Glossa a journal of general linguistics

Gleim, Daniel. 2019. A feeding Duke-of-York interaction of tone and epenthesis in Arapaho. *Glossa: a journal of general linguistics* 4(1): 97. 1–27. DOI: https://doi.org/10.5334/gjgl.805

RESEARCH

A feeding Duke-of-York interaction of tone and epenthesis in Arapaho

Daniel Gleim
University of Leipzig, DE
daniel.gleim@uni-leipzig.de

In the Algonquian language Arapaho, epenthetic vowels only show up if they can attract an underlying floating high tone. I argue that this co-dependency of tone and epenthesis should not be analysed as tone-triggered epenthesis (which has been claimed not to exist, Blumenfeld 2006). Instead, I conclude that the pattern should be analysed as an opaque interaction of epenthesis, tone assignment and vowel deletion. Since the epenthetic vowel is first inserted and later deleted, this interaction constitutes an instance of what is called a Duke-of-York gambit or derivation – more precisely a feeding Duke-of-York derivation, because the epenthetic vowel leaves traces behind. This type of opacity is conceptually intriguing for both constraint and rule-based models of phonology, but proves especially problematic for Optimality Theory (OT). I claim that the best analysis with constraint-based frameworks lies in the adoption of Stratal OT (Kiparsky 2000; Bermúdez-Otero 2011). Epenthesis applies in a first stratum where the epenthetic vowel is involved in segmental processes, deletion then applies on a higher stratum.

Keywords: Duke-of-York; epenthesis; tone; Stratal OT; Harmonic Serialism

1 Introduction

In tone languages, vowels prefer to have a tone and tones a vowel. Toneless vowels will readily receive a tone – in many cases an inserted, epenthetic default tone. On the other hand, cases of vowel epenthesis for a floating tone to receive a host are claimed to be unattested, even impossible (Blumenfeld 2006). Blumenfeld (2006) states in his work on possible procedures that tone is not a possible trigger for epenthesis without going into detail. In this paper, I discuss data from the Algonquian language Arapaho (Cowell & Moss 2008) that has not been accounted for in theoretical phonology. In this language, surface epenthetic vowels that resyllabify coda-consonants are restricted to positions preceding morphemes that carry a floating high tone. This tone is then realised on the epenthetic vowel (1-b). If there is only a coda, but no floating high tone, epenthesis fails to apply (1-a).

(1) Cowell & Moss (2008: 481–2)
  a. [hoow-bén]
     /hoowbén/
     'S/he doesn't drink'
  b. [hoowúbetéee]
     /hoow-^{H}betéee/
     'S/he doesn't dance'

An analysis as epenthesis triggered by the floating tone hence suggests itself. Nevertheless, a closer examination of the data reveals that such an analysis cannot be correct and that Blumenfeld's claim can be maintained. I argue that the floating tone is not responsible for the epenthesis, rather it merely protects the epenthetic vowel from deletion at a later step. Put differently, both forms in (1) contain a floating vowel at an intermediate stage of the derivation. This vowel is deleted later in (1-a), but not in (1-b).

Such a derivation in which one operation undoes a previous operation involves what is called a Duke-of-York gambit (Pullum 1976) and is problematic for various phonological theories, especially though for Optimality Theory (OT). McCarthy (2003) argues that the Duke-of-York phenomena described in the literature are vacuous, they do not need the intermediate step and are thus no problem for OT. In addition, he claims that real, that is non-vacuous, and especially feeding Duke-of-York phenomena do not exist. I contend that Arapaho constitutes exactly such a non-vacuous, feeding Duke-of-York derivation. The epenthetic vowel is predictably either an [u] or an [i]. If it is an [i], it triggers certain consonantal changes like other front vowels in the language (2), in this case /w/ → [b].

(2) Cowell & Moss (2008: 18–19)
   a. [tʃebíse]
      /tʃew-^{H}see/
      ‘to walk along’
   b. [néé?eesínihíínoo]
      /néé?eeθ-^{H}nihíí-noo/
      ‘that’s what I’m saying’

However, those changes are also found where a) we would expect epenthesis based on syllable structure alone and b) the epenthetic vowel would be an [i], see (3). I argue that this is evidence that epenthesis applies to every word-internal coda and that epenthetic vowels that have not received a high tone are later deleted. However, the epenthetic vowel is present long enough to leave its traces in form of the consonantal changes.

(3) Cowell & Moss (2008: 16, 19)
   a. [nihbebíistiit]
      nih-bebíiθ-tii-t
      ‘s/he fixed it’
   b. [hétʃesnówo?]
      étʃex-nówo?
      ‘small fish’

Due to the necessary intermediate step, parallel OT is not able to derive this kind of non-vacuous Duke-of-York pattern. Harmonic Serialism (HS) is a version of OT that allows for intermediate steps, but is still incapable of deriving the pattern because of its requirement for *harmonic improvement*. I conclude that inside the family of OT-theories, Stratal OT is the best equipped for modelling the Arapaho data. Stratal OT presupposes a limited number of intermediate steps and allows the re-ranking of constraints between them. These instruments suffice to account for the data correctly. What distinguishes the Arapaho Duke-of-York pattern from others discussed in the literature (Bermúdez-Otero 2003; 2006; Rubach 2003)[1] is that it is a *feeding* Duke-of-York – the intermediate step feeds a process that would otherwise not apply. Note that I do not offer an argument against

[1] Bermúdez-Otero’s (2003; 2006) case (blocking of spirantisation in Catalan) is an instance of a bleeding Duke-of-York. Rubach’s (2003) case (Palatalisation in Polish) is rather an argument for strata, the Duke-of-York patterns follow only if very specific assumptions on representations and processes in Polish are adopted. Interestingly, the Catalan case depends on Richness of the Base, while the Polish case implies morpheme structure constraints. The Duke-of-York gambit in Arapaho does not depend on specific assumptions on underlying representations.

rule-based approaches; the data I present is compatible with a rule-based account as long as there are both intermediate representations and rule-reversal.

The paper is structured as follows: in Section 2, the notion of tone-triggered epenthesis is introduced and it is shown what a language with this type of epenthesis would look like and why HS cannot derive it. Then, I discuss Duke-of-York derivations, focussing mostly on McCarthy's (2003) classification, and which role they play in different frameworks. In Section 4, the core data from Arapaho, epenthesis under the presence of a floating tone, is introduced and in Section 5 analysed as tone-triggered epenthesis. After that, additional data shows that this surface-near analysis misses some crucial generalisations and cannot be correct. Then, in Section 6, I develop an analysis in Stratal OT that is able to account for all the facts.

2 Tone-triggered epenthesis

Vowel epenthesis is a rather simple phonological process that appears to be employed only to solve a limited range of phonologically marked structures: consonant clusters, syllable structure and word-subminimality (Blumenfeld 2006; Moore-Cantwell 2016). So far, a language in which a floating tone[2] induces insertion of an epenthetic vowel has not been described.[3] Blumenfeld (2006) claims that it is impossible for floating tones to induce epenthesis, but he does not provide an elaborate discussion on this matter.

In most models of Optimality Theory (Prince & Smolensky 2004) however, tone-triggered epenthesis can be modelled easily. Its factual absence is thus unexpected. However, a language in which floating tones are the sole trigger of epenthesis is conceptually not that easy to imagine. If the epenthetic vowel always emerges when the floating tone is present, like in (4) and they always associate, the tone-vowel complex that the two form would rather be analysed as an underlying representation including the vowel.[4]

(4)
$$\begin{array}{cc} \mathrm{L} & \mathrm{H} \\ | & \vdots \\ \tau & \tau_{EP} \end{array}$$

A condition in which there is no epenthesis is thus crucial in order to identify the epenthesis as such. The language therefore needs underlying toneless syllables in addition, which can function as a preferred host for the floating tone (5).

(5)
$$\begin{array}{cc} \mathrm{L} & \mathrm{H} \\ | & \vdots \\ \tau & \tau \end{array}$$

A language with these patterns should be analysed as tone-triggered epenthesis and is straightforwardly modelled in parallel OT (6). The undominated constraints force the floating tone to be realised (candidate a.) and penalise the formation of a contour tone (candidate b.) or the deletion of a tone (candidate c.). All these constraints are well established and their effects can be seen in a wide array of languages (Yip 2002). The winning candidate d. epenthesises a vowel as a host for the floating tone, violating a lower ranked constraint against epenthesis.

---

[2] The tone needs not be underlyingly floating. It could be displaced or spread by any sort of tonological process. For the sake of easier exposition, I will limit the discussion to genuine floating tones.

[3] But see Downing (2018) for the claim that a floating tone may be the trigger for reduplication. If this and my claims on epenthesis are both true, phonological theories must include a meaningful way of distinguishing epenthesis and reduplication.

[4] τ is used as a symbol for tone bearing unit (TBU) (Trommer 2011), and subscript EP marks epenthetic entities.

(6)

L H | τ	MAX-T	*CONT	*FLOAT	DEP-V	DEP|
a. L H | τ			*!		
b. L H |- - - τ		*!			*
c. H - - - τ	*!				*
☞ d. L H | ¦ τ τ_{EP}				*	*

As said before, such a language is unattested. The only counterexample I am aware of is due to Frajzyngier & Shay (2002), who describe the Chadic language Hdi as having floating tones that demand the insertion of epenthetic vowels. The data that they offer is however not conclusive: The most clear-cut case, the wh-pronoun [nú], is described in one part as consisting only of the consonant and the floating tone (Frajzyngier & Shay 2002: 31), at a later point, the vowel is analysed as part of the affix (Frajzyngier & Shay 2002: 356). It is striking, that this vowel behaves differently from epenthetic vowels inserted to repair syllable structure.

In contrast to parallel versions of OT, Harmonic Serialism (McCarthy 2000; 2010; 2016) is able to exclude tone-triggered epenthesis without complicated additional assumptions. HS is a serial version of OT in which the Generator (GEN) is allowed to perform only one operation before a round of evaluation (EVAL) chooses an optimal candidate. That candidate is then used as a new input to GEN, which again performs one operation. This GEN-EVAL cycle ends if the optimal output candidate is identical to the input, which is called convergence. The ranking of the constraints is fixed during this process – every candidate generated by GEN is subject to the same constraint ranking. This entails a crucial property of HS, *harmonic improvement*: the winning candidate may never be worse than its input, even though the worsening could lead to a globally more optimal outcome at a later step. An optimum that can only be reached by temporarily worsening the violation profile can never be attained. One of the central topics in HS literature is what counts as one operation and which processes can apply freely in every iteration. The impossibility of employing epenthesis to host the floating tone follows directly if we assume that the epenthesis of the vowel is one operation – this seems to be rather uncontroversial – and the association of the epenthetic vowel to the floating tone is another operation (7). The ranking in the HS tableau in (7) is the same as in (6), accordingly the candidates which involve deletion, surface floatingness and contouring are still out and omitted from the tableau. Candidate c., the winner in parallel OT, is not a possible candidate, since it needs two operations, epenthesis and association. This is marked by the lightning symbol. Candidate b., which involves epenthesis without association, is the necessary intermediate step for HS in order to emulate candidate c. in the second step. However, this candidate is harmonically bounded: it does not improve the violation profile – under any ranking of the given constraints – and is thus suboptimal. As this is the candidate that should win in order for the derivation to be successful at a later step, it is indicated with the telephone symbol.

(7)

L H | τ	MAX-T	*CONT	*FLOAT	DEP-V	DEP|
☞ a. L H | τ			*		
☎ b. L H | τ τ_{EP}			*	*!	
ϟ c. L H | ⁞ τ τ_{EP}				*	*

Particularly important for this analysis is the assumption that insertion of the vowel and tone-association are two different operations and cannot apply in one step. Outside HS, claims have been advanced that association to epenthetic material is gratuitous and does not violate faithfulness constraints (Trommer 2011). Translated to HS, this would mean that the association of the vowel to the floating tone does not count as an operation. Under such an approach, HS loses its advantage over parallel OT. It is however striking that analyses with free association to epenthetic material mostly address the association to material that it needs to be associated to in order to be phonetically interpretable. This is, in the case of the vowel, the syllable and not the floating tone. Toneless vowels are very well phonetically interpretable cross-linguistically, see e.g. McPherson (2013).

3 Duke-of-York derivations

The term Duke-of-York derivation was coined by Pullum (1976), who observed that there was a general suspicion shared by many linguists, phonologists and syntacticians alike, of derivations of the type A→B→A. He himself shares this scepticism, but argues that there were, at that point in time, no derivational frameworks that could exclude Duke-of-York derivations without stipulations. Furthermore, he claims that there are cases in which a Duke-of-York derivation may be simpler than the alternatives, or even the only possible one. However, in most cases analyses without a Duke-of-York gambit are preferable. A central but mostly implicit argument against Duke-of-York derivations is that they are considered to be unlearnable. However, there are no psycholinguistic studies that would confirm this, evidence points rather to the opposite (Dinnsen et al. 2001). McCarthy (2003) re-examines Pullum's (1976) claims in the light of Optimality Theory. He classifies Duke-of-York phenomena into vacuous ones, where the output is exactly identical to the input – all examples discussed in Pullum (1976) fall in this category – and non-vacuous ones. Vacuous Duke-of-York derivations are only an issue in rule-based frameworks,[5] based on the assumption that all rules must apply in a strict order: if there is evidence for a rule AB→AD and another rule DC→AC and underlying ABC surfaces as ABC, we must assume a Duke-of-York derivation like the one in (8).

(8)

UR	ABC
AB→AD	ADC
DC→BC	ABC

[5] This does not mean at all that rule-based phonology cannot derive vacuous Duke-of-Yorks. Rather, rule-based phonology might be forced to assume a Duke-of-York gambit, which is undesirable under the assumption that Duke-of-Yorks are inelegant/unlearnable.

Parallel OT can discard the intermediate step of the Duke-of-York gambit, turning it into a regular optimisation. It suffices to let a constraint *DC outrank a constraint *AB (9).

(9)

ABC	*DC	*AB
☞ a. ABC		*
b. ADC	*!	

More problematic for OT are non-vacuous Duke-of-York cases. McCarthy (2003) uses this term to refer to cases where something else happens to the structure at the intermediate, Duke-of-York step. These can be further divided into *bleeding* and *feeding* Duke-of-Yorks. In a bleeding non-vacuous Duke-of-York derivation, the intermediate step blocks the application of a rule that would apply in the input/output (10).

(10)

UR	ABC
AB→AD	ADC
AB→EB	*does not apply*
AD→AB	ABC

Bermúdez-Otero (2003; 2006) suggests exactly such an analysis for voicing assimilation in Catalan. McCarthy (2003) comments on the same case and claims that most bleeding non-vacuous Duke-of-Yorks can be reduced to vacuous ones for OT by employing slightly more complex constraints that are sensitive to a wider context (11).

(11)

ABC	*EBC	*DC	*AB
☞ a. ABC			*
b. ADC		*!	
c. EBC	*!		

True non-vacuous Duke-of-Yorks are, according to McCarthy, *feeding* non-vacuous Duke-of-York derivations. Here, the intermediate step feeds another process, the consequences of which are still visible after the structure has changed back to its original state (12).

(12)

ABC	UR
ADC	AB→AD
ADE	DC→DE
ABE	AD→AB

Feeding non-vacuous Duke-of-York derivations cannot be translated to parallel OT nor HS.[6] In McCarthy's (2003) eyes, this is a desirable result, as he claims that this type of Duke-of-York phenomenon does not exist. He constructs a toy-language – Pseudo-Tiberian Hebrew – where an epenthetic vowel spirantises a consonant and is then deleted. I show that the interactions of epenthesis, consonantal mutations[7] and tone in Arapaho are strikingly similar to this toy example and that non-vacuous, feeding Duke-of-York phenomena do indeed exist.

[6] They also constitute a type of opacity that is impossible in sympathy theory (McCarthy 2003).
[7] I will use the term *mutation* to refer to purely phonological processes, synonymously to change.

4 The core data

Arapaho is a Plains Algonquin language spoken in Wyoming and Oklahoma with between 500 (Cowell & Moss 2008) and 1000 speakers (Ethnologue 2018). As an Algonquian language, it has been traditionally described as a pitch accent language and non-tonal (Mithun 1999; Cowell & Moss 2008), but as Zimmermann (2011) and Zimmermann & Trommer (2011) point out, the language is better analysed as tonal.[8] To the author's knowledge, there has been no attempt to analyse the interaction of epenthesis and tone in Arapaho, except the rather descriptive rules in Cowell & Moss (2008). They suggest a similar approach as I do, though without a formal theoretical framework. I will start with a description of the tonal system of the language and the most relevant phenomena for this paper, epenthesis and floating tones. Later I will add more data that show that the Duke-of-York analysis is on the right track. All the data I use is drawn from Cowell & Moss (2008).

4.1 Phoneme inventory

The phoneme inventory of Arapaho is rather small, for all vowels, consonants and tonemes. Arapaho has a rather unusual four-vowel inventory of *ɛ, ɔ, i, u*, characterised by the lack of a phonetic low vowel (13). Length is a contrastive phonemic feature on plain vowels as well as on diphthongs. In the following, I will follow Cowell & Moss (2008) and Arapaho orthography and represent the vowels as *e,o,i,u*, and length by doubling.

(13)

front	back	
ɪ, iː	ʊ, uː	high
ɛ, ɛː	ɔ, ɔː	low
ɛi, ɛiː	ɔu, ɔuː	

The consonant inventory is quite small as well, with only twelve consonants (14). It is important to introduce the consonantal system, because the traces that the Duke-of-York epenthetic vowel leaves behind will manifest themselves mostly through consonantal changes. In addition, the quality of adjacent consonants bears an influence on the quality of the epenthetic vowel.

(14)

Non-Dorsal				Dorsal	Glottal
b		t	tʃ	k	ʔ
	θ	s		x	h
		n			
			j	w	

The distribution of /i/ and /u/ is almost allophonic, as [u] can be analysed as a rounded /i/ in almost all instances. The round vowel is restricted to a position preceded by dorsal consonants, and the unrounded high vowel to syllables with non-dorsal onsets. Between a dorsal onset and a palatal glide however, there is free variation (15).

(15) Cowell & Moss (2008: 15)
bííʔoxíjoo ~ bííʔoxújoo 'found in the grass'

[8] According to Hyman's (2009) criteria, Arapaho is clearly tonal, too: The high pitch is not cumulative, not obligatory and not metrically restricted. However, whether it is tonal or not does not play a crucial role for the analysis: stress-triggered epenthesis is equally unattested.

A preceding /o/ induces rounding (or blocks derounding) of an /i/ across velar and glottal consonants, but also across underlying /θ/ which dorsalises to [x] in this case (16).[9]

(16) Cowell & Moss (2008: 18)
  a. [nonóóhowún]
     /nóóhow-ín/
     'you see me'
  b. [bíxooxú]
     /bíxooθ-í/
     'love me!'

There are two contrasting level tones in Arapaho, low and high (17). Since Cowell & Moss (2008) regard Arapaho as a pitch accent language, following Algonquianist traditions, they define the high tone as "accented" and the low tone as "normal pitch". I argue that there is evidence that even the low tone is indeed (at least potentially) an underlying tone and not just the phonetic realisation of tonelessness. High tone is marked with an acute, and low tone with the lack of marking. Both tones can appear in any position of the word, but words not containing at least one high tone are extremely rare (17).

(17) Cowell & Moss (2008: 63, 23)
  a. hetibeseb 'your firewood'
  b. tetʃénoo 'door'
  c. tétʃenoo 'roll it out!'
  d. hónosóóʔ 'it is fancy'
  e. honosóóʔ 'it is raining'

A long syllable – a syllable that contains a long vowel or a diphthong, even a short one – can be level low, level high or have a falling contour (18). The fall is marked with an acute on the first mora. There are no tautosyllabic rises, a high tone is always left-aligned to the syllable.

(18) Cowell & Moss (2008: 25)
  a. θííkonéʔ 'skull'
  b. heneenetíθoot 's/he speaks to him/her'
  c. nííseijoonoθóo 'pocketbook'

The position of high tones is generally free, but severely constrained by two conditions. A single high tone can maximally span a syllable (two morae), and as said above, minimally the first mora. In addition, a strong OCP prohibits adjacent high tones. There must be at least one low toned mora between them. If a sequence of two high toned syllables arises through concatenation, the left high tone deassociates from the adjacent mora if it is on a long syllable. This process accounts for most but not all falling tones. If the left high tone is associated to a short syllable, the tone is displaced and shifts to the left (19).[10] It can only shift on morae belonging to the same morpheme as itself (Zimmermann 2011), and if there is no such mora available, the tone is deleted.

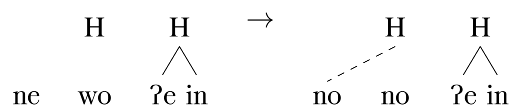
[9] The reduplication visible in (16) is an instance of *initial change*, a morphological process common in Algonquian languages that marks certain aspects. In Arapaho, it manifests itself as infixation of -Vn- or lengthening. Since this process is irrelevant for the topic discussed in this paper, I will not dedicate much attention to it.

[10] Clusters that involve /j/ are not repaired by epenthesis, but by deletion (19-a). -en- in (19-b) is again an instance of initial change.

(19) Cowell & Moss (2008: 18, 29, 492)
  a. [tóusóó]
     /tóúθ-jóó/
     'how is it?'
  b. [tʃeníínenóʔu]
     /tʃiinén-óʔu/
     'they are putting it down'
  c. [nííʔenebeθénee]
     /nííʔeneb-éθe-^{H}nee/
     'I like you'

Some morphemes, roots as well as affixes, are lexically specified as containing a floating high tone. This floating tone can never land on the morpheme it belongs to but instead docks to an adjacent morpheme (20).[11] I will represent this floating tone with a superscript H as shorthand for the autosegmental structure (21).

(20) Cowell & Moss (2008: 61)
  a. [nonotéʔ]
     /ne-wotéʔ/
     'my hat'
  b. [nónoʔéín]
     /ne-^{H}woʔéín/
     'my necklace'

(21)


If docking of the floating tone creates a sequence of two consecutive high tones, the underlyingly linked tone deassociates forming a falling contour, shifts onto another syllable or deletes (22)[12] – the expected OCP pattern. If a floating high tone docks to a syllable which is already high-toned, nothing happens at the surface. The first syllable of such floating tone bearing morphemes is always phonetically low.

(22) Cowell & Moss (2008: 29, 17, 492)
  a. [heniisíiténoot]
     /heniisíiten-^{H}oot/
     's/he has caught him/her'
  b. [heníísetéíʔi]
     /heniisétee-^{H}ʔ-i/
     'they are ripe'
  c. [nííʔenebeθénee]
     /nííʔeneb-éθe-^{H}nee/
     'I like you'

A floating high tone normally attaches to the morpheme left of its morpheme of origin. However, there is at least one morpheme that triggers a high tone on the morpheme to its

[11] The change /ne-w/ → [non] is morpheme specific and affects w-initial roots prefixed with the 1st person singular possessive prefix.
[12] (22-b) shows yet another process of Arapaho, diphthongisation of long vowels across ʔ.

right (23). In (23-b), the high tone of the third morpheme deletes because it cannot shift inside the same morpheme. Delinking of the high tone from the second mora is also ruled out, since this would create a rising tone.

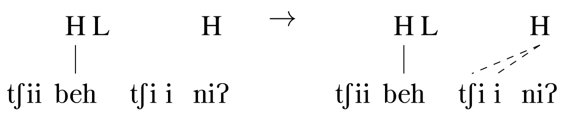
(23) Cowell & Moss (2008: 27)
a. [seneesesíínooʔóónoo]
/seneeseesíín-ooʔóó-noo/
'I am aching all over'
b. [seesíínetóóʔoonoo]
/seesíín-et^{H}-ooʔóó-noo/
'I have an earache'

As I have mentioned above, Cowell & Moss (2008) and also Zimmermann (2011) assume, at least implicitly, that the phonetic low tone is nothing but the realisation of phonologically toneless TBUs. This assumption leads mostly to correct predictions, there is however some evidence for floating low tones as well. Some morphemes "repress" a high tone, either on a preceding or on a following morpheme. This pattern is not exactly parallel to the floating high tones, because the floating low tone does not land on the closest mora, it lands on the closest high tone bearing mora.[13] If a high tone is replaced by a floating low tone, it does not seem to be able to shift, the evidence for this however is scarce. The deletion of the high tone in the first example of (24) can neither be due to the OCP (see Section 5.1 for more on the OCP) nor general tone rules: those would predict that both high tones of the second morpheme shift to the right.

(24) Cowell & Moss (2008: 28)
a. [tʃiibéhnohohóúhu]
/tʃiibéh^{L}-nóhohóúhu/
'don't hurry!'
b. [nonoohobéínoo]
/nonóóhob-^{L}éínoo/
's/he sees me'

The floating low tone can force underlyingly associated high tones to deassociate, but it loses against floating high tones if they compete for the same TBU. However, even though it fails to associate, the floating low tone leaves a trace, see (25) and the autosegmental representation in (26). A clash of two high tones on two adjacent TBUs becomes licit if a floating low tone intervenes between them.

(25) Cowell & Moss (2008: 28)
[tʃiibéhtʃííniʔíθetʃoo]
/tʃiibéh^{L}-tʃii-^{H}niʔ-íθetʃoo/
'don't feel bad!'

(26)


These data suggests that the OCP in Arapaho does not target adjacent syllables that are associated to a high tone, but the high tone-mora combinations that are adjacent on both the tonal and the moraic tier.

[13] Unlike floating high tones, it never creates falling surface tones. The reason for this is unclear.

4.2 Epenthesis

The syllable structure is simple and basically CV, however there are two exceptions. Word-final codas are allowed and any consonant can be in the word coda. In contrast to onsets, coda consonants are not restricted by the preceding vowel (27). The glottal fricative /h/ is a licit coda even word internally and may form a coda cluster word finally (28). Other clusters are ungrammatical.[14]

(27) Cowell & Moss (2008: 24, 25, 22, 56, 44, 62)
a. bénes ‘one’s arm’
b. betóoθét ‘one’s saliva’
c. héθ ‘dog’
d. wóxhoox ‘horse’
e. híitʃóón ‘pipe’
f. síísiitʃ ‘duck’
g. neb ‘fish’
h. hibééθeiw ‘his/her owl’

(28) Cowell & Moss (2008: 74, 48)
a. tʃíítʃhooʔ ‘jar’
b. heeʔéíht ‘s/he is wide’

Arapaho thus avoids (word-internal) codas with place features, which is a typologically common restriction on codas (O’Brien 2012). If, however, a word internal coda arises through concatenation, the unwanted configuration is not resolved by debuccalisation, but by epenthesis.[15] The quality of the epenthetic vowel is inserted by default, and it is – typologically not unexpected – the high front vowel [i] (29). It rounds to [u] under exactly the same circumstances as morphemic /i/ does, preceded by the low, rounded vowel if no non-dorsal consonant intervenes.

(29) Cowell & Moss (2008: 16, 18)
a. [béteenítoonoo]
/béteen-too-noo/
‘I am worshipping’
b. [hoowúsee]
/oow-see/
‘to walk downward’

4.3 Tone and epenthesis

Epenthesis appears to be restricted to configurations where consonant clusters co-occur with a floating high tone (30).

(30) Cowell & Moss (2008: 16, 18)
a. [béteenítoonoo]
/béteen-too-noo/
‘I am worshipping’

[14] As we see throughout the paper, many word-internal clusters exist on the surface due to the deletion of the (epenthetic) vowel. hC cluster however do not show any signs of repair, that is even if followed by a floating high tone, there is no epenthetic vowel: /nih-ʔ^{H}oosóó-ʔ → [níhʔoosóóʔ] ‘it was fancy’ (Cowell & Moss 2008: 26).

[15] Nasal-glide clusters are resolved by deletion of the nasal: /en-jóón-eet/ → heejóóneet ‘s/he has long legs’ (Cowell & Moss 2008: 16).

b. [hoowúsee]
/oow-^{H}see/
'to walk downward'

If there is no floating high tone, instead of an epenthetic vowel it is a consonant cluster that is realised (31).

(31) Cowell & Moss (2008: 56)
[wóxhoox] *[wóxuhoox]
/wóxhoox/
'horse'

These data look strikingly like a case of floating tone induced epenthesis, as defined in Section 2. A major difference is, that in the case of Arapaho tone cannot be the only trigger of epenthesis, since there is no epenthesis when the coda condition is not violated. In that case the floating tone is shifted onto the adjacent morpheme, as seen in (20). Epenthesis is thus a possible operation if it breaks up a coda and can host a floating tone.

5 Tone-triggered epenthesis and its problems

In this section, I lay out an analysis in parallel OT based on the assumption that epenthesis is indeed (co-)triggered by a floating tone. I then introduce further data, from OCP related tone shift and consonantal mutations, which show that this assumption is incorrect and that an analysis assuming tone as the trigger cannot account for the entire dataset.

The collaboration of the floating tone and the coda condition is a typical case of what has been called a cumulative ("gang") effect in the literature: two or more lower ranked constraints gang up against a normally higher ranked constraint, in this case DEP. I assume that the lower ranked constraints are NOCODA[16] and a constraint that evaluates the tonal faithfulness of TBUs (32). The ganging up effect can either be formalised with weights in Harmonic Grammar (Legendre et al. 1990; Smolensky & Legendre 2006) or with Local Conjunction (Smolensky 1993; 1995; Suzuki 1995; Kirchner 1996). For the sake of simplicity I will demonstrate it here with a Local Conjunction (33), the local domain of the conjunction being the syllable. This means that the conjunction is violated if a syllable is unfaithful to its tone and has a coda. The equivalent in HG would be x (weight of ID-T) + y (weight of NOCODA) > z (weight of DEP) while $z > y$ and $z > x$.

(32) IDENT-T Count a violation for any TBU that is associated to a tone of quality Q1 in the input but to a tone of quality Q2 in the output.[17]

(33) NOCODA& IDENT-T$_{\sigma}$ Count a violation for any syllable that has a coda and is associated to a tone of a different quality than its input tone.

The other relevant constraints for the analysis are given in (34).

(34) a. *FLOAT Count a violation for any tone not associated with a TBU (Yip 2002).
b. MAX-T Count a violation for any deleted tone (Yip 2002).

[16] A more precise formulation would be a constraint against codas with place features or the feature [-cont], since the glottal fricative [h] is a licit coda.
[17] Under this definition, it is important to assume that low tone TBUs are indeed underlyingly specified. However, the definition can be easily changed so that it includes faithfulness to tonelessness, compare Tranel (1995).

c. NoCoda Count a violation for any coda consonant. (Prince & Smolensky 1993; 2004)

d. Dep Count a violation for any epenthesised segment. (Prince & Smolensky 1993; 2004)

Because epenthesis happens only in the presence of a coda and a floating tone, Dep must outrank both NoCoda and Ident-T respectively, but in turn be dominated by the local conjunction of these two constraints (in the tableaux NCIT). *Float and Max-T are also highly ranked, because the floating tone does not stay floating nor does it delete, at least in the cases relevant here. The tableau in (35) demonstrates the derivation of an epenthetic vowel, co-triggered by the floating tone and the preference for open syllables.

(35)

tʃew -^{H}see	NCIT	Max-T	*Float	Dep	No Coda	Id-T
☞ a. tʃebísee				*		
b. tʃéwsee	*!				*	*
c. tʃewsee		*!			*	
d. tʃew^{H}see			*!		*	
e. tʃébisee				*		*!

Candidate a. is the winning candidate, as it violates only Dep. Candidate b. is the candidate we would expect if Arapaho did not have epenthesis: the floating tone lands on the nearest available TBU, and the coda stays as it was. This candidate, of course, violates the conjoined constraints: the syllable *tʃéw* has a coda in addition to being tonally unfaithful. Candidate c. and d. either delete the floating tone or let it float, and, as said above this is not what we find in the language. Candidate e. places the floating tone on the prefix and epenthesises a vowel with a default low tone next to it. This candidate violates the tonal faithfulness constraint and Dep. It is thus harmonically bounded by the winner. However, this is the candidate expected in a system of ordered rules or in HS if the operation of docking precedes the operation of epenthesis. For parallel OT it is impossible to model such a hypothetical interaction – this candidate is harmonically bounded by the winner.

The tableaux in (36) and (37) show how epenthesis is blocked if only one of the necessary conditions for it holds. In (36), the input has a coda but no floating tone. Inserting an epenthetic vowel thus solves the problem of the coda (candidate b.), but the underlying tone on the closed syllable is never threatened. The winner is thus the completely faithful candidate a.

(36)

wóxhoox	NCIT	Max-T	*Float	Dep	No Coda	Id-T
☞ a. wóxhoox					*	
b. wóxuhoox				*!		

In (37), there is a floating tone, but it is preceded by a vowel. Inserting an epenthetic vowel and letting the floating tone dock to it saves the underlying tone, but there is no consonant to resyllabify. The winner is in this case not the faithful candidate – it violates the highly ranked *Float – but the candidate that associates the floating tone with the preceding syllable, violating the constraint on tonal faithfulness. It is the case that we have seen in the instances of regular floating tones.

(37)

ne-^{H}woʔéín	NCIT	MAX-T	*FLOAT	DEP	NO CODA	ID-T
☞ a. nónoʔéín						*
b. noúnoʔéín				*!		

As sketched in Section 2, HS is not able to replicate such an analysis if we maintain the assumption that inserting a vowel and associating it to a tone are two separate processes. This is shown by tableau (38). Candidate a, the winner in (36), is here an impossible candidate, indicated by the lightning, because GEN needs to execute two operations, tone association and vowel epenthesis. Candidates b. to d. are all potential winners, depending on the precise ranking of the high-ranked constraints. Candidate e. would be the necessary intermediate step in order to reach tone-triggered epenthesis in two steps, but it is harmonically bounded by the faithful candidate d.

(38)

tʃew -^{H}see	NCIT	MAX-T	*FLOAT	DEP	NO CODA	ID-T
ϟ a. tʃebísee				*		
☞ b. tʃéwsee	*				*	*
☞ c. tʃewsee		*			*	
☞ d. tʃew^{H}see			*		*	
☎ e. tʃebi^{H}see			*	*!		

In the remaining part of the section, I give additional data that demonstrate that first, tonal faithfulness – and thus the tonal part – cannot be a co-trigger of epenthesis and second that there is evidence for epenthesis even if the epenthetic vowel does not show up.

5.1 The OCP

As mentioned in Section 4, OCP violations in the tonal domain are dispreferred (Zimmermann 2011). A high tone span is maximally tautosyllabic, encompassing two morae, and there are no adjacent high tone spans. If concatenation creates a high tone clash, the furthest tone to the left deassociates, deletes or shifts, as shown in (39), repeated from (19).

(39) Cowell & Moss (2008: 18, 29)

a. [tóusóó]
/tóúθ-jóó/
'how is it?'

b. [tʃeníínenóʔu]
/tʃiinén-óʔu/
'they are putting it down'

Floating high tones are, just like non-floating high tones, responsible for the same OCP related processes (40), repeated from (22). However if, a floating high tone lands on an already high toned syllable, there is no visible effect on the surface (41).

(40) Cowell & Moss (2008: 29, 17, 492)

a. [heniisíiténoot]
/heniisíiten-^{H}oot/
's/he has caught him/her'

b. [heníísetéíʔi]
/heniisétee-^{H}ʔ-i/
'they are ripe'

c. [nííʔenebeθénee]
/nííʔeneb-éθe-^{H}nee/
'I like you'

(41) Cowell & Moss (2008: 17)
[nííhoojóúʔu]
/níhoo-jóó-^{H}ʔi/
'they are yellow'

The data point crucial for the argumentation is the combination of a floating high tone that follows a high toned syllable with a coda (42).

(42) Cowell & Moss (2008: 20)
/oséít-^{H}see-noo/
backwards-go-1SG

Now, there are two logical possibilities about what is happening. If epenthesis is due to the demand to keep the tonal quality constant, as assumed above, we expect no epenthesis. The floating tone should be able to dock onto the high tone that is already there. This, however, is not what happens (43).

(43) Cowell & Moss (2008: 20)
[hooséitíseenoo] *[hooséítseenoo]
/oséít-^{H}see-noo/
'I'm walking backwards'

The epenthetic vowel is realised and attracts the tone. This would create a clash, violating the OCP. The high tone on the prefix, though, behaves like any other high tone in a configuration violating the OCP on adjacent high tones. In the case of (43), it deassociates from the second mora. As we see, epenthesis is actually enabling tonal unfaithfulness, not preventing it. An analysis where epenthesis is partially triggered by tonal faithfulness, like the one laid out in the previous subsection, makes thus wrong predictions and fails to derive the correct output (44). The telephone symbol indicates the candidate that wins in the actual language. The concrete implementation of the OCP is not relevant, since neither of the candidates in (44) violates it.

(44)

oséít-^{H}see	NCIT	MAX-T	*FLOAT	DEP	NO CODA	ID-T
☞ a. oséítsee					*	
☎ b. oséitísee				*!		*

This problem can be avoided if the constraint in (32) is redefined as referring to tokens of tone. If this assumption is adopted, whatever we do leads to a violation of the constraint – the original high tone is either replaced by a low tone or by another high tone. In order to avoid a violation of the constraint conjunction, an epenthetic vowel must be inserted. This however yields a hardly natural generalisation: epenthesise in order not to change the tone, or if the tone changes anyway.

5.2 Segmental processes

Another, and probably stronger, argument that tone is not a co-trigger of epenthesis in Arapaho comes from consonantal processes. There are two types of consonant-vowel interactions in the context of (high) front vowels and, as already mentioned, the epenthetic vowel is one of those. The first process is a palatalisation-like process that I will call develarisation, and the second one is a rather unusual chain shift that I will refer to as dental sonorisation. The important aspect of these processes is that they affect every word-internal coda that would be followed by an epenthetic [i], if a floating high tone were available.

Develarisation is a productive and general process that affects all velar consonants /k,x,w/ to different degrees. These consonants are fronted if they precede a front vowel /e, i/ following the scheme in (45). It is not an instance of palatalisation because not all segments turn into a palatal/coronal.

(45) develarisation
k → tʃ
x → s
w → b

Examples for each change are given in (46).[18] Just like the front vowels, the palatal glide triggers develarisation, unlike them it is deleted in the process (46-c).[19]

(46) Cowell & Moss (2008: 19)
a. [hétʃesííhiʔ]
/étʃex-ííhiʔ/
'small.ADV'
b. [nonóóhobéθen]
/nóóhow-éθen/
'I see you'
c. [nonootʃóóʔ]
/nook-jóó/
'it is white!'

Develarisation is blocked by high vowel rounding, compare example a. in (16), repeated in (47). Develarisation of /k/ and /x/ is also blocked if they follow an /o/ and precede an /e/, the glide /w/ however is develarised in this position (48). Develarisation induced by /j/ is never blocked, see (46-c).

(47) Cowell & Moss (2008: 18)
[nonóóhowún]
/nóóhow-ín/
'you see me'

(48) Cowell & Moss (2008: 19)
a. [nonookéíht]
/nook-éíhi-t/
'it is white.ANIM'

[18] The *no-* prefixation/reduplication in (46), (47) and (48) is again an instance of *Initial Change*.
[19] This could also be analysed as coalescence. However, /j/ is also deleted after non-paltalisable consonants, e.g. /tóxuʔ-jóó-ʔ/ → [tóxuʔóóʔ] 'it is sharp' (Cowell & Moss 2008: 22).

b. [nonóoxéíht]
/nóox-éíhi-t/
'
s/he has left tracks'

c. [nonóóhobéθen]
/nóóhow-éθen/
'I see you'

The three triggers of develarisation, *i, e, j*, are thus not completely identical. Develarisation triggered by [i] is always blocked by a preceding low round vowel, feeding the rounding of the potential trigger, while develarisation caused by [e] is partially blocked by a preceding /o/, this blocking though does not result in rounding of the low front vowel. The palatal glide on the other hand triggers develarisation regardless of the context.

The other process, dental sonorisation, occurs in a similar environment: before the high front vowel [i] and the palatal glide, but not the mid front vowel [e]. Anterior coronal obstruents become gradually more sonorous before front vowels, as in (49). This process takes the form of a chain shift , which by itself is a difficult issue for (parallel) OT (Kirchner 1996; Farris-Trimble 2008). The complications that arise because of the chain shift will be ignored in the following. Examples are given in (50).

(49) Dental sonorisation
t → θ
θ → s

(50) Cowell & Moss (2008: 19–20)
a. [tooθííhiʔ]
/toot-ííhiʔ/
'nearby'

b. [bebíisííhiʔ]
/bebíiθ-ííhiʔ/
'properly'

The additional process of /θ/ velarisation, which changes underlying /θ/ to [x] between a back and a high vowel, blocks this process, as could be seen in (16), repeated in (51).

(51) Cowell & Moss (2008: 18)
[bíxooxú]
/bíxooθ-í/
'love me!'

In contrast to develarisation, dental sonorisation is a derived environment effect. Monomorphemic /ti/ and /θi/ sequences surface unaltered (52). There are some lexemes which idiosyncratically do not undergo dental sonorisation, even across a morpheme boundary (53).

(52) Cowell & Moss (2008: 21, 19)
a. [étʃetii]
/ék-etii/
'close your mouth'

b. [hiinónoʔéítisíθiʔ]
/inónoʔéítiθ-íθiʔ/
'they speak Arapaho to me'

(53) Cowell & Moss (2008: 19)
[wóosóóθii]
/wóosóóθ-ii/
'arrowheads'

The epenthetic vowel behaves with respect to develarisation and dental sonorisation just like any other front/front high vowel. Develarisation is triggered unless the epenthetic vowel is preceded by an [o], and dental sonorisation is triggered unless the morpheme is specified as a non-undergoer (54).

(54) Cowell & Moss (2008: 18–19)
a. [tʃebíse] *[tʃewíse]
/tʃew-^{H}see/
'to walk along'
b. [néé?eesínihíínoo] *[néé?eeθínihíínoo]
/néé?eeθ-^{H}nihíí-noo/
'that's what I'm saying'

These changes also occur in contexts where we would expect an epenthetic vowel due to syllable-structure constraints, i.e. where we have a word internal coda, but the vowel fails to surface due to the lack of a floating high tone (55).

(55) Cowell & Moss (2008: 16, 19)
a. [nihbebíistiit]
/nih-bebíiθ-tii-t/
's/he fixed it'
b. [hétʃesnówo?]
/étʃex-nówo?/
'small fish'
c. [tʃebkóóhu]
/tʃew- kóóhu/
'run along'

It is not possible to argue that these changes are due to a constraint that forces codas to undergo independently the [i] induced processes independently, since any consonant can be a word-final coda (but the condition on word-final codas might still be different) and changes do not occur if the expected epenthetic vowel would be [u] (56).

(56) Cowell & Moss (2008: 56, 482)
a. [wóxhoox] *[wóshoos]
/wóxhoox/
'horse'
b. [hoowbén] *[hoobbén]
/hoow-bén/
's/he doesn't drink'

A mechanism that forces word-internal codas to undergo exactly the same processes they would undergo if followed by an [i] seems like a redundant duplication of processes in the language. Additionally, word internal codas may arise through a separate process of /o/ deletion, in which case the derived codas do not show any of the effects (57). Furthermore, there is no phonetic motivation for such changes in a coda at all.

(57) Cowell & Moss (2008: 47)
[benéétno] *[benééθno]
/benééton-o/
'drinks'

These data clearly suggest that the epenthetic vowel is there long enough to influence its segmental surroundings and attract a high tone, and then be deleted. A deletion hypothesis receives further support from different data: every non-final, non-initial low toned high vowel may delete. This deletion is obligatory for epenthetic vowels, except for very deliberate, slow speech, but optional for lexical morphemic vowels. It has been claimed that such patterns should not exist (de Lacy 2006). However, such tone sensitive reduction phenomena are not unattested. For example Stojković (2017) argues that this is exactly what happens in Bosnian: reduction (including deletion) of insufficiently sonorous vowels, in the case of Bosnian they are low toned mid vowels, and all high vowels regardless of tonal quality.

6 Analysis

If these elements are put together, the pattern defined by McCarthy (2003) as a true or non-vacuous feeding Duke-of-York emerges. If conceived of in a rule-based fashion, the epenthetic vowel would be inserted at a first step, turning the underlying structure ABC into ADC. Then the segmental and the tonal processes apply: consonants are develarised or sonorised, yielding EDC, and the floating tone, if present, lands on the epenthetic vowel, potentially leading to OCP related changes. At a later step, the epenthetic vowel is either a) deleted if it has not received a high tone or b) preserved if it has received a high tone. In the case of former, the results of develarisation and dental sonorisation remain, giving us EBC. This derivation is illustrated in (58).

(58)

bebííθtiit	UR	ABC
bebííθitiit	Epenthesis	ADC
bebíísitiit	dental sonorisation	EDC
bebíístiit	Vowel deletion	EBC

This insight cannot be transferred to parallel OT, because there is no possible ranking that can demand insertion and deletion of an element at the same time. The intermediate step is irreducible, but it is still not an intermediate step that HS can replicate. In the remaining of Section 6 I propose an analysis in Stratal OT which will be able account for the Duke-of-York epenthesis in Arapaho.

6.1 A solution in Stratal OT

Stratal OT (Kiparsky 2000; Bermúdez-Otero 1999; 2003; Bermúdez-Otero 2011; Trommer 2011) is a serial variant of OT that transfers some major insights from Lexical Phonology (Kiparsky 1982; 1985) into Optimality Theory. The evaluation of outputs is distributed on several levels or strata, normally but not necessarily assumed to be three: stem level, word level and phrase level. Affixes select the stratum in which they concatenate. Between the strata, a re-ranking of constraints is possible, which makes Stratal OT capable of accounting for many cases of opacity. Stratal OT puts no inherent restrictions on the generator.

For the Arapaho case, I assume that the relevant strata are the stem and the word level. There are no very strong reasons that make this assumption necessary, however, there are two arguments in its favour. First, the deletion of the low toned, low sonority high vowels is sensitive to the boundaries of the phonological word: it does not affect last or first vowels of prosodic words. Second, there are a few prefixes that do not trigger vowel epenthesis or show its traces, they also do not block stem-initial [h]-epenthesis, see (59).

(59) Cowell & Moss (2008: 234)
a. [tootbiikóusíis] *[tooθbiikóusíis]
/toot-biikóusíis/
'where is the moon?'
b. [tootheθóoxé] *[tooteθóoxé]
/toot-e-θóoxé/
'where is your glove?'

The first is an argument for deletion at the word-level while the second is an argument for epenthesis at the stem level. Especially the first argument is weak, as even processes on the phrase level might be sensitive to word boundaries. In addition, the deletion process is optional and optional processes tend to occur rather at the outer-most stratum. To put epenthesis on the stem level and deletion on the phrase level might thus be just as valid.

Almost all of the processes discussed so far apply at the stem level: epenthesis of course, and along with it develarisation, dental sonorisation, docking of floating tones and the tonal displacement caused by the OCP. Re-ranking between strata is possible and the sole constraint responsible for epenthesis, NoCoda, is demoted. At the next stratum, the word level (or potentially the phrase level, skipping the affixation of prefixes like the ones in (59)), low toned, short high vowels are (optionally) deleted. This deletion is again actually a cumulative effect: a vowel is deleted if it does not have a high tone *and* it has [+high] feature *and* is dominated by only one mora. Such vowel deletion that depends from multiple factors can either be analysed with Harmonic Grammar, as in Stojković (2017), or with complex cover constraints, as in McCarthy (2008). For the sake of exposition, I employ the latter, here called Syncope and defined as in (60).

(60) Sync(ope) Count a violation for any short, [+high] vowel not associated to a high tone.

Develarisation and especially dental sonorisation are complex on their own and cannot be fully analysed in this paper. I suggest that develarisation is the response to a markedness constraint that penalises [DOR][-back] sequences inside a syllable (61).

(61) *[DOR][-b(ack)] Count a violation for any velar consonant adjacent to a [-back] feature in the same syllable.

The velar obstruents /k/ and /x/ are then associated with an epenthetic feature [COR], turning them to [tʃ] and [s]. The glide /w/ on the other hand has an additional labial feature from the beginning and thus does not need to insert a new one. It just loses its [DOR] feature and becomes a labial, [b].[20]

Dental Sonorisation is even more problematic, mostly because it is a derived environment effect and a chain shift and hence comes along with all the associated difficulties. For the time being, it will be derived by the ad hoc constraint D(ental)S(onorisation), given in (62).

[20] Of course, much more has to be said about develarisation: why is a new place features inserted instead of debuccalisation? Why is it sometimes blocked by a preceding [o]? Why do the triggers [e,i,j] seem to have diverging strength, in the unexpected order j > e > i?

(62) D(ENTAL)S(ONORISATION) Count a violation for any [+anterior] obstruent that has not increased in sonority across a morpheme boundary preceding a high front vowel.

Future research should address an in-depth analysis of these two intriguing processes and especially put them in relationship to other vowel-consonant interactions triggered by front vowels. While the OCP and the changes related to it constitute an argument against a tone-triggered analysis, they do not give a good argument for a Duke-of-York analysis either: every time tones get unexpectedly shifted in front of an epenthetic vowel, that epenthetic vowel has received a high tone and is thus not deleted. In other words, the derivation stops at the EDC stage. This is a regular feeding interaction. I will therefore leave the OCP cases out of the following discussion.

Let us now turn to the technicalities of the derivation. At the stem level, NOCODA outranks DEP and SYNCOPE, a ranking that enables epenthesis. I assume that the insertion of a [-high] vowel is ruled out due to a higher ranked DEP constraint. It has long been noted in the literature, that the vowels which tend to be epenthesised and the vowels which tend to be deleted are very often the same, see e.g. Lombardi (2002). The tableau in (63) illustrates the stem level computation of an input with a coda but without a floating tone. In this particular case, the coda consonant is the dental fricative /θ/. Candidate a. is faithful and consequently violates the high ranked NOCODA. Both candidate b. and c. satisfy this constraint by epenthesising an [i], but candidate c. fails to undergo dental sonorisation making b. the winner.

(63) Stem level

bebíiθ-tii	NO CODA	*FLOAT	DEP	DS	SYNC	ID-T	ID [±str]
a. bebíiθtii	*!						
☞ b. bebíisitii			*		*		*
c. bebíiθitii			*	*!	*		

A stem level derivation for an input with a coda consonant and a floating tone does not look very different (64). The faithful candidate a. does not satisfy NOCODA. Candidates b. to d. are ruled out because they fail to land the floating tone or to develarise the glide /w/ or both. Candidate e. is the winner: it epenthesises, avoiding a violation of NOCODA, develarises and attaches the floating tone. Candidate f. does this too, but it lands the floating tone on the prefix instead of the epenthetic vowel. This candidate is here ruled out by the low ranked ID-T because a TBU does not surface with its underlying tonal specification.

(64) Stem level

tʃew-^{H}see	NO CODA	*FLOAT	DEP	*[DOR] [-b]	SYNC	ID-T	ID [DOR]
a. tʃew^{H}see	*!	*					
b. tʃewi^{H}see		*!	*	*	*		
c. tʃebi^{H}see		*!	*		*		*
d. tʃewísee			*	*!			
☞ e. tʃebísee			*				*
f. tʃébisee			*		*	*!	*

After the stem level has been computed, its output serves as the input for the word level. At this stratum, the constraint ranking has changed. The formerly high ranked NoCoda is now lower ranked, while Syncope has gained importance. In the case without the floating tone, in tableau (65), this becomes crucial. The faithful candidate a. contains a low toned short high vowel, which violates Syncope. The winner is thus candidate b. which deletes the vowel that has just been inserted at the last stratum.

(65) word level

input: bebíisitii	Sync	*Float	Dep	DS	No Coda	Id-T	Id [±str]
a. bebíisitii	*!						
☞ b. bebíistii					*		

In the case of *tʃebísee* (66), the high tone protects the epenthetic vowel from deletion. It does not fall under the scope of Syncope any more.

(66) word level

tʃebísee	Sync	*Float	Dep	*[dor] [-b]	No Coda	Id-T	Id [dor]
☞ a. tʃebísee							
b. tʃébsee					*!	*	
c. tʃeb^{H}see		*!			*		

Stratal OT, due to its ability to have both intermediate representations and re-ranking, is thus able to account for the Duke-of-York epenthesis in Arapaho.

6.2 Harmonic Serialism

A central argument in favour of HS is that it allows and presupposes intermediate representations, and can therefore derive patterns that are impossible to derive for parallel OT, exactly because parallel OT lacks such representations (Elfner 2016). The intermediate representation is necessary for Arapaho, too, but HS still fails to derive it, because it does not allow for re-ranking.

Cases of (optional) deletion of underlying high vowels that have triggered segmental changes are also not unproblematic since they constitute an instance of counterbleeding, see McCarthy (2016) for an analogous problem. However, there are several ways out for HS – for example, Syncope can be defined in such a way, that it becomes active only after DS has been satisfied (see Elfner 2009; 2016 for similar approaches to opacity in HS). Extending such an analysis to the cases of visible epenthesis, a high ranked NoCoda is needed to enforce epenthesis in the first place. This constraint will prove to be fatal for this account, but it derives data like *tʃebísee* correctly, as is shown in the derivation from (67) to (70). The ordering of docking the floating tone and changing the consonants and hence the ranking of *[Dor][-bk] and *Float is arbitrary.

(67) Step 1: Epenthesis

tʃew-^{H}see	NO CODA	MAX T	*FLOAT	DEP	*[DOR] [-b]	SYNC	ID-T	ID
☞ a. tʃewi^{H}see			*	*	*			
b. tʃéwsee	*!							
c. tʃewsee	*!	*						
d. tʃew^{H}see	*!		*!					
e. tʃeb^{H}see	*!		*					*

(68) Step 2: H-Association

tʃewi^{H}see	NO CODA	MAX T	*FLOAT	DEP	*[DOR] [-b]	SYNC	ID-T	ID
a. tʃewi^{H}see			*!		*			
☞ b. tʃewísee					*		*	
c. tʃewisee		*!			*	*		
d. tʃew^{H}see	*!		*					
e. tʃebi^{H}see			*!			*		*

(69) Step 3: Develarisation

tʃewísee	NO CODA	MAX T	*FLOAT	DEP	*[DOR] [-b]	SYNC	ID-T	ID
a. tʃewísee					*!			
☞ b. tʃebísee								*

(70) Step 4: Convergence

The HS approach, (71) to (73), however cannot account for the deletion of epenthetic vowels, even if it satisfies SYNCOPE. The epenthetic vowel is per definition toneless. Its introduction therefore always violates SYNCOPE. It follows from this that the epenthesis triggering constraint NOCODA must outrank SYNCOPE. At a later step, though, NOCODA must be outranked by SYNCOPE, so that the epenthetic non high-toned vowel can be deleted. A re-ranking of the two constraints in the middle of the derivation is however not a possibility in the framework of HS.

(71) Step 1: Epenthesis

bebíiθ-tii	NO CODA	*FLOAT	DEP	DS	SYNC	ID-T	ID
a. bebíiθtii	*!						
☞ b. bebíiθitii			*	*	*		
c. bebíistii	*!						*

(72) Step 2: Dental sonorisation

bebíiθiti			No Coda	*Float	Dep	DS	Sync	Id-T	Id
	a.	bebíiθiti				*!	*		
☞	b.	bebíisitii					*		*
	c.	bebíiθtii	*!						

After the consonant has been modified, the derivation converges on the wrong candidate (73). The winner of the actual language is marked with the telephone symbol (73-a), it can never be optimal in this derivation because NoCoda is so highly ranked.

(73) Step 3: convergence

bebíisitii			No Coda	*Float	Dep	DS	Sync	Id-T	Id
☎	a.	bebíisitii	*!						
☞	b.	bebíisitii					*		

7 Discussion and conclusion

Arapaho displays a challenging interaction of epenthesis, tonal processes and consonantal changes. This conundrum makes any simple analysis difficult. The pattern seems at first glance to exhibit the properties of tone-triggered epenthesis – a type of epenthesis that has been claimed not to exist (Blumenfeld 2006). However, such an analysis fails for the Arapaho data, because it cannot account for OCP related tone shifts and consonantal mutations. The correct analysis instead involves a feeding Duke-of-York gambit – a derivation that comprises creating an intermediate step just to undo it later. McCarthy (2003) claims, that vacuous Duke-of-Yorks are never necessary in OT and that non-vacuous, feeding Duke-of-York phenomena do not exist. Epenthesis in Arapaho fulfils all the requirements to be considered as exactly this type of Duke-of-York. Constraint based analyses need to satisfy two conditions in order to be able to model non-vacuous Duke-of-York derivations: allowing intermediate steps and re-ranking between them. For a rule-based system, this translates to a need for rule-ordering or stratification and the possibility of rule-reversal. Of the versions of OT that I compare, parallel OT fulfils neither, HS has intermediate steps but no re-ranking while Stratal OT meets the necessary criteria and is thus able to derive the core of the Arapaho data. The question of how to restrict the grammar in such a way that it excludes tone-triggered epenthesis is still unanswered. An elegant way to exclude it would be Harmonic Serialism, which however is too restrictive as it cannot derive the attested Duke-of-York pattern in Arapaho.

Acknowledgements

For invaluable feedback at various stages of this work, I wish to thank Eva Zimmermann, Jochen Trommer, Jelena Stojković, Ezer Rasin and Asia Zaleska. I would also like to thank the audiences of OCP 15 in London and GLOW 41 in Budapest for fruitful discussions, as well as three anonymous reviewers for *Glossa*. This work was completed as part of DFG research training group *Interaction of Grammatical Building Blocks* (GRK 2011).

Competing Interests

The author has no competing interests to declare.

References

Bermúdez-Otero, Ricardo. 1999. *Constraint interaction in language change: Quantity in English and Germanic*. Manchester: Manchester University dissertation.

Bermúdez-Otero, Ricardo. 2003. The acquisition of phonological opacity. In *Variation within optimality theory: Proceedings of the Stockholm workshop on variation within optimality theory*, 25–36.

Bermúdez-Otero, Ricardo. 2006. Phonological domains and opacity effects: A new look at voicing and continuancy in Catalan. *Handout presented at the workshop "approaches to phonological opacity", GLOW 2006*, Barcelona. www.bermudez-otero.com/GLOW2006.pdf.

Bermúdez-Otero, Ricardo. 2011. The architecture of grammar and the division of labor in exponence. In Jochen Trommer (ed.), *The morphology and phonology of exponence*, 8–83. Oxford: Oxford University Press. DOI: https://doi.org/10.1093/acprof:oso/9780199573721.003.0002

Blumenfeld, Lev. 2006. *Constraints on phonological interactions*. Stanford, CA: Stanford University dissertation.

Cowell, Andrew & Alonzo Moss. 2008. *The Arapaho Language*. Boulder, CO: Colorado University Press.

de Lacy, Paul. 2006. *Markedness: Reduction and preservation in phonology*. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9780511486388

Dinnsen, Daniel A., Kathleen M. O'Connor & Judith A. Gierut. 2001. The puzzle-puddle-pickle problem and the Duke-of-York gambit in acquisition. *Journal of Linguistics* 37(3). 503–525. DOI: https://doi.org/10.1017/S0022226701001062

Downing, Laura J. 2018. Blurring the line between duplication and reduplication. *Talk given at OCP 15*, London.

Elfner, Emily. 2009. Stress-epenthesis interactions in Harmonic Serialism. Manuscript, University of Massachusetts, Amherst.

Elfner, Emily. 2016. Stress-epenthesis interactions in Harmonic Serialism. In John J. McCarthy & Joe Pater (eds.), *Harmonic Grammar and Harmonic Serialism*, 261–300. Sheffield: Equinox.

Ethnologue. 2018. Arapaho. https://www.ethnologue.com/language/arp.

Farris-Trimble, Ashley W. 2008. *Cumulative faithfulness effects in phonology*. Iowa City, IA: University of Iowa dissertation.

Frajzyngier, Zygmunt & Erin Shay. 2002. *A grammar of Hdi*. Berlin, New York: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110885798

Hyman, Larry M. 2009. How (not) to do phonological typology: The case of pitch-accent. *Language Sciences* 31(2–3). 213–238. DOI: https://doi.org/10.1016/j.langsci.2008.12.007

Kiparsky, Paul. 1982. Lexical morphology and phonology. In In-Seok Yang (ed.), *Linguistics in the morning calm*. Seoul: Hanshin.

Kiparsky, Paul. 1985. Some consequences of Lexical Phonology. *Phonology Year-book* 2. 82–183. DOI: https://doi.org/10.1017/S0952675700000397

Kiparsky, Paul. 2000. Opacity and cyclicity. *Linguistic Review* 17(2–4). 351–366. DOI: https://doi.org/10.1515/tlir.2000.17.2-4.351

Kirchner, Robert. 1996. Synchronic chain shifts in optimality theory. *Linguistic Inquiry* 27(2). 341–350.

Legendre, Géraldine, Yoshiro Miyata & Paul Smolensky. 1990. Harmonic Grammar: A formal multi-level connectionist theory of linguistic well-formedness: Theoretical foundations. Manuscript, University of Colorado, Boulder.

Lombardi, Linda. 2002. Markedness and the typology of epenthetic vowels. *Linguistics and Phonetics 2002*, 1–22.

McCarthy, John J. 2000. Harmonic serialism and parallelism. In *Proceedings of NELS 30*, 501–524. Amherst, MA: GLSA Publications.

McCarthy, John J. 2003. Sympathy, cumulativity, and the Duke-of-York gambit. In Caroline Féry & Ruben Van de Vijwer (eds.), *The syllable in optimality theory*, 23–76. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9780511497926.003

McCarthy, John J. 2008. The serial interaction of stress and syncope. *Natural Language & Linguistic Theory* 26(3). 499–546. DOI: https://doi.org/10.1007/s11049-008-9051-3

McCarthy, John J. 2010. An introduction to Harmonic Serialism. *Language and Linguistics Compass* 4. 1001–1080. DOI: https://doi.org/10.1111/j.1749-818X.2010.00240.x

McCarthy, John J. 2016. The theory and practice of Harmonic Serialism. In John J. Mccarthy & Joe Pater (eds.), *Harmonic Grammar and Harmonic Serialism*. Sheffield: Equinox.

McPherson, Laura. 2013. *A grammar of Tommo So*. Berlin, Boston: Mouton de Gruyter. DOI: https://doi.org/10.1002/ejoc.201200111

Mithun, Marianne. 1999. *The languages of Native North America*. Cambridge, New York: Cambridge University Press.

Moore-Cantwell, Claire. 2016. Contexts for epenthesis in Harmonic Serialsm. In John J. McCarthy & Joe Pater (eds.), *Harmonic Grammar and Harmonic Serialism*, 236–260. Sheffield: Equinox.

O'Brien, Jeremy. 2012. *An experimental approach to debuccalization and supplementary gestures*. Santa Cruz, CA: University of California Santa Cruz dissertation.

Prince, Alan & Paul Smolensky. 1993. *Optimality Theory: Constraint interaction in generative grammar*.

Prince, Alan & Paul Smolensky. 2004. *Optimality Theory*. Malden, Oxford, Victoria: Blackwell. DOI: https://doi.org/10.1002/9780470759400

Pullum, Geoffrey K. 1976. The Duke of York gambit. *Journal of Linguistics* 12(1). 83–102. DOI: https://doi.org/10.1017/S0022226700004813

Rubach, Jerzy. 2003. Duke-of-York derivations in Polish. *Linguistic Inquiry* 34(4). 601–629. DOI: https://doi.org/10.1162/002438903322520160

Smolensky, Paul. 1993. Harmony, markedness, and phonological activity. *Handout of keynote address, Rutgers Optimality Workshop 1*.

Smolensky, Paul. 1995. On the structure of the constraint component Con of UG. *Handout of talk given at UCLA*.

Smolensky, Paul & Géraldine Legendre. 2006. *The harmonic mind: From neural computation to optimality-theoretic grammar (cognitive architecture)* 1.Cambridge, MA: MIT press.

Stojković, Jelena. 2017. Interaction of tone and vowel height in BCS vowel reduction – an argument for Harmonic Grammar. *Talk given at the Manchester Phonology Meeting 25*, Manchester.

Suzuki, Keiichiro. 1995. NN: Rendaku and licensing paradox. In *Proceedings of the sixth annual Japanese/Korean conference.*

Tranel, Bernard. 1995. The phonology of mixteco's floating high tones: Theoretical implications. Manuscript, University of Irvine, Irvine.

Trommer, Jochen. 2011. *Phonological aspects of Western Nilotic mutation morphology*. Leipzig: Universität Leipzig habilitation.

Yip, Moira. 2002. *Tone*. Cambridge: Cambridge University Press.

Zimmermann, Eva. 2011. Tone in Arapaho. *Talk given at the Manchester Phonology Meeting 19*, Manchester.

Zimmermann, Eva & Jochen Trommer. 2011. Special treatment for stems and closed syllables: Tone in Arapaho. *Talk given at WSCLA 16*, Amherst.

How to cite this article: Gleim, Daniel. 2019. A feeding Duke-of-York interaction of tone and epenthesis in Arapaho. *Glossa: a journal of general linguistics* 4(1): 97. 1–27. DOI: https://doi.org/10.5334/gjgl.805

Submitted: 15 September 2018 **Accepted:** 13 February 2019 **Published:** 14 August 2019

]u[*Glossa: a journal of general linguistics* is a peer-reviewed open access journal published by Ubiquity Press.

OPEN ACCESS