosz, 2006; Tessier, 2007; Jesney & Tessier, 2011; Tesar, 2014; Alderete *et al.* , 2005; Merchant, 2008)
  - To find the most restrictive grammar, faithfulness constraints are biased low (as close to 0), and markedness constraints are biased high (as close to 100).
    - (Jesney & Tessier, 2011)
  - In order to learn the lexicon, MaxLex assigns a probability distribution across a set of possible URs.
    - (Jarosz, 2006)

- The phonotactic grammar must learn the surface distributions of /e/ and /ɪ/.
- Thus, $w(F) + w(PosFaith(F, P)) > w(*\textsc{Mid})$, for each faithfulness Constraint F, and each position where /e/ surfaces, or else /e/ would repair somehow in that position.
  - $w(\textsc{Id}(\textsc{hi}))+w(\textsc{Id}(\textsc{hi})/\textsc{Noun})> w(*\textsc{Mid})$
  - $w(\textsc{Id}(\textsc{hi}))+w(\textsc{Id}(\textsc{hi})/\sigma_1)> w(*\textsc{Mid})$
  - $w(\textsc{Id}(\textsc{hi}))+w(\textsc{Id}(\textsc{hi})/\mathrm{V}ː)> w(*\textsc{Mid})$
- In order for /ɪ/ to surface nowhere in Klamath, $w(*\text{-ATR}) > w(F) + \sum_P w(PosFaith(F, P))$.
- To ensure restrictiveness, the learner minimizes the sum of the squares of the faithfulness constraints.
  - $\textsc{Id}[\textsc{hi}]$must be weighted above $\frac{n}{n+1} w(*\textsc{Mid}\mathrm{V})$, where n is the number of specific constraints violated with it (here 3).
  - $\textsc{Id}[\textsc{hi}]/\mathrm{V}ː$, $\textsc{Id}[\textsc{hi}]/\sigma_1$, $\textsc{Id}[\textsc{hi}]_{\textsc{Noun}}$all must be weighted near $\frac{1}{n+1} w(*\textsc{Mid}\mathrm{V})$.
  - $\textsc{Id}[\mathrm{ATR}]$ is weighted 0 since it never has to outweigh anything, alone or with other constraints.

- I ran simulations of the phonotactic learner looking just at verbs without noninitial long e.
  - I biased faithfulness constraints near 0 and markedness constraints near 100.
  - (I did not use the constraints $\textsc{Id}[\textsc{hi}]/\mathrm{V}ː$ or $\textsc{Id}[\textsc{hi}]_{\textsc{Noun}}$ in the sim)
- Since my simulation uses MaxEnt rather than HG, the weights of the constraints must be more extreme than they need to be in HG.
- However the distribution of weight between general and specific constraints will remain the same.
  - For this sim, $n = 1$ so $w(\textsc{Id}[\textsc{hi}]) \sim w(\textsc{Id}[\textsc{hi}]/\sigma_1) > \frac{w(*\textsc{Mid}\mathrm{V})}{2}$

Constraint Weights Learned by Phonotactic Grammar

Constraint	Learned Weight	Constraint	Learned Weight
Id[hi]	40.1280662622	Id[ATR]	0
Id[hi]/σ_1	40.1280662622	Id[ATR]/σ_1	0
Max-V	40.1050314302	Dep-V	8.25610961151
Max-V/σ_1	40.1050314302	*[-ATR]	100.000031978
*MidV	74.4312330447	PhTac	100.000031978

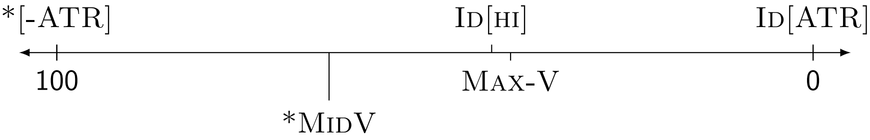


- We see that the Id[hi] and Id[hi]$_{\text{Noun}}$ share equal distribution of the weight.
- On the other hand since ATR contrasts are never maintained in Klamath, Id[ATR] never dominates anything and gets 0 weight.

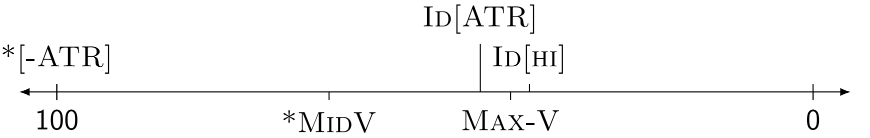
Morphologically aware learning

- I consider the possible URs /ʔeːwe̥/ and /ʔeːwɪ̥/, along with the concrete URs.
- For /e/ in unprivileged positions to show the [i]∼[∅] alternation:
  - $w(\textsc{Id}(\textsc{Hi})) > w(\textsc{Max-V})$
  - Both must be outweighed by $*\textsc{Mid}$.
  - $w(\textsc{Max-V}) + w(\textsc{PhTac}) > w(\textsc{Id}(\textsc{Hi}))$
- For /ɪ/ to show the alternation:
  - $w(\textsc{Id}(\text{ATR})) > w(\textsc{Max-V})$
  - Both must be outweighed by $*[\text{-ATR}]$.
  - $w(\textsc{Max-V}) + w(\textsc{PhTac}) > w(\textsc{Id}(\text{ATR}))$

- In order for /ʔeːw̥e/ to model the alternation:
- $w(\textsc{Id}[\textsc{hi}])^2 + w(\textsc{Max-V})^2 + w(\textsc{Id}[\textsc{ATR}])^2 \sim 3,364$



- In order for /ʔeːw̥ɪ/ to model the alternation:
- $w(\textsc{Id}[\textsc{hi}])^2 + w(\textsc{Max-V})^2 + w(\textsc{Id}[\textsc{ATR}])^2 \sim 4,733$



- The top option does better on the learning bias, and is a more restrictive grammar.

- My simulation started with equal distribution across 4 possible URs, /ʔeːw̥e/, /ʔeːw̥ɪ/, /ʔeːw̥/, and /ʔeːw̥i/.
- After the simulation runs, the URs with /e/ have each accrued over .999999999 probability.
- This confirms that the URs with /e/ are learned over other abstract URs.

Generalization of results

- The more privileged positions a faithfulness constraint is respected in (a contrast is maintained in), the higher weighted it will be.
- The higher weighted a faithfulness constraint is, the more likely an alternate repair is chosen to prevent that contrast from appearing in those positions it doesn't.
- Thus, the more positions a featural contrast occurs in, the more likely that feature can be used to represent abstract alternations in the positions where it does not occur.

Conclusion

- Analyzing the [i]∼[∅] alternation as a loss of vowel contrasts in unprivileged positions simplifies the grammar of Klamath, and is the most restrictive grammar available.
- This analysis not only explains this phenomenon but explains gaps in the distribution of [e].
- This abstract UR is learnable, and easier to learn than any other abstract UR.

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Constraints

- ID[HI]- Violated by changing the [hi] feature of a segment. /e/→[i]
- MAX-V- Violated by deleting a vowel. /e/ →[∅]
- *MIDV- Violated by mid vowels in output. [e].
- PHTAC- Violated by illicit clusters. [Ctk^h]
- *F*/*P*- Violated by violations of a faithfulness constraint *F* in a position *P*.

- However, most of the verb stems in Barker (1963) with noninitial long /e/ have allomorphs where the /eː/ deletes.
- An investigation of this allomorphy shows that these /eː/-less forms surface in the same environments where short /e/ deletes.
  - /nt'useːʔ-tk^h/→[nt'useːtk^h], but
  - /nt'useːʔ-a/→[nt'usʔa]

Long /e/s in verbs are not totally protected

PhTac, Id[hi]/Vː≫*MidV≫Max-V/Vː

/ntʼuseːʔ-tkʰ/	PhTac	Id[hi]/Vː	*MidV	Max-V/Vː
☞ a. ntʼu.seːtkʰ			$*_{eː}$	
b. ntʼu.siːtkʰ		$*_{iː}$ W	L	
c. ntʼustk	$*_{stk}$W		L	$*_{eː}$W
/ntʼuseːʔ-a/	PhTac	Id[hi]/Vː	*MidV	Max-V/Vː
☞ d. ntʼusʔa				$*_{eː}$
e. ntʼu.siːʔa		$*_{iː}$ W		L
f. ntʼuseːʔa			$*_{eː}$W	L

Glottalization Effects

- The glottal stop in Klamath tends
  to coalesce with the previous consonant when in a CʔV context.
  /pʰetʃ-ʔaːk'/ [pʰetʃ'aːk] 'little foot' (Barker, 1964, p. 54)
- The [constricted glottis] node usually deletes when not in syllable onset.
  /n-tʰit'-tqi/ [ntʰittqi] 'defecates' (Barker, 1963, p. 408)

[i] Epenthesis?

- In order to get [ʧimaːʔas], [a] epenthesis must bleed [cg] deletion.

U.R.	/ʧimaːʔ-s/	/ntʰeːw’-tkʰ/
[a]-Epen	ʧimaːʔas	ntʰeːw’atkʰ
[cg]-Del	—	—
S.R.	[ʧimaːʔas]	[ntʰeːw’atkʰ]

- But in order to get [ntʰeːwitkʰ], through [i]-epenthesis, [i]-epenthesis must counter-bleed [cg]-deletion.

U.R.	/ʧimaːʔ-s/	/ntʰeːw’-tkʰ/
[cg]-Del	ʧimaːs	ntʰeːwtkʰ
[i]-Epen	—	ntʰeːwitkʰ
S.R.	[ʧimaːs]	[ntʰeːwitkʰ]

[i] Epenthesis?

- However, if we assume this ordering, [a]-Epenthesis should bleed [i]-Epenthesis, since [i]-Epenthesis occurs in contexts where we expect to see [a]-Epenthesis.
- Without some sort of abstract feature preventing [a]-epenthesis, we cannot get [ntʰeːwitkʰ]

U.R.	/ʧimaːʔ-s/	/ntʰeːw'-tkʰ/	/ntʰeːw'-tkʰ/$_{\text{No a-epen}}$
[a]-Epen	ʧimaːʔas	ntʰeːw'atkʰ	—
[cg]-Del	—	—	ntʰeːwtkʰ
[i]-Epen	—	—	ntʰeːwitkʰ
S.R.	[ʧimaːʔas]	[ntʰeːw'atkʰ]	[ntʰeːwitkʰ]

- Thus, this analysis is just as abstract as the /i̲/ analysis, since all the same stems must be marked.

Richness of the Base

- Under this analysis, verbs with /e/ in non-initial positions have either /e/ raising or /e/ deletion.
  - Typically, non-initial /e/ deletes.
  - If deletion would create a phonotacticly illicit cluster, /e/ raises instead.
- [Ctk^h] is an illicit coda in Klamath.
- If the /e/ is morpheme final, we see the [i]∼[∅] alternation, because /e/ must raise to avoid [Ctk^h].
  - /...Ce-a/→[...Ca]
  - /...Ce-tk^h/→[...Citk^h], *[...Ctk^h]

Richness of the Base II

- If a glottal stop intervenes between /e/ and the end of the stem, the glottal stop will delete in order to avoid the [ʔtk^h] coda, so /e/ will raise before /-tk^h/.
  - /...Ceʔ-a/→[...C'a]
  - /...Ceʔ-tk^h/→[...Citk^h],*[...Ctk^h]
- If any other consonant intervenes between /e/ and the end of the stem, this alternation will not appear, because epenthesis will break up the [Ctk^h] cluster.
  - /...CeC-a/→[...CCa]
  - /...CeC-tk^h/→[...CCatk^h]
- These stems will be lexicalized as having no /e/, since this /e/ deletes in all contexts.
- If an /e/ exists stem internally breaking up a large cluster, it should always raise, no matter what suffixes are applied.
  - /...CCeCC-a/→[...CCiCCa],*[...CCCCa]
  - /...CCeCC-tk^h/→[...CCiCCatk^h]
- These stems will always be lexicalized as containing /i/.

Richness of the Base III

- With this analysis, any gaps in the distribution of /e/ throughout the lexicon are caused by total neutralization with /i/ or /∅/.
- No abstract phonemes have highly specific distributions in the lexicon.