The Dene verb: how phonetics supports morphology*

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Abstract: A model of the polysynthetic Dene or Athabaskan verb is elucidated by providing evidence for its internal structure based on phonotactic distributions and phonetic properties which implicate a type of internal structure best accounted for in a word-and-paradigm model in which paradigms are organizational principles in lexicon, with implications for lexical access and learning. Evidence for this structure is presented using data from Navajo. The data underscores the importance of phonetic documentation especially in understudied/resourced languages.

Keywords: Morphology, polysynthesis, Athabaskan

1 Introduction

There are two primary principles issues at play in a discussion of word formation in languages with complex inflectional morphology, both concern speakers' knowledge of word structure. The first concerns the units that speakers use to build words, and the second, how those words are stored and retrieved. These are interrelated issues, of course, and are best treated as aspects of the same problem, but approaches to answering them are very different. In this paper I will take up the first of these, the units speakers work with to build words. The answer to the question involves an investigation of sound forms and phonotactics, what, in effect, phonetics can tell us about word structure. From a study of the phonetic structure of Dene, I'll present evidence for the existence of specific units within the Dene (Athabaskan) verb that are likely to be salient in word formation, and how they might work using a model of Dene verb argued for in McDonough (1996, 2000a, 2000b, 2003, 2010). I'll make two uncontroversial assumptions: one that speaker simplification of sound forms is a force in language change and variation, and two, word formation is built on learnability. I'll provide a working model of the verb within a Word-and-Paradigm framework, demonstrating how words are put together in this model, using paradigms.

The first of these assumptions is a first principle of language change (Campbell, 1996; Bybee, 2002, 2012). Most or all language change is phonetically based. This has repercussion for models such as the Athabaskan slot-and-filler template often used in the description of the Dene verb (Sapir & Hoijer, 1967). While this model has been important as a comparative device, and is useful in determining the morphosyntactic properties of the verb, it is highly unlikely to provide the forms speakers are using to build and store words, or learn them. The reason is straightforward, the sound forms of the template are too theoretical, too abstract. The processes required to produce full forms contradict what we know about sound change. Speakers will tend to simplify overly complex or opaque underlying-to-surface representations of sound forms, and to reorganize and make use of more emergent and transparent versions of these forms; this simplicity impulse overrides morphosyntactic complexity. Also, in the Dene languages, the morpheme combinations and rules that govern the underlying-to-surface forms required by this template model have never been shown to work,[1] which is not the same as saying that they are not useful. But they are highly unlikely to

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[1] That the template doesn't work as a word formation device in Athabaskan has been acknowledged for a couple decades. In an attempt to use the template as a word formation device, for instance, Kari (1989) stated

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be what a fluent native speaker is learning, using and storing. For this reason it becomes incumbent on us to figure out what forms native speakers are using and how this evidence might inform a realistic, working and learnable model of a morphologically complex lexicon.

In this paper I will present evidence in the Dene verb for the existence of 1) a major domain break between the rightmost stem which I will call the LEX stem and all the material in the word to the left of the stem, what we will call the *pre-stem* or TAM domain,[2] 2) the adjunction of these two units LEX and TAM as the basis for a viable model of Dene word formation. In this view, each domain is comprised of at least one morpheme, an obligatory morpheme that is the base of that domain. Thus the boundary between these two morphemes is a domain boundary that represents the two major parts of the verb and is significant in the word formation process. The two morphemes, one from each domain, comprise a minimal fully inflected word form, the core verb, with the minimal morphosyntactic specification. The minimal verb form is two syllables by morpho-syntactic imperative. These two morpheme forms have clearly distinct phonetic and phonotactic properties across the language family.

(1) [TAM]x [LEX]y = verb word $_{x(y)}$
σ σ

The following discussion of this basic verb structure is rooted in two theoretical strategies, laboratory phonology, in which phonological generalizations arise from phonetic realities, and word-and-paradigm morphology, in which paradigms are well-formed categories of morphological organization, fully inflected words are lexical units. The paper may be taken as an argument against a purely syntagmatic approach to word formation as found in theories such as distributed morphology (Halle & Marantz, 1993; Lieber, 1992).

2 Paradigmatic structure

In a morphologically complex lexicon, words reside in dense neighborhoods of related forms, the more highly inflected a word, the denser its neighborhood by virtue of its inflectional and derivational variants. In work on lexical access, dense neighborhoods delay word recognition, which opens the question of the strategies used by speakers of complex morphologies, like the Dene languages, to access highly inflected forms. Although it might be supposed that delays caused by richly inflected words may impede recognition, the Dene languages, as a case in point, are highly stable over centuries, and in fact seem to resist innovations. There appears to be no discernable disadvantage to inflection (except to a second language learner). One way to approach this question is to examine the structure of the lexicon in polysynthesis. The most striking property of inflected forms in any language is their paradigmatic structure, i.e. change-outs that occur at particular places in the word, vertical structure, so to speak, rather than linear concatenation. Slot-and-filler templates by definition are devices that take this vertical change-out and impose linear concatenation on them. Instead we take another approach, paradigms exist as organization principles in a lexicon. The inflected forms can be seen to form an inflectional or conjugational paradigm, these are used in lexical access.

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that it was only partially successful and the model has 'many grey areas'. Kari suggested instead a 'zone' approach to Athabaskan word structure formation, which is close in spirit to the present model.

[2] Putting aside for the purpose of this paper a discussion of the make up and morphosyntactic properties of this domain. For a discussion of these properties in this view, see McDonough (1990, 1999).

Over the past several years a body of work has emerged on the processing of these type paradigmatic relationships (Baayen, 2003; Milin et. al., 2009; Kuperman et. al., 2008, Moscoso del Prado Martin et al, 2004; Blevins, 2003; Kostic et.al, 2003). In this view, paradigms themselves are well-defined organizing units in the lexicon; they have an effect on learnability, word processing and word retrieval. Words, including fully inflected words, are the basic units in the lexicon. Inflected words are organized into paradigms by definition. By definition, a paradigm is an organized set of the inflected variants of a word. In the rest of the paper I will elucidate a model of the Dene verb that uses paradigms.

2.1 Dene morphological structure

In Table 1, for instance, is a paradigm for the Navajo word *bits'á'nisht'ááh,* here inflected in the n-imperfective paradigm for the 1st person singular (nIPFV.1s), glossed in (2) taken from Young and Morgan (1987, hereafter YM).

(2) bits'á'nisht'ááh

bi-	ts'á'-	nish+	t'ááh
3S-	away.out.of.sight-	nIPFV.1S+	fly(INTR.IPFV)

'I'll (fly away and) leave it behind out of sight.' (YM 1987:d247)

In Table 1 below, a common paradigm layout, the verb stem ***t'ááh*** (the LEX morpheme in this model) has been bolded; it is the rightmost morpheme (baring enclitics) in the Dene verb word. The columns represent number, for Navajo, singular and dual; the rows represent person, 1st and 2nd person, and two rows of the rich set of Navajo third person markings (see Young and Morgan, 1987 for further explanation.)

Table 1 Example of the Navajo word in (53) in its n-imperfective paradigm

	singular	*dual*	*tense/mode*
1	bits'ánish**t'ááh**	bits'á'nii**t'ááh**	IMPV
	I (fly away) leave it		
2	bits'á'ní**t'ááh**	bits'á'nóh**t'ááh**	
3	yits'á'í**t'ááh**	—	
3a	bits'á'jí**t'ááh**	bits'á'da'jí**t'ááh**	*plural*
3	yits'á'ní**t'á'**	yits'á'da'as**t'á'**	PFV

It is an uncontroversial assumption that a fluent speaker, given one form in one conjugation (here n-imperfective), can inflect the verb word for the other forms in other conjugations, can parse conjugated forms, does not produce 'bad' forms (McDonough & Willie, 2000) and can recognize conjugation errors.

What is striking about the Dene verb is its complex structure. The traditional Athabaskan template may have up to 23 different morpheme positions covering both inflection and 'derivational' morphemes (YM, 1980:38 for an example).[3] The free concatenation of morphemes from these positions results in massive production of ill-formed words. To produce well-formed words using the template, the morpheme concatenations must be strongly constrained by principles operating on the occurring outputs. As such, the template has no predictive power whatsoever. Much work

[3] It is not the role of this paper to argue against the template, which is used by convention alone in discussion of word formation in these languages. The template is a comparative device, not a word formation device.

has been done on the nature of the syntactic and phonological constraints on templatic morpheme orderings in Athabaskan (Kari, 1976; Willie, 1996, 1991; Speas, 1984, 1988; Hale, 1996; Hale & Platero, 1997; Hargus, 1988; Stanley, 1969).[4] However, the number of these constraints in the literature needed to account for occurring forms and the stipulative nature of the constraints indicate that the primary issues with the template are two: in the reduction and the production of licit morpheme concatenations (Kari, 1989).

Another approach to the verb structure problem adopted here is to examine emergent distribution properties in the patterns in the words and paradigms themselves. In Table 1 above, the last row represents the 3rd person form in the n-*perfective* conjugation, in contrast to the imperfective. Note the imperfective verb stem **t'ááh,** present in this form in all the cells, except the last row**.** This form changes to its perfective form **t'á'** with the perfective conjugation. So we have at least two forms of the verb stem, **t'ááh, t'á',** marked for aspect**.** This kind of variability in the stems, associated to aspectual contrasts, has been called 'stem set alternations' in the literature. The variation involves vowel length, vowel quality, tone, codas. I'll consider this to be a type of paradigmatic variation (vertical change-out). Although there are patterns in the alternations, the variation in the forms is not productive (Reichard, 1949; YM, 1980, 1987; Young, Morgan and Midgett, 1992; Hardy, 1985; Eddington and Lachler, 2006). The aspect of the fully inflected verb arises from the combination of the aspect of the TAM domain combined with the aspect of the LEX domain[5] (Smith, 1996; see full explanation and examples in YM 1987:164). What is of interest to the present discussion are the forms the stem takes. The alternations occur *within* the stem syllable, even prefixation does not alter this (the d-effects and 'classifier' alternations, and tonogenesis hypotheses). YM write the abstract root in CAPS, below in (3), in this case the three stems are the occurring alternations of the root form **T'ÁÁH:** *t'ááh, t'ah, t'a'*.[6] We will return to the special phonetic and phonotactic status of stems in the next section.

(3) **T'ÁÁH** 'fly' / t'ááh, t'ah, t'a'

For a full discussion of how the stem shape encode aspect and combine with the TAM domain to produce the aspect of the full verb see YM (1987) and their root and stem dictionary (YM 1992). I will consider these alternation patterns a type of paradigmatic variation, particular to the stems.

2.2 The TAM paradigms

Table 2 is a repeat of Table 1 with the LEX stem *t'ááh* removed. What remains is the TAM domain.

Table 2 The TAM paradigm in the n-imperfective

	sing	dual	tense/mode
1	*bits'á'**nish***	*bits'á'**nii***	IMPV
2	*bits'á'**ní***	*bits'á'**noh***	
3	*yits'á'**í***	----	
3a	*bits'á'**jí***	*bits'á **da'jí***	*plural*

[4] In no way is this a complete bibliography of work done on these topics in the Dene languages. Many references have been omitted due to space limitations.

[5] It is not the case that they must agree. The rich set of aspectual variation present in these languages comes from the differences in aspect in these two domains. See YM 1987 for discussion.

[6] This verb stem is related to the noun stem 'wing' in *'at'a'* (YM 1987).

This domain has a base, which carries the obligatory morphosyntactic information necessary to the TAM domain; these bases are conjugational forms. In Table 3 are the base forms of the n-imperfective and n-perfective paradigms, as listed in YM (1987:200), classic paradigmatic forms, varying in person (column) and number (row). The forms are bolded in red. These forms carry morphosyntactic information associated to the cell they are associated to.

Table 3 The n-imperfective and perfective conjugational morphemes

	nIMPV		*nPFV*	
	sing	*dual*	*sing*	*dual*
1	nish	nii(d)	ní	nii(d)
2	ní	noh	yíní	noo
3	yí, jí		ní, jí	

These are *conjugational* paradigms. YM (1987:200ff) list 16 distinct paradigms that come out of 5 basic conjugational patterns for Navajo, of which the n(i)-conjugation is but one. (It goes without saying that not all words inflect in all conjugations). For a fully articulated set of the 16 distinct conjugational paradigms for Navajo see YM (1987:200ff).[7] Similar conjugational paradigms have been identified in Tsuut'ina (Sarcee) (Starlight & Donavan, 1990; Cox, 2010).

The *bits'á'* 'away out of sight' below in (4) sits at the left edge of the word, in the so-called disjunct domain[8] and is attached to the *n-impf* base and conjugates as such (*yi* is an alternate form of *bi*, see YM 1987:65; Willie, 2000).

(4) bi- ts'á'-
3S- away.out.of.sight

Note, importantly, *bits'á'* is attached to the conjugational form here *nish* nIPFV.1S. In current view, the structure of the verb in the model we are assuming is in (5).

(5) bits'á'nísht'ááh

[-	TAM]	[LEX]
[bits'á'-	**nish**]	[**t'ááh**]
from it : away out of sight-	**nIPFV.1S**	**fly(INTR.IPFV)**

Both the TAM and LEX stems are inflected for aspect (and the TAM stem for person and number). These domains are the base of productive verb formation in the Dene verb. The conjugational forms are the base of the TAM domain, just as the stem variants of the root (as in (3)) are the base of the LEX domain.

In (6) is the sketch of the model: the word is a conjunction of two independent domains, each with distinct morphosyntactic and lexical features.

(6) Dene word structure domains

[[(af) - TAM]$_x$ [(af)- LEX]$_y$] Word$_{(x(y))}$

[7] These are necessary because they are not concatenative; they do not arise out of the template. These are the forms that the rules must produce.
[8] A domain of more loosely attached forms.

The argument is that speakers/learners are aware of these two units and use them productively in word formation and lexical retrieval. Note also that in the word and paradigm model, the *whole inflected word* is listed. This is necessary to produce the many opaque combinations of morphemes available to a fluent speaker.

In the next section phonotactic and phonetic evidence for the two morphemes and the domains will be reviewed, then I'll return to the predictions the model makes about word formation processes; the ability of the model to produce well-formed fully inflected Navajo words.

3 Phonotactics and phonetic structure

3.1 Phonotactics

One area that has not received much attention is the unusual phonotactic patterns in the Dene languages. Two facts in the Dene phonotactic patterns surface, both refer to the morphological stems:

- Noun and verb stems carry lexical meaning, they are monosyllables and considered classificatory.
- They are a closed class set of morphemes.

YM (1987:267) propose that there are around 550 stems in Navajo. Given these facts, the productive parts of the grammar are the verbs, not nouns. New words are verbal. In this paper, we are referring to these verbal stems as the base of the LEX domain as in (1).

The stems are phonotactically prominent. To see this consider the Dene phoneme inventory. All the Dene languages tend to share a similar sound inventory (for examples of the phoneme inventories of the northern Dene languages with example sound files, see the Dene Speech Atlas).[9] Ladefoged and Maddieson (1996:90) refer to Dene Sųłine as having 'one of the largest and most complex' set of affricate contrasts In the UPSID database of 317 language families (Maddieson, 1984), the ratio of sonorant to obstruent is 3/7. The Dene Sųłine inventory is approximately 16% sonorants, with around 30 obstruents and 5 sonorants; this is a typical Athabaskan pattern. Additionally, most of the Dene obstruent consonants are complex: there are six sets of stops, 4 of them are affricates, all the affricates are coronal, that is the consist of a coronal closure followed by a fricative release.

[9] Dene Speech Atlas is at http://www.ling.rochester.edu/DeneSpeechAtlas/

(7) Phoneme inventory of Dene Sųłine

Dene Sųłiné (after Li, 1946) (Orthography)

	lab	Inter dental	alveolar		Post-alveolar	Velar (uvular)	gl
			central	lateral			
stops	(b)		d t t′			g k k′ gʷ kʷ kʷ′	ʔ
affricates		dð tθ t′θ	dz ts ts′	dl tɬ tɬ′	dj tc t′c		
fricatives		ð θ	s z	ɬ l	c y	x xw ɣ ɣʷ	h
rhotic			r				
nasals	m		n				
approx					y	w	

Of note is the fact that the onset of stems is the single place in the lexicon where these sound contrasts occur; i.e. the rich affricate inventory is basically an inventory of stem onsets. This is of particular significant because they occur in the onset of a closed class of morphemes. Outside the stems, in the pre-stem TAM domain, basically the inflectional domain, the sound contrasts are reduced to a much smaller set of contrasts. McDonough (2003) observed that the consonantal phonemes of the prefixes are not much greater than those found in English inflectional morphemes. This holds of the vowel contrasts also, the prestem domain exhibits a loss of vowel quality contrasts, typically a Dene language will have a 'default' vowel, with 'default' (or 'marked') tone. Length, nasality are also neutralized in the prestem morphemes. The contrast set outside of stems is very reduced.

There is one exceptional morpheme in the pre-stem domain. At the left edge of word in the so called 'disjunct domain' there is a single position for what YM call 'postpositional stems'. These morphemes have stem-like phoneme distribution patterns; i.e. affricate and ejective onsets may appear here. This is the position of incorporated nouns in the Dene languages that have them. In Table 4 (a) below are examples from YM of Navajo words with complex stem onsets (affricates and ejectives), and forms with postpositional stems in (b). The stems are bolded. The 'postpositional' stems (which is the position of incorporated nouns in Dene languages that have them) have similar properties to the noun and verb stems. We will take this issue up again in the discussion of the model outputs in above.

Table 4 Stem distribution in Navajo words (from YM 1987)

a. stems		***b. stems***	
neheshk'ǫ́ǫ́h	*I slice it (as bread)*	bits'ánistsóós	*I took it from them*
'ahéénísht'ééh	*I jogged around in a circle*	bik'ehdishdleeh	*I overcame him*
diniiishjih	*I grabbed it and hung on*	bits'ánéiit'aash	*we left him*

Finally, in terms of phonotactic patterns, most pre-stem morphemes are CV(V), except at the right edge of the TAM domain, the TAM conjugational morphemes. Consonant clusters consistently occur at this point in the word, as we see demonstrated in Table 4. This is a breaking point in the word, we return to this point in Section 4. These patterns are clear and may be observed by perusing the verbs of any Dene grammar or dictionary.

Thus in examining the basic phonotactics of the lexicon, a structure within in the verb emerges, separating out the stems from other morphemes in the verb. The stems are prominent, distinguished

as units by strong phonotactic properties. This is an uncontroversial fact. The contribution the model makes is that these stem morphemes vary independently of the rest of the word.

3.2 Phonetics

These phonotactic patterns are reflected in the phonetics in the duration patterns of the stem onsets and nuclei versus the prefixes of the TAM domain. The phonetic prominence of the stems are related to these facts.

McDonough and Wood (2008) provided evidence that the Athabaskan phoneme inventory involved a fundamental contrast between simplex and complex segments. The simplex segments involved a single gesture; these were the approximants, fricatives, and the plain (unaspirated) stops (/b, d, g/)). Complex segments involved two gestures, a closure and a fricated release; these are the affricates, the ejectives and the affricated plain stops /t/ and /k/. In Figure 1 are the duration measurements for the plain stops /d, g/ versus the ejectives /t'/ and /k'/ and the affricated plain 'aspirated' stops /t, k/ from this paper.

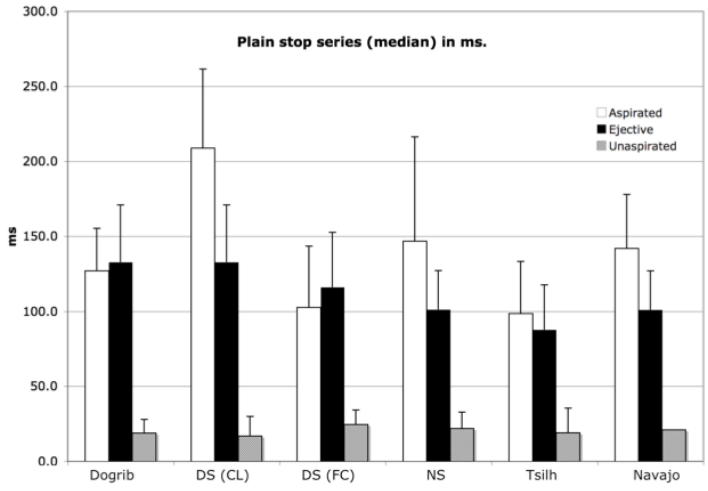

Figure 1 Durations of plain stops versus aspirated and ejectives in 4 Dene languages, adapted from McDonough and Wood (2008)

The plain ejective and affricated stops, the set /t, t', k, k'/, have the same release duration profile as the affricates, a fact observed by many linguists.[10] YM classify the /t/ as an affricate and not a stop. McDonough and Wood demonstrated that this is a pervasive phonetic property across several of the Dene languages, likely inherited from the parent language. This fact affects the manner contrasts. For instance it is responsible for the characteristic Dene ejective pattern as shown in Figure 2. The ejective is realized between the release of the stop closure and the release of the glottal closure, indicated by the dotted arrow in Figure 2; the length of the release period results in an audible 'period of silence' in the production of the Dene ejective. Note also the length of the stem onset indicated by the solid arrow.

[10] See discussion and references in McDonough and Wood (2008). The /t / and /k/ are not aspirated stops, but affricates /tx/ and/kx/. Like the other affricates, the sounds written as <t> and <k> are not found outside the stems in Navajo. Whether or not this holds true of other Dene languages is an open question, but I think it is more likely than not.

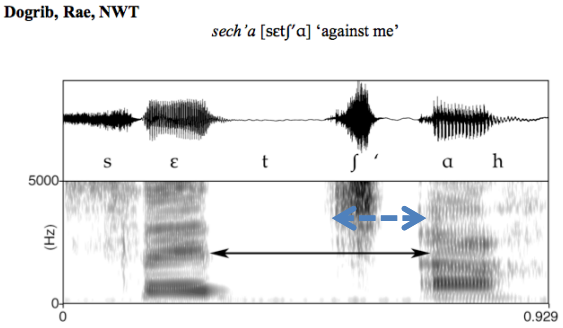

Figure 2 A demonstration of the characteristic ejective pattern, in Dogrib

Thus all the complex sounds are composed of a stop closure followed by a long release, including the ejectives (Figure 3). Since the stop closure is always coronal (there are no labial or velar affricates); the contrasts between these segments are in the release periods, which carry the cues to the place and manner distinctions of these segments.

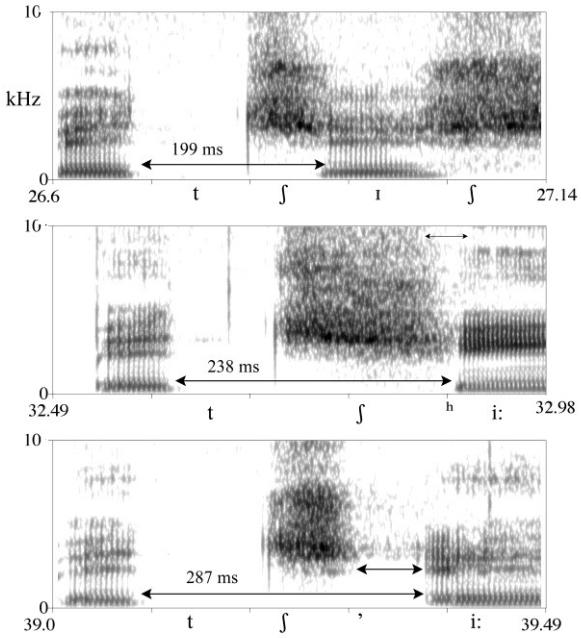

Figure 3 Examples of stem initial complex stem onsets in Navajo, affricates series /j [tʃ], ch [tʃʰ] , ch' [tʃˀ]/ adapted from McDonough (2003).

It is not surprising that the duration of the release periods is maintained in speech; it is, however not a necessary fact, but it is strikingly consistent across several of the Dene languages, and in the face of the geographic isolation of the speech communities, a situation where considerable variation at the phonetic level might be expected, but is not found. These are the stems of the LEX domain.

Concomitantly, when the stems are preceded by a syllable (in TAM) with a coda as in (8), it is the closure period that is compacted; the release period maintains its significant duration profile.

(8) bił dzidishkaad 'I gave him a slap' (YM:d354)

bił	[dzid	-ish	] [ø	kaad		]
with him	['using arm'	-øIPFV.1s	] [CL	'move in a spreading way'		]
	[TAM		] [LEX			]

In Figure 4 are spectrograms of longer more complex words *biłtsidiłkaad* and *biłtsidishkaad*, the 1st and 3rd person forms of the verb translated 'I gave him a slap'. The gloss is above in (8).

The last two syllables contain the core verb (marked by dotted arrow). The stem (marked by solid arrow) remains prominent even in longer words. In the model I am assuming, the last syllable is the LEX domain. The penult syllable is the TAM domain. There is a break in the word between these two domains critical for word formation.

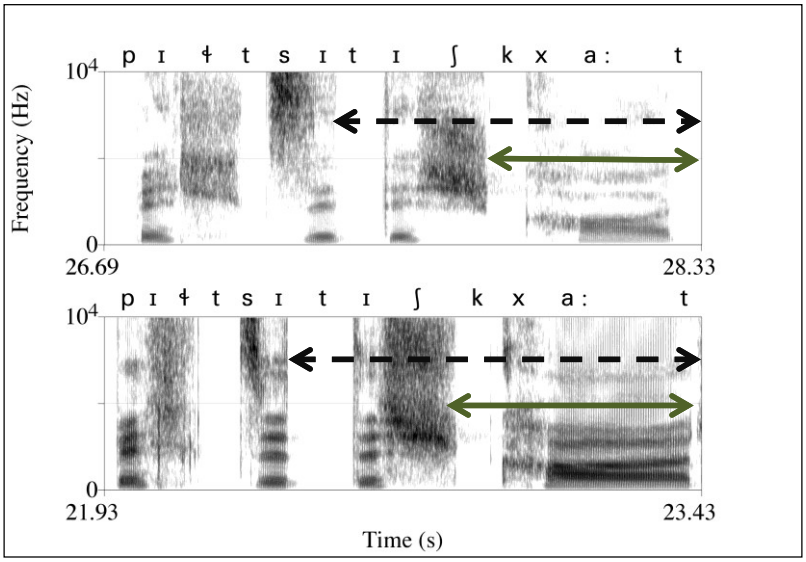

Figure 4 Spectrograms of Navajo verbs demonstrating the prominence of the stem, final syllable, and the LEX domain from McDonough (2003)

In summary, while it is unsurprising that the phonetics would reflect and support the phonotactic structure of the verb, especially given the distribution facts discussed in the previous section, it is quite interesting, even remarkable, the consistency with which this is accomplished at the phonetic level across the Dene languages. The stems are phonetically prominent in words; especially stem onsets. In this position, a distinction exists between simple segments, i.e. plain 'unaspirated' stops (b, d, g), fricatives and approximants, and the complex segments: affricates (including the 'aspirated' stops, *t* and *k*), and ejectives, all of which consist of a stop (closure) plus a long and characteristic fricative release. The distinction between place of articulation and manner among affricates is realized in these releases. In non-stem morphemes, only simplex segments are found. The vowel contrasts too are reduced in non-stems to short vowels, and in general there is a tendency for non-stems to have a CV syllable structure and a language specific default vowel. Exceptions to these generalizations are found among the conjugational morphemes of the TAM

domain, in which both long vowels and codas may appear, making these morpheme also distinct. Finally the length and prominence of the stems makes the boundary between the stems and the pre-stem or TAM domain an observable break in the word.

In Section 4, I'll demonstrate how a model using this structure might work, followed by a discussion and summary.

4 Modeling the verb

The model of the verb we are using is repeated in (9). In this structure the verb word is a compound of two separate domains with distinct phonological and phonotactic properties, what we have called TAM and LEX. Each domain has a base, i.e. obligatory, morpheme.

(9) (repeated from 6) Dene word structure

[[(af) - TAM]$_x$ [(af)- LEX]$_y$] Word$_{(x(y))}$

The constraints on the minimal verb word in Dene are determined by the morphological structure, not the phonology (10). The basic word requires two domains, TAM and LEX. These domains have base forms,[11] one from one of the conjugational paradigms: aspect inflected for person and number. The other is from the LEX domain, the verb stem.

(10) Minimal Word$_{(x(y))}$ = [[TAM$_X$]x [LEX$_Y$]y]$_{x(y)}$

Thus the minimal verb is a licit compound of these two morphemes. In (11) is an example of a minimal word *yishcha* 'I'm crying' with a TAM base in the ø-imperfective conjugation: the 1st singular *ish* (glide is epenthetic, the null prefix *ø-* is a valence marker on the verb stem, not under discussion in this paper[12]).

(11) [[TAM]$_{1S/IMPF}$ [LEX]$_{IMPF}$]$_{1S/IMPF\ (CRYIMPF)}$

(y)ish	ø-cha
øIPFV.1S	'cry'$_{mprf}$

yishcha
'I'm crying'

The pre-stem TAM domain can be complex, with prefixes to the conjugational base, as we see in (12) below the verb form *'áhodishcha* 'I pretend to be crying' (YM 1987:71). The TAM domain consists of the prefix *'áhodi- 'fake, pretend' (*which consists of the reflexive + area prefixes), conjugated in the ø-imperfective, the form *'áhodishcha* has the øIMPV.1s form *ish* as its base (as in (61)).

[11] Or fix-up rules which provide a default specification for the base, in the case that the cell for that specification is empty, often the 3rd singular. This is what the 'pepet vowel' of Athabaskan literature is, a place filler for the 3rd singular null imperfective conjugation (McDonough 1990, 1999). Note the pepet vowel of Hoijer comes with the conjugational information of the cell it belongs to (3rd singular, null imperfective).

[12] See the discussion of the so-called (and misnamed) 'classifier' alternations that refer to the alternations on the stem onset that this morpheme triggers (Howren, 1971; McDonough, 2001). Prefixation only changes the stem onset from a simple segment to a complex one, it does not otherwise affect the size of the LEX domain.

(12) *'áhodishcha* 'I pretend to cry'

[af-	TAM]	[af-	LEX]
['áhod-	ish]	[l-	cha]
pretend-	*øIPFV.I*		*'cry'*

The conjugation pattern for person and number for *'áhodish* is listed in YM 1987:71. This TAM morpheme can be added to verb stems such as *cha* 'cry' and *hosh* 'sleep' to produce more compositional meanings 'pretend to sleep' and 'pretend to cry', but also less transparent ones as in Table 5.

Table 5 Forms with 'pretend' morpheme

'ahodishwosh	*'I pretend to be asleep'*
'ahodish'į'	*'I lie' (make a pretend)*
'ahodiyiilkah	*'we dilly-dallied' (pretend to walk, 3+ actors)*

These forms are constructed from the verb stems *l-wosh* sleep, *l-į* 'make', and *l-kad* '3+ actors walking'. In (13) is a longer form with a positional stem /ch'í/ 'on horizontal surface'.

(13) ch'íninishkaad 'I herd them out'

[ch'í-	ni-	nish]	[ł -	kaad]
'horizontal'	*term*	*nIPFV.1S*	*'trans'*	'move in a spreading way'

I cause them to move out along a horizontal surface YM:d290

The forms in Table 6 all have the pre-stem – in the n-imperfective conjugation – and are joined to different stems.

Table 6 The TAM domain morphemes *ch'íninish* 'on a horizontal surface'+ LEX stem

ch'íninishchéél	*'I drove them out'*
ch'íninish'ááh	*'I lure him out' (deceive)*
ch'íninish'íih	*'I snuck it out" (act without being seen)*

While the full compounds are fairly transparent, they are so only after you know their meaning; the actual meaning of the word may be difficult to interpret accurately even if you are familiar with the meaning of the two independent units. The form with the verb stem *'ááh* to deceive, with the pre-stem domain, conjugated in the n-conjugations, means to 'deceive him out along a horizontal surface' i.e. to lure, or to 'act on something without it being seen out along a horizontal surface', i.e. to sneak something out.

4.1 Example outputs

In its simplest form the model combines a conjugational morpheme from TAM with a stem morpheme from LEX; the output is a fully inflected word (in (52)). Fully inflected words are also paradigmatically organized. The TAM paradigms may have a rich set of prefixes that build meaning into the word (Table 7 and Table 8), these constrain the stems they may occur with. An investigation of these combinations is an open area of research, and includes research into the output of the extensive aspectual combinations the two domains provide.

In Table 7 is the TAM *bits'á'nish* 'away from x' with different stems that conjugate with this pre-stem domain. The whole is considered to be a lexical unit insofar as the combinations are not compositional.

Table 7 TAM domain *bits'á'nish 'away from x'* with different LEX stems

bits'á'nish kǫǫh	swim away from it
bits'á'nish 'eeł	sail away from it
bits'á'nish dlǫǫsh	move away 'on all fours'
bits'á'nish báás	drive away from it

In Table 8 are several different pre-stem domains that build meaning units from the same stem.

Table 8 Different TAM domains with the same LEX stem dzíįs 'pull '

'iis dzíįs	pull or drag obj out of sight
'adaas'iis dzíįs	pull obj down from a height
'ałts'ás dzíįs	pull apart obj
bíis'iis dzíįs	pull and add obj to a pile
bikiis dzíįs	cover obj
'adah ch'és dzíįs	drag obj over the edge
haas dzíįs	pull O out (like a splinter)

To be a fluent native speaker and part of the speech community is to know the licit forms: which conjugational patterns are concatenated to which stems, the stem's possible conjugations and the conventional meanings associated to the inflected forms. The TAM and LEX combinations are only semi-compositional. The morphology is striking (and frustrating for non-fluent speakers) for the lack of transparency in the combinatorial units. Anecdotally, it is not uncommon to hear a Navajo say that they were talking to an elderly person who used words they didn't know. This is common feature of morphology and happens much less often at the syntagmatic level, where sentence production tends to be strongly and transparently compositional. This kind of lack of full compositionality is a property of paradigmatic variation in particular and thus of morphology.

5 Discussion

Paradigmatic variation is a type of grammatical variation, associated with word formation and the lexicon, distinct from syntagmatic (syntax). It is not linearly concatenative, though it may have concatenative properties (compounding); this type concatenation is more compositional than paradigmatic processes. Paradigmatic organization differs from syntagmatic processes in a number of ways worth investigating, but not under discussion in this paper. The point here is that the Dene verb makes exquisite use of paradigmatic encoding in the lexicon.

The paradigmatic model makes several predictions:

- Paradigmatic organization is efficient and viable
- The two domains, TAM and a LEX, are the basis of all productive verb formation and the core verb is two syllables long by morphological imperative
- The domains are independent
- They represent distinct types of paradigms.
- The meaning of the whole, all its morphosyntactic specification, is x(y), as TAM (LEX)
- The TAM paradigms are conjugational, marked for person and number

- These paradigms are organizational principles in the lexicon
- Stems are very phonetically and phonologically prominent and carry base lexical meaning.
- Speakers learn to produce licit inflected forms by association of a fully inflected word to its conjugational paradigms via knowledge of its compound structure.
- Speakers are aware of this structure and use it.
- Children are likely to learn the stems first

The claim of this paper that this model discussed in this paper will be useful as a teaching model, a model of lexical access and language acquisition.

6 Summary

Generalizations about structure and constituency in lesser studied languages will emerge from examining phonetic data and undertaking phonetic analyses, examining features that emerge. Language documentation will benefit from careful and systematic phonetic studies of segmental and prosodic structure. Studies of the combinatorial properties of TAM and LEX in the Dene verb are likely to yield fruitful insights into word formation and meaning important to models of grammar, as well as modeling a speaker's knowledge of structure as constrained by principles of sound change and simplicity.

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