

An Optimality Theoretic Account of the Athapaskan D-Effect(s)

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1.0 Introduction

In Athapaskan languages, the classifier prefix /d/ enters into several prosodic and segmental alternations with the initial segment of a following root-- alternations referred to as the 'D -Effect'; see, for example, Howren 1971, McDonough 1990, Rice 1987, Shaw 1991 for discussion. In some cases this prefix merges with the root-initial segment to form a 'contour' segment; in others it syllabifies either as a coda of a preceding syllable or as the onset of a syllable supported by an epenthetic vowel, in still others it is lost. The effects of the classifier prefix /d/ on an immediately following root-initial consonant are presented in the table in (1):

- (1) Effects of classifier prefix /d/ on an immediately following root-initial consonant

d+root-initial	Navajo-type	Ahtna-type	Koyukon-type	Hupa-type
d+?	t'	t'	t'	dV.?
d+fricative d+S, d+L, d+Š, d+X, d+X̣	dz, dl, j, g	dz, dl, g/dy, G/dỵ	dV.C	dV.C
d+other C	C	d.C if C is not coronal stop; C if C is coronal stop	dV.C	dV.C
d+V	dV	dV	dV	dV
d+n	n', n, d, dn	d.n	dV.n	dV.n

The above table is partitioned into four cross-family patterns: Navajo-type, Ahtna-type, Koyukon-type, and Hupa-type¹. Each pattern is characterized by five distinct contexts: from top-to -bottom, /d/ affixed to a root beginning with a glottal stop; /d/ affixed to a root beginning with a fricative; /d/ affixed to a root beginning with a consonant other than a glottal stop or a fricative; /d/ affixed to a root beginning in a vowel; and finally, /d/ affixed to root beginning with the coronal nasal /n/. The cells of the table illustrate the segmental and prosodic alternations exhibited by the prefix in a specific context.

The full range of generalizations, prosodic and segmental, which emerge from a close inspection of the table in (1) are listed in (2) and summarized in (3).

- (2) Generalizations

- (a) In the Hupa-type languages, epenthesis is always found.
- (b) In the Koyukon-type, epenthesis occurs except when the /d/ is followed by a glottal stop (the only laryngeal in the language), in which case the two segments fuse to a single segment.
- (c).i. In the Ahtna and Navajo types, a single segment is created whenever possible; this is the case when the root begins with a non-stop.
 - ii. When the root begins with a stop, the /d/ syllabifies as a rhyme in Ahtna-type languages and is lost in the Navajo-type.

(3) Summary of D-Effects

d+root-initial	Navajo-type	Ahtna-type	Koyukon-type	Hupa-type
d+?	merger	merger	merger	epenthesis
d+fricative	merger	merger	epenthesis	epenthesis
d+other consonant	deletion	syllabification as rhyme	epenthesis	epenthesis

The present paper is concerned with providing an initial characterization of the D-Effect facts across the language family within the constraint-based framework of Optimality Theory (Prince and Smolensky forthcoming). To this end we will focus primarily on accounting for the alternations exhibited by the /d/ classifier when it combines with a root-initial stop or glottal stop, leaving the fricative alternations as a topic for future research (see Lamontagne and Rice, in preparation). We will show that interactions between the /d/ classifier prefix and the root-initial segment follow from the interactions between a small number of universal constraints which may be ranked on a language-specific basis. Hence, the present work may be taken as support for the optimality theoretic characterization of particular grammars as the reorganization of universal constraints.

The structure of the paper is as follows: In Section 2 we provide some background on the structure of Athapaskan languages relevant to the current discussion; in Section 3 we outline the claims underlying the theoretical framework in which we couch our analysis of the D-Effect; finally in Section 4, we provide an analysis of the prosodic and segmental alternations exhibited by the /d/ classifier prefix in combination with a root-initial stop (4.1) and glottal stop (4.2).

2.0 The Relevant Structure of Athapaskan Languages

The /d/ classifier is one of four voice/valency markers found in languages of the Athapaskan family. These morphemes have both productive and non-productive uses. In its productive capacity, the /d/ classifier marks, for example, passives (a) and reflexives (b). All examples are drawn from Slave (Rice 1989), and are typical of the family. Root-initial segments, both underlying and resulting from the D-Effect, are in bold face.

(4) Active marker of voice/valency (examples from Slave, Rice 1989)

- a. *sómba néʔi* 's/he stole money'
 money
 /ne + **ʔ** + *ʔi/*
 steal
- sómba néht'i* 'money was stolen'
 money
 /ne + **h** + d + *ʔi/*
 d steal
- b. *eniðe* 's/he thinks'
 /e + ne + n + **ðe/**
 think
- ʔedenedðe* 's/he thinks of him/herself'
 /ʔede + ne + d + **ðe/**
 d think

The d-classifier is also lexically frozen with some verb stems, as in (5).

- (5) -ji ‘sing’ cf. šj ‘song’
 /d+šj/ /šj/

Athapaskan languages have large consonant inventories. An example of an inventory is given in (6), this one from Ahtna. The inventories of the languages differ primarily by the number of distinctive places of articulation found.

(6) Ahtna (Alaska) consonant inventory (Kari 1990, modified transcription)

	labial	alveolar	lateral	alveo-	velar	uvular	glottal
							palatal
stops/affricates							
voiceless unaspirated	b	d	dl	dz	g	G	
voiceless aspirated		t	tʰ	ts	k	q	
glottalized		tʼ	tʰʼ	tsʼ	kʼ	qʼ	ʔ
non-stops							
voiceless			ɬ	s	x	χ	h
voiced	m	n	l	z	ɣ	ʁ	

With the exception of the labial place of articulation, all places of articulation include stops of different laryngeal qualities. All places of articulation include voiced non-stops: a nasal or fricative, depending on the place of articulation. The labial and alveolar places of articulation aside, all places of articulation also have a voiceless fricative, labelled voiceless non-stop.²

3.0 Theoretical Assumptions

In this section we present the theoretical assumptions essential to our analysis of the D-Effect in Athapaskan languages. First we present a brief description of the general framework assumed (3.1) and then we outline our assumptions concerning the representation of stricture features (3.2).

3.1 Optimality Theory

As noted above, we assume the Optimality Theory framework presented in the work of Prince and Smolensky (forthcoming). For reasons of space, the present discussion of Optimality Theory (OT) is extremely condensed, hence the reader is referred to the more comprehensive discussion of the foundations of OT found in the above work as well as in Prince and Smolensky (1991), McCarthy and Prince (forthcoming), McCarthy and Prince (forthcoming), and references cited within these works.

In OT the pairing of an underlying form with a (unique or *optimal*) surface form is achieved by evaluating a large set of potential (or *candidate*) surface forms with a set of universal constraints. The universal constraints are assumed to be violable and ranked in a hierarchy of domination-- i.e., an optimal surface form may violate several (low ranked) constraints so long as it satisfies other more highly ranked constraints. In this framework, particular grammars differ only in the ranking of universal constraints and, of course, in the form of their underlying representations. A schematic example is given in (7).

(7) Schematic Example:

Constraint Tableau, $A \gg B$, / in_k / \rightarrow { $k-cand_1, \dots$ }

Candidates	A	B
a) $k-cand_1$	*!	
b) $k-cand_2$		

In the above Constraint Tableau, the potential surface forms (candidates $k-cand_1$ & $k-cand_2$) are GENERATED from the input form / in_k /. These candidate surface forms are then evaluated by a language specific ranking of the universal constraints A and B -- in this case A is higher ranked than B ($A \gg B$), hence A is positioned to the left of B in the tableau. Candidate $k-cand_1$ violates constraint A -- this is indicated with an asterisk in the appropriate cell of the tableau. Candidate $k-cand_2$ does not violate A, hence the blank cell, but it does violate B-- again this is indicated with an asterisk. Reading the tableau from left to right, we see that candidate $k-cand_1$ violates constraint A while candidate $k-cand_2$ satisfies it. This difference with respect to the satisfaction of constraint A is enough to distinguish the two candidates -- indicated in the tableau with an exclamation mark. Even though candidate $k-cand_2$ violates constraint B, it is still the optimal surface form for / in_k / since, unlike candidate $k-cand_1$, it satisfies the higher ranked constraint A.³

In Optimality Theory, each underlying form is GENERATED into a possibly infinite number of candidate analyses. The function which generates an underlying form into a candidate set is restricted as follows:

- (8) Three Principles underlying GEN (Prince & Smolensky forthcoming, McCarthy & Prince forthcoming)
- Freedom of Analysis. Any amount of structure may be posited.
 - Containment. No element may be literally removed from the input form. The input form is thus contained in every candidate form.
 - Consistency of Exponence. No change in the exponence of a phonologically-specified morpheme are permitted.

3.2 The representation of stricture

We follow Steriade (1992, forthcoming) in assuming that stops have two slots, closure and release, while continuants have a single slot. These slots are represented phonologically as aperture positions, indicated by the symbol 'A' (for aperture). The representations that are relevant to this paper are given in (9).

- (9) $AoAmax = stop$ (o = maximal closure; max = approximant release)

$Amax = glottal\ stop$

|
[cg]

$AoAmax = ejective$

|
[cg]

When two A positions are present, the first represents closure and the second release; when a single position is present, it represents release. The only exception to this is unreleased stops, which are represented simply as Ao. See Lamontagne &

Note that complex onsets are not allowed in Athapaskan languages, eliminating the candidate V.AoAoV.

In Navajo, unlike Ahtna, not all of the input is parsed--i.e., the /d/ deletes. This is accomplished by a strong avoidance of codas over faithfulness to the input. In this language-type, No-Coda is ranked above Parse.

- (13) Navajo: d+stop --> stop
 /ʎi+ii+D+kááh/ --> [ʎiikááh] 'we make a sandpainting' (Kari 1973:53)
 Input: /...Ao + [AoA].../

Candidates	Align-L	No-Coda	Parse
a. V Ao.[AoA]V		*!	
b. V<Ao>.[AoA]V			*
c. V.Ao<[AoA]>V	*!		*

Notice that an Alignment constraint governing the coincidence between morphological (root) and prosodic (syllable) categories is relevant here. It is this constraint which ensures that the candidate with an unparsed /d/ (13b) is favored over one with the root-initial stop unparsed (13c).

The crucial difference in the rankings of the universal constraints between the Ahtna-type and the Navajo-type patterns is given below in (14).

- (14) crucial rankings:
 Navajo: No-Coda >> Parse
 Ahtna: Parse >> No-Coda

Here the difference between the two types of languages is characterized by the re-ranking of the two constraints No-Coda and Parse.

In the Koyukon and Hupa patterns, an epenthetic vowel appears between the /d/ and the root-initial stop. This follows from a low ranking of the faithfulness constraint Fill (11c). If Fill is ranked below Parse and No-coda, the optimal candidate will be one which exhibits an epenthetic vowel (15c).

- (15) Koyukon, Hupa: d+stop --> dV.stop
 /no + ghə + D + nəG/ --> [naghədənəG] 'it (string, seam, cloth) unravelled'
 (Koyukon; Axelrod 1993:38)
 Input: /...Ao + [AoA].../

Candidates	No-Coda	Parse	Fill
a. V Ao.[AoA]V	*!		
b. V<Ao>.[AoA]V		*!	
c. V.Ao□.[AoA]V			*

In (16) we present a summary of the constraint rankings which account for the cross-language alternations of the /d/ classifier prefix when followed by a root which begins with a stop. Crucial here is the re-ranking of Faithfulness constraints (Fill and Parse) with the constraint No-Coda.

- | | | | | |
|------|----------------------|------------------|----|---------|
| (16) | (a) Navajo: | No-Coda
Fill | >> | Parse |
| | (b) Ahtna: | Fill
Parse | >> | No-Coda |
| | (c) Koyukon/
Hupa | No Coda
Parse | >> | Fill |

4.2 Case 2: /d/ + glottal stop

In this section we focus on the segmental alternations exhibited by the /d/ when it precedes a glottal stop. In three of the four language groups, /d/ combines with a root-initial glottal stop to form a glottalized coronal [tʰ], while in the fourth group, epenthesis is found. These facts are summarized in (17).

- | | | |
|------|----------------------|---------------|
| (17) | Navajo/Ahtna/Koyukon | D + ? --> tʰ |
| | Hupa | D + ? --> dV? |

To account for these effects we assume that the interaction between constraints prohibiting the proliferation of both prosodic and segmental structure are at play.⁵ The first constraint, which we call *Single-Segment*, favors representations where two *compatible* aperture positions are fused into a single segment. In other words, following Steriade (1992), we assume that if a sequence of segments (like Ao and A) can be interpreted as a single segment, they must fuse to form a single segment -- thus the single segment [AoA[cg]] (i.e. an ejective) will be favored over the sequence Ao + A[cg]. This constraint thus favors complex segments over sequences. In essence this entails a reduction of 'complex' prosodic structure.⁶

- | | | |
|------|-----------------|--|
| (18) | Single-Segment: | A sequence of different aperture positions must be interpreted as a single segment: [AxAy] |
|------|-----------------|--|

The second constraint which plays a role here characterizes the marked status of complex and contour segments. Such segments are marked by an excess of structure when compared with simple segments -- for example, branching under a place node in the case of complex segments, or a combination of two aperture positions (like Ao & Af [fricative release], or Ao & A[cg]) in the case of contour segments. This constraint, which we call **Seg-Structure*, governs the richness of structure at the segmental level.

- | | | | |
|------|----------------|-----|--------------------------|
| (19) | *Seg-Structure | *X | Where X, Y, and Z are |
| | | /\ | feature geometric nodes. |
| | | Y Z | |

4.2.1 Navajo and Ahtna

We turn now to the individual cases. In Navajo and Ahtna the /d/ merges with the root-initial glottal stop to form an ejective, [tʰ]. This follows from the effects of *Single-Segment* and *Parse*.

- (20) Navajo/Ahtna: d + ?--> [t']
 Navajo: /y + ii + D + ?i/ --> /yiit'ɨ/ 'we see it' (Kari 1973:54)
 Ahtna: /na + ?i + D + ?aan/ --> [na?it'aan] 'it was found' (Kari 1990:650)
 Input: /...d + ?.../ = /...Ao + A[cg].../

Candidates	Single-Segment	Parse
a. VAo.AV [cg]	*!	
b. V.AoAV [cg]	*!	
c. ☞ V.[AoA]V [cg]		
d. V<Ao>.AV [cg]		*!

(20c) is the optimal candidate since it is faithful to the input in containing all input features and it violates neither Single-Segment nor Parse.

4.2.2 Koyukon

In Koyukon, as in Navajo and Ahtna, merger is found. Since in other contexts Koyukon-type languages exhibit epenthesis (see (1)), the ranking of Single-Segment and Parse with respect to Fill must be established. In this case the latter constraint is ranked low:

- (21) Koyukon: d + ?--> [t']
 /niɬ + to + u + D + ?it/ --> [niɬto?ut'it] 'they are mating' (Thompson 1977:73)
 (b) Input: /...d + ?.../ = /...Ao + A[cg] .../

Candidates	Single-Segment	Parse	Fill
a. VAo.AV [cg]	*!		
b. V.AoAV [cg]	*!		
c. ☞ V.[AoA]V [cg]			
d. V<Ao>.AV [cg]		*!	
e. V.Ao□.AV [cg]			*!

Candidate (21a) violates Single-Segment since it is two segments with compatible aperture positions; this is also true of candidate (21b). Candidate (21d) presents a parse violation since one of the segments, Ao, remains unparsed. Finally, candidate (21e) contains an epenthesis site, creating a Fill violation. Candidate (21c) violates no constraints, with Ao and A_[cg] combined to form a single segment. It is thus the favored candidate.

4.2.3 Hupa

Finally, in Hupa the /d/ and the glottal stop do not merge -- instead we see epenthesis. In fact, contour segments never surface across morpheme boundaries in Hupa-type languages. This fact is accounted for in following Constraint Tableau by ranking *Seg-Structure, the constraint from (19) that prohibits complex and contour segments, above Fill.

- (22) Hupa: d + ʔ-> [dV.ʔ]
 Input: /...d + ʔ.../ = /...Ao + A_[cg] .../

Candidates	Single-Segment	Parse	*Seg-Struct	Fill
a. V Ao.AV [cg]	*!			
b. V.AoAV [cg]	*!			
c. V.[AoA]V [cg]			*!	
d. V<Ao>.AV [cg]		*!		
e. V.Ao□.AV [cg]				

Here the optimal candidate is the one with an epenthetic vowel between the /d/ and the glottal stop, (22e). Candidates (22a) and (22b) both violate Single-Segment in that two compatible aperture positions are parsed as distinct segments. Candidate (22c) violates *Seg-Struct with the /d/ and the root-initial glottal stop merged to form the contour segment [tʔ]. Finally, the candidate where /d/ (or for that matter the glottal stop of the root) is deleted violates Parse which is itself ranked above *Seg-Struct.⁷

Although the Koyukon and Hupa patterns exhibit epenthesis in the /d/ plus root-initial stop cases (see (1)), they differ here in that only the latter exhibits epenthesis when /d/ is followed by a glottal stop. This fact suggests the following grammar particular ranking differences:

- (23) crucial rankings
 Koyukon: Fill >> *Seg-Struct
 Hupa: *Seg-Struct >> Fill

5.0 Conclusions

In this paper we have provided a cross-family survey of the Athapaskan D-effect, and examined in particular the ways in which the /d/-classifier combines with a stem-initial stop and a stem-initial glottal stop, leaving the combination with a stem-initial fricative for later study. The prosodic differences in the family follow from different rankings of constraints on structure (No-Coda) and faithfulness (Parse, Fill). We have examined one of the segmental markedness constraints as well, *Seg-Struct. The differences between the languages are easily captured in Optimality Theory, with the languages differing in the rankings of a small number of general constraints.

¹ A partial classification of Athapaskan languages according to language type is given below:

Navajo-type: Navajo, Apache, Slave, Chipewyan, Sekani, Beaver, Sarcee, Dogrib, Oregonian Athapaskan, Gwich'in, Athapaskan languages in Yukon territory

Ahtna-type: Ahtna, Tanaina

Koyukon-type: most of Alaskan Athapaskan

Hupa-type: California Athapaskan

Data is drawn from the following sources: Axelrod 1993, Golla 1970, Howren 1971, Kari 1973, Kari 1990, Rice 1989, Thompson 1977, Young & Morgan 1987. Thank you to Victor Golla for his assistance.

² Whether a consonant is realized as a stop or an affricate is predictable from its place of articulation. The primary contrast in stricture is between stop and non-stop.

³ The shading in the tableau indicates that the cells in question play no role in determining the optimal form.

⁴ Fill and Parse belong to the set of Faithfulness constraints identified by Prince and Smolensky forthcoming.

⁵ Such constraints ultimately belong to the class of constraints *Struct (see Prince and Smolensky, forthcoming; McCarthy and Prince, forthcoming, for discussion)

⁶ This constraint is similar in spirit to Prince and Smolensky, forthcoming, *Complex.

⁷ This ranking between Parse and *Seg-Struct follows from the fact that contour segments are allowed in the inputs of all languages under investigation. Hence, Parse >> *Seg-Struct.

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