Consonant Cluster Alternations in Pawnee: An Optimality Account*

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1. Introduction

I examine in this study certain consonant cluster alternations in Pawnee, and propose an Optimality-theoretic account. The alternations discussed in this work involve a number of distinct phonological processes. I argue that, while they are diverse in quality, these alternations are triggered for the same reason: to optimize syllable contact (Venneman (1988)). This analysis has the following advantages: (i) unlike a rule-based analysis as in Parks (1976), this constraint-based analysis gives an unified account for the alternations that would otherwise seem unrelated to one another; (ii) in addition, it follows from this analysis why geminates are not allowed in Pawnee; (iii) it explains why different geminates undergo different degemination processes.

2. The Pawnee language

2.1. Background

Pawnee belongs to the northern branch of the Caddoan language family along with Wichita and Arikara (Parks (1976)). The people of Pawnee currently live in and around the town of Pawnee, Oklahoma. However, there is no fluent speaker today (Parks (p.c., May 2005)).

2.2. Phonemic inventory

As shown in Table 1, Pawnee has a relatively small number of consonants.

	Labial	Alveolar	Velar	Laryngeal
Stops	p	t	k	
Affricates		c		
Fricatives		s		h
"Sononants"	w[1]	r[2]		

Table 1: Phonemic Inventory of Pawnee Consonants

First of all, Pawnee lacks in voiced obstruents. Second, Pawnee has a relatively robust series of alveolar consonants, but it only has a very limited number of phonemes for the labial, velar, and laryngeal. As it will become clear, this second point crucially bears on our main discussion of geminates in Section 5.

* The empirical observations made in this paper were first reported at the Conference on Manner Alternations in Phonology (see Deguchi (2005)). I would like to thank the participants of the conference for their comments.
[1] /w/ is a bilabial glide.
[2] /r/ is an alveolar tap.

3. Observations

As the contrast between (1) and (2) illustrates, the voiceless alveolar stop /t/ undergoes alternations when it is followed by a homorganic consonant.

(1) Presence of alternations

	Paradigm	Example	Translation	Process
a.	/**t**/ + /**t**/ → [**ct**]	/ta+**t**+**t**au:t+0/ → [ta**c**.**t**a.ʔu]	'I stole it.'	Affrication
b.	/**t**/ + /**s**/ → [**ct**]	/ta+**t**+**s**a+0/ → [ta**c**.**t**a]	'I'm lying.'	Affrication & stopping
c.	/**t**/ + /**c**/ → [**ct**]	/ta+**t**+**c**ak+0/ → [ta**c**.**t**at]	'I shot it.'	Metathesis

(2) Absence of alternations

	Paradigm	Example	Translation
a.	/**t**/ + /**p**/ → [**tp**]	/ta+**t**+**p**aks+riwu+0…/ → [ta**t**.**p**aks.ti.wu …]	'I hit the boy ….'
b.	/**t**/ + /**k**/ → [**tk**]	/ta+**t**+**k**awicak+:hus/ → [ta**t**.**k**a.wi.ca:.ku]	'I'm grinding it.'

In addition, clusters involving /t/ undergo distinct processes. For example, /t/ affricates before another /t/ as in (1a); /t/ affricates before /s/, and the /s/ undergoes stopping as in (1b); /t/ followed by /c/ undergoes metathesis as in (1c).

While the above contrast indicates that homorganic consonants play a crucial role in triggering the alternations, it is important to observe that the output clusters remain homorganic. This observation thus suggests that, while homorganicity is relevant, there is another essential factor inducing the alternations.

I argue that these alternations are triggered to improve the transition between syllable boundaries. More specifically, clusters undergo alternations in such a way that the coda becomes more sonorous than the following onset. In summary, I claim that the alternations are induced when homorganic consonants come in contact, and if the first segment is not more sonorous than the second.

4. Optimality analysis

4.1. Constraints

In order to account for the above syllable transition fact, I adopt a version of the syllable contact condition (Venneman (1988)) defined in terms of sonority (e.g., Davis and Shin (1999)) as shown in (3a).[3] In addition, I adopt an OCP constraint (Goldsmith (1976)) to account for the homorganicity effect. Since the alternations are present only when both of the two constraints are simultaneously violated, I propose to conjoin the two constraints as in (3c).

(3) Main constraints

a. SYLLCON: the coda of a syllable must be higher in sonority than the onset of the immediately following syllable (i.e., "avoid rising and flat sonority over a syllable boundary).[4]

[3] Vennemann (1988) defines syllable contact condition in terms of "strength."

[4] Davis and Shin's (1999) syllable contact constraint only militates against raising sonority.

b. OCP[place]: avoid consecutive segments with the identical place specification (i.e., "avoid homorganic clusters").
c. LC: local conjoined constraint of SYLLCON and OCP[place], where the domain is adjacent syllables.

To evaluate SYLLCON, we adopt the following sonority scale.

(4) Adopted sonority scale

Stops Affricates Fricatives Liquid
(least sonorous) → (most sonorous)

We assume that fricatives are more sonorous than stops. In addition, we assume with Hankamer and Aissen (1974) that the sonority of affricates falls somewhere between that of stops and that of fricatives.

Note here that it is possible to "repair" bad consonant clusters either by avoiding bad sonority sequence or by avoiding consecutive homorganic segments. In particular, (a) manner alternations, (b) metathesis, or (c) cluster reduction may be in principle induced to avoid bad sonority sequence; (d) change of place or cluster reduction may be induced to avoid homorganicity. Based on this observation, I propose the faithful constraints in (5), which are antagonistic to the markedness constraints in (3).

(5) Additional constraints
a. IDENT[manner]: corresponding segments in the input and output must be identical with respect to the manner specification (i.e., "avoid manner alternations").
b. LINEARITY: corresponding segments in the input and output must be in the same order (i.e., "no metathesis")
c. MAX: the segments in the input must have corresponding elements in the output (i.e., "no deletion").
d. IDENT[place]: corresponding segments in the input and output must be identical with respect to the place specification (i.e., "no change of place").

4.2. Constraint ranking

Let us now consider the ranking of the constraints. First, LC must be ranked higher than its conjuncts as shown in (6) to have its "intended" effect.

(6) Partial ranking 1: LC >> SYLLCON, OCP[place]

The above partial ranking is universal to any conjoined constraint since the violation of an individual conjunct is tolerated as long as the whole is not violated.

Second, to avoid a violation of LC, Pawnee opts for manner alternations, rather than cluster reduction. The presence of manner alternations itself suggests that IDENT[manner] is outranked by LC, and since Pawnee prefers manner alternations to cluster reduction as illustrated in (7), MAX is ranked higher than IDENT[manner].

(7) Manner alternations vs. cluster reduction

		MAX	IDENT[manner]
a. Optimal:	/t+t/ → [ct]	ok	*
b. Suboptimal:	/t+t/ → [t]	*	ok

(8) Partial ranking 2

MAX >> IDENT[manner]

In addition, it is important to note that the Pawnee manner alternations always preserve place specification. This fact indicates that IDENT[place] is undominated in Pawnee. The following is thus our preliminary ranking of the constraints.

(9) Preliminary ranking: LC, IDENT[place], MAX >> OCP[place], SYLLCON, IDENT[manner]

4.2.1. Affrication

Let us first consider a case of affrication as in (1a) with the ranking in (9).

(10) Affrication [see (1a)]

/ta+$\mathbf{t}_1$+$\mathbf{t}_2$au:t+0/	LC	IDENT [pl]	MAX	OCP [pl]	SYLLCON	IDENT [man]
a. [ta$\mathbf{t}_1$.$\mathbf{t}_2$a.ʔu]	*!			*	*	
☺b. [ta$\mathbf{c}_1$.$\mathbf{t}_2$a.ʔu]				*		*
c. [ta$\mathbf{t}_1$.$\mathbf{p}_2$a.ʔu]		*!			*	
d. [ta.$\mathbf{t}_1$a.ʔu]			*!			

Since it has two consecutive identical segments over a syllable boundary, the faithful candidate (10a) necessarily violates SYLLCON as well as OCP[place].[5] Therefore, it incurs a fatal violation of LC. On the other hand, since it only violates one conjunct of LC, candidate (10c) satisfies LC. It however renders suboptimal due to the violation of undominated IDENT[place]. Candidate (10d) avoids a violation of LC altogether due to cluster reduction. However, (10d) loses to (10a) since it violates a high ranked faithful constraint, MAX. As a result, candidate (10b) is correctly selected as the optimal output.

It is important to note that here the coda /t/ alternates with an affricate, not with a fricative or a liquid, to comply with IDENT[manner]. In other words, as shown in (11), IDENT[manner] is violated minimally in the optimal output.

[5] Recall that the version of SYLLCON adopted here militates against flat sonority sequence as well as rising sonority sequence.

(11) Minimal violation of IDENT[manner]

			IDENT[manner]
a.	Optimal:	/t+t/ → [**c**t]	*
b.	Suboptimal:	/t+t/ → [**s**t]	**
c.	Suboptimal:	/t+t/ → [**r**t]	***

Based on this observation, I propose to adopt a gradient evaluation of IDENT[manner].

4.2.2. Absence of Alternations

As we discussed earlier, no alternation is triggered when non-homorganic consonants come in contact with each other as illustrated in (12).

(12) No alternations with non-homorganic clusters

			SYLLCON	IDENT[manner]
a.	Optimal:	/t+k/ → [tk]	*	ok
b.	Suboptimal:	/t+k/ → [ck]	ok	*

This fact suggests that IDENT[manner] is ranked relatively high, at least higher than SYLLCON as shown in (13).

(13) Partial ranking 3: IDENT[manner] >> SYLLCON

Let us now consider a case of non-homorganic clusters with the revised ranking of the constraint in (14).

(14) Revised ranking: LC, IDENT[place], Max >> IDENT [manner] **>>** OCP[place], SYLLCON

(15) Non-homorganic clusters [see (2)]

/ta+$\mathbf{t_1}$+$\mathbf{k_2}$awicak+:hus/	LC	IDENT [pl]	MAX	IDENT [man]	OCP [pl]	SYLLCON
☺a. [ta$\mathbf{t_1}$.$\mathbf{k_2}$a.wi.ca:.ku]						*
b. [ta$\mathbf{c_1}$.$\mathbf{k_2}$a.wi.ca:.ku]				*!		
c. [ta.$\mathbf{t_1}$a.wi.ca:.ku]			*!			

Candidate (15c) fatally violates one of undominated constraints: MAX. On the other hand, since candidate (15a) is a faithful candidate, it complies with both of the undominated faithfulness constraints. In addition, it does not violate the undominated markedness constraint (LC) since it only violates one of the conjuncts. Finally, while (15b) violates a high-ranked faithfulness constraint (IDENT[manner]), (15a) does not since it is a faithful candidate. Therefore, the faithful candidate is chosen optimal.

4.2.3. Affrication and stopping

We saw in (1) that both manner alternations and metathesis are observed in Pawnee. However, as illustrated in (16), Pawnee resorts to a manner alternation, rather than metathesis, when both are in principle available.

(16) Manner alternations vs. metathesis

		IDENT[manner]	LINEARITY
a. Optimal:	/t_1+s_2/ → [c_1t_2]	***	ok
b. Suboptimal:	/t_1+s_2/ → [s_2t_1]	ok	*

The above observation indicates that LINEARITY crucially outranks IDENT[manner] in Pawnee as shown in (17).

(17) Partial ranking 4

LINEARITY >> IDENT[manner]

The following revised ranking reflects the partial ranking in (17).

(18) Revised ranking 2

LC, IDENT[place], MAX, LINEARITY **>>** IDENT [manner] >> OCP[place], SYLLCON

With this ranking in mind, consider the following tableau.

(19) Affrication and stopping [see (1b)]

/ta+**t_1**+**s_2**a+0/	LC	IDENT [pl]	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [ta**t_1**.**s_2**a]	*!					*	*
☺b. [ta**c_1**.**t_2**a]					***[6]	*	
c. [ta**s_2**.**t_1**a]				*!		*	

First, the faithful candidate (19a) makes a fatal violation of LC since it violates both OCP[place] and SYLLCON. While it incurs 3 violations of IDENT[manner], candidate (19b) wins against the candidate with metathesis in (19c), which fatally violates the high-ranked LINEARITY constraint.

4.2.4. Metathesis

As we saw in (16), metathesis is avoided in Pawnee when manner alternations are available (i.e., LINEARITY >> IDENT[manner]). However, as shown in (20), a violation of LINEARITY is tolerated in order to avoid cluster reduction.

[6] In the (b) candidate, the coda violates IDENT[manner] once and the onset violates it twice, totaling 3 violations.

(20) Metathesis vs. cluster reduction

			LINEARITY	MAX
a.	Optimal:	/t_1+ c_2/ → [c_2t_1]	*	ok
b.	Suboptimal:	/t_1+ c_2/ → [t_1]	ok	*

This fact indicates that MAX outranks LINEARITY as follows.

(21) Partial ranking 5

MAX >> LINEARITY

(22) Revised ranking 3

LC, IDENT[place], MAX **>>** LINEARITY >> IDENT [manner] >> OCP[place], SYLLCON

With this revised ranking of the constraints, consider the tableau for the metathesis case.

(23) Metathesis

/ta+**t_1**+**c_2**ak+0/	LC	IDENT [pl]	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [ta**t_1.c_2**at]	*!					*	*
b. [ta**c_2.t_1**at]				*!		*	
c. [ta.**t_1**at]			*!				
☺d. [ta.**c_1.t_2**at]					**	*	

As it involves a homorganic cluster, the faithful candidate necessarily violates OCP[place]. Since it also violates SYLLCON because of the rising sonority, (23a) fatally violates the undominated LC constraint. Candidate (23c) loses to candidate (23b) because metathesis violates one of the undominated constraints, MAX. Notice, however, that candidate (23d) wins against candidate (23b) since it does not violate LINEARITY (or MAX) although it incurs two violations of IDENT[manner]. The OT analysis presented here thus suggests that the apparent metathesis be analyzed as a case of manner alternations, in particular a combination of affrication and stopping as shown in (23d).

5. Support: Geminates

The OT analysis presented here makes predictions about geminates in Pawnee. First of all, since geminates are by definition homorganic, they necessarily violate OCP[place]. In addition, since they always have "flat" sonority, they necessarily violate SYLLCON as well. Therefore, geminates necessarily violate the undominated LC constraint. It is thus predicated that geminates are not allowed in Pawnee. As illustrated in (24), this prediction is borne out.

(24) Geminates

Paradigm	Example	Process
a. /t/ + /t/ → [c.t]	/ta+**t**+**t**au:t+0/ → [tac.ta.ʔu]	Affrication [=(1a)]
	'I stole it.'	
b. /s/ + /s/ →[s.c]	/i+**s**+**s**a+0/ → [is.ca]	Affrication
	'if I lie.'	
c. /r/ + /r/ → [r]	/ti+ra**r**+**r**a:hur+uk+0/ → [ti.ra.ra:.hu.ʔu]	Cluster reduction
	'They are ruined.'	
d. /k/ + /k/ → [k]	/ti+ut+a**k**+**k**aksa…/ → [tu:.ta.ka.ksa…]	Cluster reduction
	'He called them.'	

Observe that some geminates undergo manner alternations (24a/b) while others undergo cluster reduction (24c/d). This asymmetry follows from the OT analysis.

Recall that, when LC is violated, manner alternations are usually evoked in Pawnee, rather than cluster reduction or metathesis (see (7) and (16), respectively). In addition, when manner alternations are triggered, the clusters always alternate with homorganic consonants, suggesting undominated IDENT[place]. Given the fact that /k/ is the only velar phoneme in Pawnee, manner alternation of /k/ necessarily incurs a violation of undominated IDENT[place]. On the other hand, alveolar consonants can undergo manner alternations without violating IDENT[place]. The contrast in (24) therefore suggests that a violation of MAX is tolerated in order to satisfy IDENT[place] (i.e., IDENT[place] >> MAX).

(25) Final ranking

LC, IDENT[place] **>>** MAX >> LINEARITY >> IDENT [manner] >> OCP[place], SYLLCON

With the final ranking in (25), consider the tableau in (26) in contrast with that in (27).

(26) Case of manner alternations: geminate /ss/[7]

/i+**s**$_1$+**s**$_2$a+0/	LC	IDENT [pl]	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [i**s**$_1$.**s**$_2$a]	*!					*	*
☺b. [i**s**$_1$.**c**$_2$a]					*	*	
c. [i.**s**$_1$a]			*!				

[7] Because of the gradient evaluation of IDENT[manner] as we have assumed in (11), the /ss/ alternates with [sc], rather than [st].

(27) Case of cluster reduction: geminate /kk/

/ti+ut+a**k**$_1$+**k**$_2$aksa+wa:+0/	LC	IDENT [pl]	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [tu:.ta**k**$_1$.**k**$_2$a.ksa.wa]	*!					*	*
b. [tu:.ta**c**$_1$.**k**$_2$a.ksa.wa]		*!			*		
☺c. [tu:.ta.**k**$_2$a.ksa.wa]			*				

First of all, since geminates necessarily violate LC as discussed at the beginning of this section, the faithful candidate always loses with geminates ((26a) and (27a)). Next, compare the (b) candidate in (26) and that in (27). While both violate low-ranked IDENT[manner], only the (b) candidate in (27) fatally violates the undominated IDENT[place]. As a result, the (b) candidate with manner alternation is selected as the optimal candidate for the /ss/ geminate on the one hand; the (c) candidate with cluster reduction is chosen for the /kk/ geminate on the other. [8]

Second, since MAX crucially outranks IDENT[manner] as we saw in (7), Pawnee opts for manner alternations, rather than cluster reduction. Note here that, while the alternation of /ss/ is consistent with this pattern, the alternation of /kk/ is not. In summary, the asymmetry between manner alternations and cluster reduction follows from an asymmetry in the phonemic inventory once the present OT analysis is adopted.

6. Residual issue

As we just saw, geminates undergo manner alternations when they have homorganic consonants to alternate with; they undergo cluster reduction instead when they do not have homorganic consonants. However, as the tableau in (28) shows, the geminate /rr/ presents itself as an apparent counter example to these patterns.

(28) Geminate /rr/

/ti+ra**r**$_1$+**r**$_2$a:…/	LC	IDENT [pl]	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [ti.ra**r**$_1$.**r**$_2$a:…]	*!					*	*
☹b. [ti.ra**r**$_1$.**s**$_2$a:…]					**	*	
c. [ti.ra.**r**$_2$a:…]			*!				

Since it is an alveolar sound, /r/ can alternate with another alveolar segment such as /s/ without violating the undominated IDENT[place]. Therefore, we predict that /rr/ would undergo a manner alternation as in (28b), rather than cluster reduction as in (28c). However, this is a wrong prediction: the geminate /rr/ undergoes cluster reduction.

Note that /r/ is an alveolar segment like /s/, /c/, and /t/, but /r/ is a sonorant unlike the rest. I propose that in Pawnee there is an undominated constraint that militates against alternations from

[8] The geminate /tt/ patterns with /ss/, and /rr/ patterns with /kk/. We only discuss /ss/ and /kk/ here. We will return to /ss/ later.

a sonorant to an obstruent, or vice versa. Consider the following tableau with this new constraint, IDENT[sonorant].

(29) Geminate /rr/ revised

/ti+ra**r**$_1$+**r**$_2$a:…/	LC	IDENT [pl]	**IDENT [son]**	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [ti.ra**r**$_1$.**r**$_2$a:…]	*!						*	*
b. [ti.ra**r**$_1$.**s**$_2$a:…]			*!			*	*	
☺c. [ti.ra.**r**$_2$a:…]				*				

Since it violates the undominated IDENT[sonorant], candidate (b) loses to candidate (c). This suggests that we need IDENT[sonorant] in addition to IDENT[manner].

This additional undominated constraint keeps the outcome of any of the cases we discussed earlier intact. For example, the tableau in (30) shows that the additional undominated constraint does not affect the outcome of the metathesis case.

(30) Metathesis revisited

/ta+**t**$_1$+**c**$_2$ak+0/	LC	IDENT [pl]	**IDENT [son]**	MAX	LIN	IDENT [man]	OCP [pl]	SYLLCON
a. [ta**t**$_1$.**c**$_2$at]	*!						*	*
b. [ta**c**$_2$.**t**$_1$at]					*!		*	
c. [ta.**t**$_1$at]				*!				
☺d. [ta.**c**$_1$.**t**$_2$at]						**	*	

Since none of the candidates, including the optimal output, does not violate IDENT[sonorant], the same candidate is chosen as the optimal output both in (23) and (30).

7. Conclusions

In this paper, I demonstrated that the syllable contact condition (defined in terms of sonority) was partially responsible for the various consonant cluster alternations in Pawnee. I then proposed an Optimality theoretic account. Crucially, observing that the syllable contact condition is in effect only in homorganic clusters, I proposed to conjoin the syllable contact constraint (SYLLCON) with the "anti-homorganic cluster" constraint (OCP[place]). Since all the geminates necessarily violate this conjoined constraint, the proposed analysis correctly predicts Pawnee's aversion to geminates.

In addition, observing that all the manner alternations preserve their manner specification, I claimed that IDENT[place] is undominated in Pawnee. While they usually undergo manner alternations, geminates undergo cluster reduction instead in cases where IDENT[place] would be otherwise violated (e.g., /kk/→[k]). Geminate also exhibit cluster reduction if IDENT[sonorant] would be otherwise violated (e.g., /rr/→[r]). These two cases of cluster reduction are motivated

by different causes: to respect IDENT[place] for the former, and to respect IDENT[sonorant] for the latter.

The constraint-based analysis that I proposed allows us to account for asymmetries such as (i) presence vs. absence of alternations, (ii) manner alternations vs. cluster reduction, and (ii) two distinct motivations for cluster reduction, as consequences/realization of constraint interaction.

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