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Be careful what you throw out: Gemination and tonal feet in Weledeh Dogrib

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The Weledeh dialect of Dogrib (Tłı̨chǫ Yatiì) is spoken by people of the Yellowknives Dene First Nation, in and around Yellowknife, Northwest Territories. Within the formal framework of Lexical Phonology (Kiparsky 1982), this paper argues for an over-arching generalization in the phonology of Weledeh Dogrib: the constraint NoContour-Ft, which prefers (High-High) and (Low-Low) feet, but militates against (High-Low) and (Low-High) feet. NoContour-Ft is satisfied differently in different morphophonological domains: vowel deletion at the Stem Level, gemination at the Word Level, and High to Mid tone lowering at the Postlexical Level. This analysis requires that consonant length be treated as phonological in Dogrib—that is, consonant length contributes to syllable weight and mora count—even though there are no minimal pairs based on consonant length. Similarly, the distinction between High and Middle tone does not distinguish any lexical items, but is nevertheless important for the prosody of the language. Thus the paper makes a methodological point about the importance of allophonic alternations for phonological theory. Our view of what counts as contrastive or allophonic, however, is to a large extent theory-dependent; therefore, the paper also emphasizes the importance of phonetic measurements when doing fieldwork.

1. INTRODUCTION: WHAT COUNTS AS PHONOLOGICAL?

> ...even such commonplace categories as subject and verb are theoretical constructs, which may or may not be the ones most appropriate for the data under consideration. (Gil 2001: 126)

The most basic task in fieldwork is simply to transcribe what we hear—whether live or from a recording, we take a noisy and chaotic speech signal, and reduce it to an idealized set of characters on the page. Without imposing some kind of order on the data, it would be impossible to talk about higher levels of grammar—subject agreement, noun incorporation, and so forth. At the same time, how we construct phonological categories depends on the methodology and assumptions of the fieldworker just as much as the speech signal itself. Our assumptions are often not our own, but those inherited from previous generations of linguists—Athabaskanists, in particular, have the benefit of a descriptive tradition going back over 100 years (Goddard 1912; Li 1933, 1946). When I talk to other linguists about geminate consonants in Dogrib, for example, I am often asked, with an air of skepticism, "are there minimal pairs?" For the American structuralist, the reason for this question is obvious: whether or not we should talk about phonological consonant length depends on whether consonant length can distinguish utterances (Bloomfield 1933). Structuralist descriptions of phoneme inventories have been left largely intact by generative fieldworkers, even when the assumptions upon which these descriptions are based would no longer be considered valid in a generative context. In this article, I will re-examine some basic assumptions about the phonology of Weledeh Dogrib, a short summary of which is given in (1).

(1) *Generally accepted views about Dogrib:*
  i. The final syllable is stressed (Marinakis 2004).
  ii. Coda consonants in Dogrib are not moraic (Marinakis 2004).
  iii. Consonant length in Athabaskan languages is phonetic, not phonological (McDonough and Ladefoged 1993, Tuttle 2005).

What we shall see is that even these simple descriptive statements, though perfectly well-motivated in earlier frameworks, are misleading when taken out of their original context and applied at face value in a new theory—in my case, that of Lexical Phonology (Kiparsky 1982) and Optimality Theory (OT). For example, it makes perfect sense for a Prague School phonologist to say that the final syllable, also the stem syllable, is stressed in Dogrib, since stress is understood as a position which licenses more contrast (Trubetzkoy 1939), and indeed there is a larger inventory of segments allowed in the stem than in the prefixes (Rice 1989, Marinakis 2004). In OT, however, we more closely associate stress with some set of phonetic properties, such as increased F0, amplitude, and duration—in which case this claim turns out to be false (in many cases). To say that consonant length is "not phonological" in an American structuralist framework means only that consonant length cannot distinguish utterances, which is largely true; yet in OT, this means that the phonetic length of consonants does not affect the number of moras, which in turn affects syllable weight. As I will show, the key generalizations about morphophonemics in Dogrib require reference to syllable weight, which in turn requires reference to consonant length—we would miss important generalizations if geminates were not included as part of the phonology.

For me, then, fieldwork on Dogrib has been a process of unraveling layers of unstated assumptions, both others' and my own. Relying on descriptive statements made by others means adopting their assumptions about what facts ought to be included in the description and what should be thrown out. Fieldwork with speakers of Weledeh Dogrib enables me to go back to the original speech signal and decide for myself what is structurally important and what is not. As I will demonstrate, once consonant length is included as part of the phonological representation for Weledeh Dogrib, a whole new set of descriptive generalizations emerge, the most important of which is the existence of the *tonal foot*, a unit of suprasegmental structure that simultaneously regulates tone, stress, and syllable weight (section 2).

Before proceeding further, a note on the language. The Weledeh dialect of Dogrib (Tłı̨chǫ Yatıì) is a northern Athabaskan language, spoken by people of the Yellowknives Dene First Nation, in the communities of Dettah and Ndilǫ, near Yellowknife, Northwest Territories. While other dialects of Dogrib are still being acquired by children, due to the community's proximity to Yellowknife, the Weledeh dialect has very few fluent speakers under age 40. The community is traditionally bilingual: many older people also speak Chipewyan (Dëne Sųłiné) as well as Dogrib. The Goyatìkǫ̀ Language Center in Dettah is actively working to preserve and revitalize both traditional languages through translator and interpreter training, literacy training, recording elders' stories, and making teaching materials for children. The data in this paper are taken from six weeks of my own field-work in Yellowknife in the summer of 2005. My primary elicitation was with two speakers, Mary Louise Drygeese and Michel Paper, and checked with a third speaker, Mary Rose Sundberg, for accuracy in transcription. The phonetic data presented here were digitally recorded on a Marantz CDR-300 recorder and analyzed in Praat (Boersma & Weenik 2007).[1]

2. TONAL FEET. My central thesis is that several seemingly unrelated morphophonological processes in Weledeh Dogrib can be explained by reference to a unit of representation called the *tonal foot*. A tonal foot is a unit of metrical structure which is sensitive to tone. Specifically, tonal feet are required to be *level*: both syllables in a disyllabic foot are required to have the same tone. While there is no consensus in the literature on how to define 'tonal foot', and several versions have been proposed (Rice 1990, Zec 1999, De Lacy 2002), they all have in common some form of interaction between tone and metrical structure. In Dogrib specifically, I claim that the tonal foot is a moraic trochee which is subject to a restriction that there be no contour tones within the foot. That is, the canonical disyllabic foot in Dogrib consists of two light syllables in which the first syllable is stressed, and both have the same tone, i.e. either (High-High)[2] or (Low-Low). Similarly, monosyllabic feet should consist of a heavy syllable and not contain a contour tone. A typology of acceptable and unacceptable tonal foot types in Dogrib is given in Table 1.

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[1] Many thanks to Mary Rose Sundberg and Betty Harnum of the Goyatikö Language Center in Dettah, Northwest Territories, and the people of the Yellowknives Dene First Nation, for all their support, both practical and moral. Thanks also to Mary Louise Drygeese and Michel Paper for the many hours they spent working with me and answering my questions. Thanks also to Will Leben, Paul Kiparsky, Arto Anttila, Larry Hyman, Rebecca Scarborough, Kevin Ryan, Marianne Mithun, Spike Gildea, Andrea Berez, participants at the 2007 WAIL conference, and one anonymous reviewer for comments on previous versions of this article. All remaining errors are my own.

[2] I follow the orthographic convention of leaving High tone unmarked in Dogrib (*a*), while Low tone is marked with a grave accent (*à*).

TABLE 1. Typology of tonal feet

Tonal foot type	Good or bad	Example
a. High-High trochee H (σ σ)	good	L H L *dze*(*k'oo*)(*lane*) 'wild rose'
b. Low-Low trochee L (σ σ)	good	L L L *bo*(*kawi*)*t'e* '2 of us will cook'
c. High-Low trochee H L (σ σ)	bad	L H L H *(*boka*)(*whewi*)*t'e* '2 of us have cooked'
d. Low-High trochee L H (σ σ)	bad	L H H *(*shets'e*)*zhe* 'we eat'
e. Low-Mid trochee L M (σ σ)	acceptable as last resort	L M H (*shets'e*)*zhe* 'we eat'

The examples in (a) and (b) illustrate well-formed tonal feet. The examples in (c) and (d) are forms which we would expect to surface in Dogrib if there were no tonal restriction on foot form, that is, they represent a faithful parse of their respective underlying forms. Candidate (e), a Low-Mid trochee, is acceptable as a last resort to repair a Low-High trochee, if no other repair strategy can be used. In the remainder of this paper, I will illustrate how several phonological processes in Dogrib are motivated by tonal feet, relying crucially on the constraint NOCONTOUR-FT (Pearce 2006), which requires that feet be level. Within the framework of Lexical Phonology (Kiparsky 1982, 2000; Mohanan 1986; Hargus 1988), I consider how the tonal foot can provide a unified analysis of phonological processes in Dogrib at the Stem, Word, and Postlexical levels.

3. DERIVING TONAL FEET. In Table 2, I give the surface footing for the imperfective and perfective paradigms of the verb *bòkà√t'è* 'cook', in Dogrib. As these feet are metrical feet, the strong position of each foot receives at least a secondary stress, and the strong position of the rightmost foot receives primary lexical stress. As we would expect in a moraic trochee language (Hayes 1995), all of the feet in Table 2 contain either two light syllables or a single heavy syllable.[3] These facts are, on the surface, consistent with ordinary moraic trochees, without any reference to tone. The evidence that tone also plays a role in the metrical structure of Dogrib comes from morphophonemics: in some cases, the surface forms, as shown in Table 2, have been modified significantly from their underlying forms, to conform to a certain prosodic pattern. Specifically, as I will argue, phonological processes in the language conspire to avoid High-Low or Low-High sequences within a foot.

TABLE 2. Paradigm for bòkà√t'è 'cook', surface forms, with footing

Imperfective[4]

	Singular	Dual	Plural
1st person	(*bòkà*)(*eh*)*t'è*	*bò*(*kàì*)*t'è*	(*bòkà*)(*ts'ee*)*t'è*
2nd person	*bò*(*kàį*)*t'è*	*bò*(*kàah*)*t'è*	*bò*(*kàah*)*t'è*
3rd person	(*bòkà*)(*et*)*t'è*	(*bòkà*)(*gee*)*t'è*	(*bòkà*)(*gee*)*t'è*

Perfective

	Singular	Dual	Plural
1st person	(*bòkà*)(*whih*)*t'e*	*bò*(*kàwhì*)*t'e*	(*bòkà*)(*ts'ih*)*t'e*
2nd person	(*bòkà*)(*whęę*)*t'e*	(*bòkà*)(*whah*)*t'e*	(*bòkà*)(*whah*)*t'e*
3rd person	(*bòkà*)(*whet*)*t'e*	(*bòkà*)(*geh*)*t'e*	(*bòkà*)(*geh*)*t'e*

In order to characterize tonal feet more precisely, let us start with the simplest case, the case in which the input string already conforms to the tonal restrictions of the language, and so can be parsed as a metrically well-formed sequence as is. An example of this is shown in Table 3 below. In Table 3, the input /bòkàgeet'è/ is parsed into moraic trochees, using three constraints that are standard in the literature: FOOTBINARITY, PARSESYLLABLE, and ALIGNRIGHT.

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[3] I assume that a syllable can be made heavy either by having a long vowel (CVV) or having a coda consonant (CVC), which includes geminates.

[4] In (*bòkà*)(*eh*)*t'è* 'I cook' the sequence *àe* is pronounced as two syllables and in *bò*(*kàį*)*t'è* 'you (SG) cook' the sequence *àį* is pronounced as a single syllable.

TABLE 3. Feet assigned atonally

/bò-kà-ge-e-t'è/	FTBIN	PARSE(σ)	ALIGN-R(FT, PRWD)
a. *bò*(*kà.gee*)*t'è*	*!	**	*
b. *bòkà*(*gee*)*t'è*		***!	*
☞c. (*bò.kà*)(*gee*)*t'è*		*	***

FOOTBINARITY refers to a general property of moraic trochees: they must have exactly two moras, either from a single heavy syllable, or from two light syllables. Candidate (a) is a violation of FOOTBINARITY because it contains the foot (*kà.gee*), which consists of a light syllable followed by a heavy syllable, giving three moras. The constraints PARSE(σ) and ALIGN-R(FT, PRWD) refer to the way in which feet are constructed within the word. The constraint PARSE(σ) penalizes any syllable that is not part of some foot. The constraint ALIGN-R(FT, PRWD), on the other hand says that every foot should be aligned with the right edge of some prosodic word. If this constraint were undominated, there would only be a single foot at the very right edge of each word. Because ALIGN-R(FT, PRWD) is dominated by PARSE(σ), however, additional feet are created, as in candidate (c), albeit as far to the right as possible.

Another constraint not considered in Table 3 is NONFINALITY. NONFINALITY requires that the final syllable of a prosodic word not be footed. The interaction of NONFINALITY with FOOTBINARITY and PARSE(σ) is shown in Table 4.

TABLE 4. NONFINALITY in metrical parsing

/bò-kà-whe-ne-t'e/	FTBIN	NONFINALITY	PARSE(σ)
a. (*bò.kà*)(*whe.ne.t'e*)	*!	*	
b. *bò*(*kà.whe*)(*ne.t'e*)		*!	*
☞c. (*bò.kà*)(*whe.ne.*)*t'e*			*

Table 4 illustrates the parsing of the form *bòkàwhenet'e*, which is an attested variant of *bòkàwhęęt'e*, shown in Table 2. Candidate (a), even though it perfectly satisfies PARSE(σ) by including every syllable in some foot, contains a tri-moraic foot (*whe.ne.t'e*) and violates NONFINALITY, as does candidate (b). Candidate (c) is therefore optimal, in that it satisfies FOOTBINARITY and NONFINALITY, with only one violation of PARSE(σ). Finally, one relevant constraint not shown in Tables 3 and 4 is RHYTHMTYPE=TROCHEE, which ensures that feet in Dogrib are trochaic (i.e. strong-weak) rather than iambic (weak-strong).

With regard to stress, the foot parsing shown in candidate (c) predicts that there should be stresses on both *bò* and *whe* since these are in the strong position of trochaic feet. We would expect these syllables to show the usual phonetic correlates of stress. Thus, a stressed, short vowel with lexical Low tone, such as *bò*, would be expected to exhibit longer duration and a higher F0, but not so long as to encroach on a lexically long vowel, nor as high to encroach on a lexically High tone, in accordance with contrast and dispersion (Flemming 1996, 2001). Future instrumental studies will be necessary to show if this is correct.

Now, given that something like the constraint-ranking shown in Tables 3 and 4 can successfully parse all of the words shown in Table 2, why should the metrical phonology of Dogrib make any reference to tone at all? What is *tonal* about tonal feet?

Table 5 presents five different inputs, and contrasts the result we would expect with standard right-to-left moraic trochees (Hayes 1995) versus the actual result, derived from tonal feet. In (a), there is no difference between simple moraic trochees and tonal feet, because the input string happens to already conform to the restriction that feet be level. In (b), however, we see that the stem-initial consonant geminates, so that (*whet*) is made to form a High-toned foot by itself, while (*bòkà*) forms a Low-toned foot to its left. In (c), (*bò.kà*)(*whe.ne*)*t'e* is one of the attested possibilities in Weledeh Dogrib, but so are the forms (*bò.kà*)(*whęę*)*t'e* and (*bò.kà*)(*whįį*)*t'e*, which have undergone a process which I call *nasal coalescence*, the latter of these having also undergone *nasal raising*. While these processes do not make direct reference to tone, they are sensitive to feet, in that they occur only within but not across foot boundaries. In (d), we see vowel syncope, perhaps the most dramatic process conditioned by tonal feet. In (d), the vowel of the prefix /whe/, which has underlying High tone, is deleted, since there is no way to parse it into a level foot. Based on examples such as these, I will use the constraint NoContour-Ft (Pearce 2006) to formally characterize the way non-level feet are penalized in Dogrib. Finally, (e) represents a prima facie counterexample to the existence of tonal feet, since the actual form, *bò.*(*kàį*) *t'è*, contains the non-level foot (*kàį*), while the form which we would expect based on standard moraic trochees does not. In this case, it is necessary to say that the constraint NoContour-Ft is dominated by other constraints, in particular Align-R(Ft, PrWd), which seeks to reduce the overall number of feet in a Prosodic Word, even if some of the resulting feet are non-level.

Table 5. Footing with a-tonal and tonal feet

Input	Expected Result (standard moraic trochees)	Actual Result (with tonal feet)
a. /bò-kà-ge-e-t'è/	(*bò.kà*)(*gee*)*t'è*	(*bò.kà*)(*gee*)*t'è*
b. /bò-kà-whe-t'e/	*bò.*(*kà.whe*)*t'e*	(*bò.kà*)(*whet*)*t'e*
c. /bò-kà-whe-ne-t'e/	(*bò.kà*)(*whe.ne*)*t'e*	(*bò.kà*)(*whe.ne*)*t'e* or (*bò.kà*)(*whęę*)*t'e* or (*bò.kà*)(*whįį*)*t'e*
d. /bò-kà-whe-wìd-t'e/	(*bò.kà*)(*whewì*)*t'e*	*bò.*(*kàwhì*)*t'e*
e. /bò-kà-e-ne-t'è/	(*bò.kà*)(*e.ne*)*t'è*	*bò.*(*kàį*)*t'è*

4. GEMINATION. While the existence of phonetically long consonants in some Athabaskan languages has been previously noted in the literature (McDonough & Ladefoged 1993, Tuttle 2005), previous works on Dogrib (Coleman 1976, Ackroyd 1982, Marinakis 2004) make no mention of geminates. In arguing for phonological geminates in Weledeh Dogrib, I will present both phonetic evidence for a categorical distinction between singleton and geminate consonants, as well as a phonological account of their distribution.

Phonetically, it seems that geminate consonants in Dogrib are 1.7-2.0 times the length of their singleton counterparts on average. This is consistent with what is known about the phonetic realization of geminates cross-linguistically (Keer 1999). The durations for singleton and geminate /t'/, /n/, and /l/ are shown in Figure 1 below.

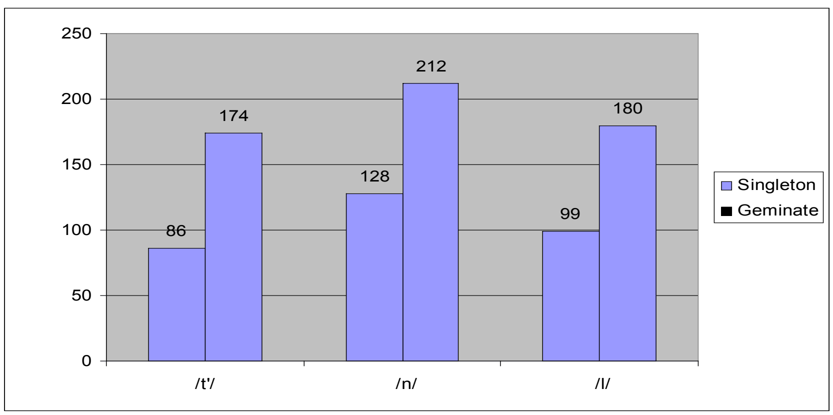

FIGURE 1. Singleton and geminate durations for /t'/, /n/, and /l/

The data in Figure 1 are based on a relatively small number of tokens: approximately 40 tokens each for /n/ and /l/, and only 12 tokens for /t'/. Nevertheless, in all cases, the difference between singleton and geminate consonants was categorical and highly significant, $p<0.001$ (*t*-test assuming equal variances). Thus when I refer to 'geminates' in the remainder of this article, I am referring specifically to consonants whose duration is 174-212 ms on average, while by 'singleton' I mean consonants that are 86-128 ms on average, as shown in Figure 1 above.

Given these facts, let us pause to consider whether consonant length in Dogrib ought to be considered 'phonetic' or 'phonological'. Under American structuralism, some category is phonological if it is able to distinguish utterances (Bloomfield 1933). Consonant length in Dogrib seems to fail this test, as there are few if any minimal pairs. On the other hand, in generative phonology, including OT, phonological status is a representational issue, not a question of contrastiveness *per se*. For example, in Italian, consonant length is contrastive, while vowel length is conditioned by stress. In the form *vá:do* 'I go,' the intial vowel is lengthened because it is stressed and in a penultimate, open syllable. There could be no minimal pair with **vádo* (short vowel) because a long vowel is required by the grammar. On the other hand, if one considers a somewhat more abstract level of representation—

namely, foot structure—(*vá:*)*do* is entirely parallel to (*ván*)*no* 'they go'. In both cases, the penultimate syllable forms a moraic trochee by itself: the former has two moras linked to a vowel, the latter has one mora linked to a vowel and another to the geminate consonant. If vowel length were removed from a phonological description of Italian, no lexical contrasts would be merged, yet at the same time important generalizations would be lost. We would not know which syllables count as light or heavy, which would in turn change our predictions about stress and segmental processes conditioned by stress.

Dogrib represents, in some sense, the mirror-image of Italian: vowel length is contrastive in Dogrib, while consonant length is prosodically conditioned. When I first began fieldwork with speakers of Weledeh Dogrib, I started hearing geminate consonants almost immediately. At first, I refused to believe my own ears: "this is just my bias as a native speaker of Italian," I thought. "Just another eurocentric category I'm trying to impose." What convinced me ultimately was that it was necessary to talk about geminates if the prosodic system was going to make any sense. I accepted geminates when I began to understand the language in terms of its own patterns. The pattern—in this case the tonal foot—is a rather abstract and unusual one. But I would never have discovered it if I had ignored geminates in the first place. Sometimes, then, a phonemic analysis is a self-fulfilling prophecy: by excluding some category from the system, we destroy the patterns that provide evidence for that category's importance. It is only by going back to the original speech signal that we can recover patterns that may have been overlooked, and the phonetic evidence for those patterns.

In my analysis, geminates are conditioned by tonal feet in the sense that the constraint NoContour-Ft plays a crucial role. This is shown in Table 6.

Table 6. Analysis of gemination in Dogrib (word level)

/bò-kà-(e)t'è/	FtBin	DepAssoc (V, μ)	Max(V)	NoCntr-Ft	DepAssoc (C, μ)
a. (*bòkà*)(*e*)*t'è*	*!				
b. (*bòkà*)(*ee*)*t'è*		*!			
c. (*bòkà*)*t'è*			*!		
d. *bò*(*kà.e*)*t'è*				*!	
☞e. (*bòkà*)(*et*)*t'è*					*

In the form *bòkàett'è*, *e* is a conjunct prefix while *bò* and *kà* are disjunct prefixes. Since I assume that conjunct prefixes are added at the Stem Level, *e* is shown as already footed in the input to the Word Level phonology, although this is not crucial to the present example.

In Table 6, each of the candidates (a)-(d) is ill-formed in the language because they violate some high-ranking constraint. Candidate (a) violates FootBinarity, on account of (*e*)*,* which is a foot consisting of a single, light syllable. Candidate (b) violates a constraint against vowel lengthening, formulated here as DepAssoc(V, μ) (see section 5 for discussion), while candidate (c) violates a constraint against vowel deletion. Finally, candidate (d) is ill-formed because it contains a Low-High trochee, which violates NoContour-Ft.

It is the ill-formedness of candidates such as (d) in Table 6 that provide evidence for tonal feet. That is, (d) is what we would expect to surface as optimal in an ordinary moraic trochee language, but it is not the optimal candidate in Dogrib, since it contains a Low-High trochee. Instead, the foot boundary is shifted one syllable farther to the left, and the winning candidate contains the Low-Low trochee *bòkà*. This means that the penultimate syllable must now form a foot all by itself, which means, in turn that weight must be added to it, otherwise it would be a degenerate (i.e. monomoraic) foot, as in candidate (a). There are two ways this could be accomplished: either lengthen the vowel itself, or geminate the following consonant. In Dogrib, vowel length is contrastive, which is expressed formally as a high-ranked constraint demanding faithfulness to underlying vowel length—DepAssoc(V, μ). On the other hand, DepAssoc(C, μ), which militates against consonant lengthening, is low-ranked, and so gemination is preferred over vowel lengthening, and thus candidate (e) emerges as the winner.

Here again it is important to stress the importance of allophonic processes in phonology. The constraints FootBinarity and NoContour-Ft, taken together, express the generalization that feet in Dogrib have two moras, both with the same tone. In a language where each affix carries its own tone and literally thousands of affix-combinations are possible, ill-formed sequences are bound to arise just by morpheme concatenation. So, how does Dogrib maintain level, bimoraic feet? That the constraint DepAssoc(V, μ) is high-ranked tells us two things: vowel length is contrastive, and there cannot be phonological processes that alter vowel length. Conversely, that DepAssoc(C, μ) is low-ranked tells us that consonant length is not contrastive and there *can* be processes that alter consonant length. In other words, the effects of tonal feet (or any other phonological restriction) are most visible on categories whose functional load is lowest. The surest way to miss generalizations, then, is to throw out allophonic processes. On the other hand, Americanist fieldwork is rooted in a tradition which, historically, threw these out as a methodological principle. The only way out of this problem, in my opinion, is to keep digital sound recordings of all the data one collects. Even the simplest descriptive statements are biased by my own assumptions, which may be just as misguided as those of previous decades. I can only hope to leave behind enough phonetic detail that a linguist 100 years from now will have no trouble refuting my analysis!

5. SYNCOPE. Perhaps the most dramatic evidence for tonal feet in Dogrib is vowel syncope. Vowel syncope is a process in which, in an underlying sequence of two light syllables, with a High-Low tone pattern, the High toned vowel deletes. This type of process is very unusual typologically, and has in fact been claimed to be impossible (Blumenfeld 2006). An example of this process is shown in Table 7 below.

Table 7 treats the Stem Level phonology, which, I assume, involves only the stem and the conjunct prefixes, /e/ and /wìd/. The disjunct prefixes /bò/ and /kà/ are shown in light gray, to indicate that they are still "invisible" to the phonology, as they will be affixed in a later cycle. The driving force behind the syncope process in Table 7 is the constraint NoContour-Ft, which militates against candidates such as (a), which faithfully preserve a High-Low sequence from the input. That being the case, the other constraints in Table 7 serve to decide what repair strategy should be used.[5] The constraint which forces some sort of deletion is MAXASSOC(V, TONE), based on Myers 1997.

TABLE 7. Tone-conditioned vowel deletion (stem level)

/bò-kà-e-wìd-t'è/	NOCNTR-FT	MAXASSOC (V, TONE)	MAXASSOC (μ, V)	MAX(L)	MAX (μ)	MAX (H)
a. *bò-kà*-(*ewì*)*t'è*	*!					
b. *bò-kà*-(*èwì*)*t'è*		*!				*
c. *bò-kà*-(*ewi*)*t'è*		*!		*		
d. *bò-kà*-(*wìì*)*t'è*			*!			*
e. *bò-kà*-(*ee*)*t'è*			*!	*		
f. *bò-kà*-(*e*)*t'è*				*!	*	
☞g. *bò-kà*-(*wì*)*t'è*					*	*

MAXASSOC(V, Tone)

(*informally*): For every vowel associated with a tone in the input, it must remain associated with its tone in the output. For every output vowel not associated to its input tone, assign a violation mark.

Crucially, this constraint is violated by any output vowel which has been de-linked from its tone; therefore, it cannot be violated if there is no output vowel. In this way, the constraint MAXASSOC(V, TONE) is able to force vowel deletion: just as a captain goes down with the ship, a vowel must go down with its tone.

In a similar fashion, moras are also forbidden from de-linking from their input vowels.

MAXASSOC(μ, V)

(*informally*): For every mora associated with a vowel in the input, it must remain associated with its vowel in the output. For every output mora not associated to its input vowel, assign a violation mark.

The constraint MAXASSOC(μ, V) serves to rule out candidates such as (d) and (e) in Table 7, in which compensatory lengthening has taken place. This is because the nature of compensatory lengthening is that some segment deletes and its mora re-associates to

[5] Gemination is, in principle, another possible strategy, though in my analysis, it is available only at the Word Level. The constraint ranking at both the stem level and postlexical level forbids altering consonant length (though the relevant constraints are not shown in Figure 9).

another segment. That tones and moras should behave this way leads us to a rather curious conclusion: the autosegmental phonology of Dogrib doesn't seem very autosegmental at all, and tones and moras behave like properties of segments. Why should this be?

There is of course no a priori reason to expect that tones and moras should float around freely on their own tier, any more than place or manner of articulation. On the other hand, the most typical situation is for tones and moras to be *stable*, that is, to remain behind even after their segment deletes. Furthermore, if some sequence of tones is ill-formed in a language, generally the repair strategy will be to fix the tone sequence, e.g. by spreading or downstepping, and not alter anything on the segmental tier. Why should Dogrib be any different?

The answer, in my opinion, has to do with the relatively recent tonogenesis in Athabaskan languages (Krauss 2005). Before tonogenesis, vowels which in modern Dogrib have Low tone were followed by a glottal stop (ʔ), while modern High tones were not. This means that Low toned vowels necessarily formed closed syllables, while High tones were mostly open syllables. This means, in other words, that modern (High-Low) sequences were historically (light-heavy) sequences. This would suggest that, originally, syncope in Dogrib was based on stress and weight: the syncope rule targeted the weak branch of an iambic foot. With tonogenesis, the final glottals were lost, and with it was lost any transparent motivation for syncope in terms of weight. Instead, the syncope rule was re-interpreted as being based on tone, which gave rise to the constraint NoContour-Ft.

Finally, one should note that the winning candidate in Table 7 represents the output to the Stem Level phonology, and is not the final output. Specifically, the glide *w* in candidate (g) will be deleted as part of a process of vowel coalescence, to be shown in section 6.2, and thus the actual output is *bòkàìt'è*.

6. COALESCENCE PROCESSES. A majority of morphophonemic alternations in Dogrib involve some form of coalescence. Marinakis (2004) argues that coalescence is driven by constraints of the type *Struc(σ), which seek to reduce the overall number of syllables within the word. While it is true that coalescence processes almost invariably do reduce the overall number of syllables, this analysis makes relatively few predictions about which syllables should be the targets of coalescence. Here I propose instead how coalescence can be derived from tonal feet. The driving force here, I argue, is the Stress-to-Weight principle, or SWP (Borrelli 2000). This is a constraint which requires, if a syllable bears primary lexical stress, that it be heavy, i.e. have two moras. This constraint poses problems for a moraic trochee system, in that by simply lengthening stressed syllables, one incurs violations of foot binarity. A light-light trochee of the form (**<u>μ</u>** . μ), which bears primary lexical stress, satisfies FootBinarity but violates Stress-to-Weight, while, conversely, a heavy-light trochee of the form (**<u>μ μ</u>** . μ) satisfies Stress-to-Weight but violates FootBinarity.

There is a way around this problem, however. Recall that, in a moraic trochee language, a well-formed trochee can consist of either two light syllables (light-light) or a single heavy syllable (heavy). A solution, therefore, is to coalesce both syllables of a (light-light) trochee into a single, heavy syllable. The stressed syllable is then heavy, while at the same time the foot is still binary. In Dogrib, this is accomplished by deleting intervocalic consonants, and merging together the newly adjacent vowels. The consonants which delete in Dogrib do not seem to form a natural class: *d, r, n,* and *w* delete intervocalically (under certain prosodic conditions), while *t, l, m,* and *wh* do not. While the seeming unnaturalness of this class of segments poses a theoretical problem, the issue is largely independent of the issue of tonal feet. Therefore, in the following sections, I will use the term 'sonorant' as a placeholder for these segments, and make use of the constraint Max(son) to refer to the faithfulness violations incurred by deleting one of these segments.

6.1. NASAL COALESCENCE. Nasal coalescence is a process by which the consonant *n*, when situated between two short oral vowels, deletes, and leaves behind a single, long nasal vowel. This process is variable, and also interacts with another process called nasal raising, in which nasal *ą* is raised to *ǫ*, and *ę* is raised to *į*. Thus for the input /nà-whe-ne-zè/ 'you (sg) have hunted', *nàwhenezè*, *nàwhęęzè*, and *nàwhįįzè* are all possible outputs (*nàwhinizè*, however, is unattested). In Figure 8, below, I show how the grammar of Dogrib can derive both *bòkàwhenet'e* and *bòkàwhęęt'e*, two variants meaning 'you (sg) have cooked'.

Table 8. Nasal coalescence (stem level)

/ bò-kà -whe-ne-t'e/	Max [±Nas]	FtBin	SWP	Max(son)
☞a. *bò-kà-(whęę)t'e*				*
(☞) b. *bò-kà-(whene)t'e*			*(!)	
c. *bò-kà-(whę)t'e*		*!	*	*
d. *bò-kà-(whee)t'e*	*!			*

The driving force behind the process of nasal coalescence in Table 8 is the constraint SWP, the Stress-to-Weight Principle, which requires that stressed syllables be heavy. In this case, however, the process itself is optional, and so candidate (b) is an attested form in Dogrib, albeit less preferred. In candidate (b), the foot (*whene*) consists of two light syllables, of which the first one is stressed. One could simply delete the nasal consonant, leaving a long oral vowel, as in candidate (d), although this violates the constraint Max[±Nas], which demands that the nasal feature be preserved. Therefore, the preferred output is candidate (a), which contains a long nasal vowel.

6.2. COALESCENCE AND GLIDE DELETION. In a similar way, the glide *w* deletes intervocalically in order to create a heavy syllable. This is illustrated in Table 9.

Table 9. Illustration of w-deletion (word level)

/bòkà(wì)t’è/	FtBin	Dep(μ)	SWP	Max(son)
a. (*bòkà*)(*wì*)*t’è*	*!		*	
b. (*bòkà*)(*wìì*)*t’è*		*!		
c. *bò*.(*kàwì*)*t’è*			*!	
☞d. *bò*.(*kàì*)*t’è*				*

Table 9 is a continuation of Table 7. The original input was /bò-kà-e-wìd-t’è/ ‘two of us are cooking,’ where the output of the Stem Level phonology is *bòkàwìt’è*, and the output of the Word Level is *bòkàìt’è*, which is the actual surface form shown in the paradigm in Table 2. As with the previous example, the driving force behind coalescence in Table 9 is the Stress-to-Weight principle. In candidate (c), *bò*(*kàwì*)*t’è*, main stress falls on *kà*, which is a light syllable. This is a violation of the SWP, and so candidate (d) is preferred, which deletes the intervocalic *w* and leaves behind the diphthong *àì*, creating a heavy syllable.

7. TONE LOWERING. Finally, we come to the phenomenon of High to Mid tone lowering. This is a postlexical process which is used as a last resort to repair (Low-High) trochees that cannot be repaired by other means. Phonetic evidence for this process is given in Table 14 below. First, however, it is necessary to address the question of how these ill-formed sequences arise in the first place. I propose that the grammar is forced to create (Low-High) trochees at the Word Level in trisyllabic words, in order to avoid having two geminates in a row. This is illustrated in Table 10 using the word *shèts’ezhe* ‘we eat’.

Table 10. Creation of non-level feet in trisyllabic words (word level)

/shè-(ts’e)zhe/	FtBin	$[{*}C_{\mu}]^2$PrWd	Parse(σ)	NoContour-Ft	*Cμ
a. *shè*(*ts’e*)*zhe*	*!		**		
b. (*shèt*)(*ts’ez*)*zhe*		*!	*		**
c. *shè*(*ts’ez*)*zhe*			**!		*
☞d. (*shèts’e*)*zhe*			*	*	

Based on the grammar of Dogrib developed so far, we might expect something like candidate (b) to surface as optimal. In this candidate, gemination has happened twice, to create two heavy syllables, *shèt* and *ts’ez*, each of which forms its own foot. What rules it out is a constraint on two adjacent geminates, also known as Schneider’s Law (Lipscomb 1992, Dresher & Johns 1995). The precise formulation of this law is problematic (see Dresher & Johns 1995 for discussion), so here as a sort of placeholder I have stated it as $[{*}C_{\mu}]^2$PrWd, or “no two geminates within a prosodic word.” This restriction is well-documented in Inuktitut, a language with which the Yellowknives Dene were in contact until the early 20th century. In short, gemination will not work as a repair strategy for trisyllabic Low-High-High words, and so some other repair strategy must be employed, which is to lower the first High tone to a Mid tone.

Tables 11 and 12 and Figure 2 describe a pilot study I conducted based on my 2005 recordings. I measured 10 tokens (randomly chosen) of short phrases containing words with Low-High-High sequences. I measured the F0 at 10ms intervals for the entire vowel duration for each vowel. From this, I calculated Δ, the difference in mean F0 between adjacent vowels. In examples such as (*shàah*)*tį*, 'you (pl) eat,' where the vowels had coalesced, I divided the vowel halfway through its duration.

Table 11. Calculation of Δ

Group 1	Group 2
(L H) H Δ_1 Δ_3 e.g., (*shène*)*tį* 'you eat', (*shèts'e*)*zhe* 'we (pl) eat'	L (H H) Δ_2 Δ_4 e.g., (*shèh*)(*tį ha*) 'I will eat', *shè*(*ts'aah*) *zhe* 'we have eaten'

My hypothesis was that, in accordance with tonal feet, there should be a greater jump in F0 across a foot boundary. To test this, I measured different values, i.e. differences in F0 between adjacent syllables, as shown in Table 11. Of several hypotheses I entertained, the strongest was that Δ_1 should be less than Δ_3, which is to say that, in a (Low-High) High sequence, the first High tone is depressed so much that it is phonetically more like a Low tone. Such an extreme effect cannot be explained by interpolation, and therefore provides strong evience for tonal feet. As shown in Table 12, this prediction is borne out, and is statistically significant.

(2) *Results of Δ calculations*

- Δ_1 was 0.7 times the value of Δ_2, though this was not significant (p=0.189).
- Δ_3 was 4.8 times the value of Δ_4, which was significant (p=0.017).
- **Δ_1 was 0.38 times the value of Δ_3, which was significant (p=0.037).**
- Δ_2 was 2.6 times the value of Δ_4, marginally significant (p=0.061).

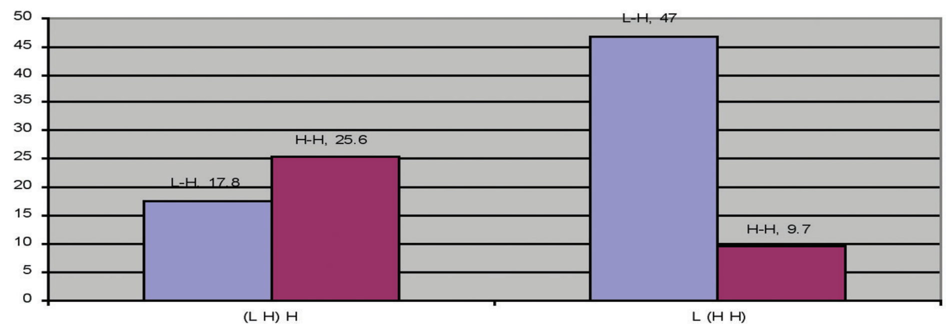

FIGURE 2. Δ-values with different tonal footings

To summarize Table 12 and Figure 2, although the number of tokens was quite small, nevertheless the effect of tonal feet on F0 was categorical and statistically significant. We now turn to the question of how to interpret such data phonologically.[6] Larry Hyman (p.c.) has suggested that in forms such as *shèts'ezhe*, what is happening is actually a *spreading* of the initial Low tone onto the adjacent syllable. This hypothesis is illustrated in Table 13.

TABLE 13. Tone lowering versus tone spreading

	Tone Lowering	Tone Spreading
(L H) H	L M H (*shèts'e*)*zhe*	L H (*shèts'e*)*zhe*
L (H H)	L H H (*shèh*)(*tį ha*)	L H H (*shèh*)(*tį ha*)

Under a tone spreading analysis, the reason that the second syllable of *shènetį* or *shèts'ezhe* shows a depressed F0, compared to other high tones, is that it has in fact been de-linked from its underlying high tone, and associated with the low tone to its left, as shown in Table 13. On the other hand, the reason why these syllables are nevertheless higher than other low tones is that there is a difference in phonetic interpretation between

6 A reviewer suggests that the phonetic effect shown in (2) and Figure 2 may be due not to lowering H to M due to tonal feet, but rather the *raising* of F0 in stressed syllables. In (L_1 H_2) H_3, a raising of the F0 of L_1 would decrease Δ_1, while in L_1 (H_2 H_3), a raising of the F0 of H_2 would increase Δ_2. This is indeed a potential confound; more instrumental studies will be necessary to tease out the effects of stress on F0.

two syllables linked to the same low tone, as in Table 13, or two syllables each linked to separate low tones.

In my estimation, this kind of analysis would indeed work to explain tone lowering postlexically, and is even consistent with the existence of tonal feet, insofar as one could say that the tonal foot is the domain of tone spreading in Dogrib. A spreading analysis is not, however, consistent with the types of segmental processes conditioned by tone that we have seen in this paper. Syncope and gemination are due ultimately to sequences of tones which are ill-formed in relation to the metrical structure of the language, but which are not fixed by reassociating tones, but rather by making changes on the segmental tier. If it were possible to reassociate tones and moras in Dogrib, then we would not expect syncope or gemination to happen.

Therefore, I will opt instead for an analysis in which, when the output of the Word Level phonology is (L H) H, the first high tone is lowered to a Mid tone, M. This is illustrated in Table 14.

TABLE 14. H → M postlexically (F0 compression)

/(shèts'e)zhe/	NOCONTOUR-FT	IDENT(Tone)
a. L H H | | | (*shets'e*)*zhe*	*!	
b. L L H | | | (*shets'e*)*zhe*		**!
☞c. L M H | | | (*shets'e*)*zhe*		*

In Table 14, I am assuming a gradient scale, whereby a lowing from H to M incurs one violation of IDENT(Tone), while H to L lowering incurs two, and is fatal. In other words, tone lowering in Dogrib represents a sort of compromise, whereby postlexically an offending High tone is lowered just enough to make it acceptable with respect to the constraint NOCONTOUR-FT, provided that no other repair strategy was possible at the Word Level or Stem Level.

8. CONCLUSION. In this paper, I have argued that the tonal foot is the driving force behind several seemingly unrelated phonological processes in the Weledeh dialect of Dogrib. Specifically, the constraint NOCONTOUR-FT, which requires that there be no Low-High or High-Low sequences within a foot, is responsible for syncope, gemination, and High to Mid tone lowering. Syncope, in particular, is unusual in this case, since it is conditioned by tone, something which has been claimed to be impossible (Blumenfeld 2006).

It seems, in general, that tones in Dogrib behave like properties of segments, which, from a historical perspective, is not surprising, since until recently they *were* segments, that is, postvocalic glottal elements. Should we, then, believe that syncope, and tonal feet in general, have any synchronic reality at all? Although I believe that syncope could only have arisen under very particular historical circumstances (that is, a weight-conditioned rule that was re-interpreted as tonal), nevertheless this process is still synchronically relevant, since it contributes to a synchronic generalization, NoContour-Ft, which is still productive in the language, since gemination and High to Mid tone lowering still apply productively. If the syncope rule did not apply in Dogrib, there would be, statistically, a much larger number of counterexamples to the generalization that feet should be level, and so learners of the language would have much less evidence that NoContour-Ft is a relevant generalization in the grammar.

In a broader sense, tonal feet in Dogrib illustrate the importance of including low-level allophonic processes in phonological descriptions. There is no necessary connection between being categorical and contrastive. Features which are contrastive in a language can show variation (Anttila 1997), just as features which are non-contrastive can be categorical. In Dogrib, no two lexical items are ever distinguished by consonant length or by High tone versus Mid tone; nevertheless it is essential to look at these phenomena if one is to come up with the right generalizations about Dogrib phonology. Subphonemic details may provide the key to unlocking high-level generalizations about morphophonemics. Tonal feet, therefore, show that it is important to re-examine our assumptions about what types of generalizations qualify as 'phonological', and look at the actual speech signal more closely.

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