ABSTRACT

METRICAL PROMINENCE IN HIDATSA: AN ACOUSTIC AND PHONOLOGICAL ANALYSIS

Various researchers have claimed that Hidatsa is a pitch-accent language or a stress-accent language. Park (2012) claimed that Hidatsa is a pitch-accent language and Boyle et.al (2016) claimed that stress does not correlate with pitch (F0) but rather duration, vowel quality and amplitude are all markers for stress. My main goal in this thesis is to use phonetic instrumentation to determine what phonetic properties (F0, amplitude, and duration) are revealed and if they coincide with accent placement in Hidatsa. My findings show that words in isolation incorporate the phonetic properties (F0, amplitude, and duration) of a pitch accent system. These findings can now be a part of the larger scope in Siouan languages such as Crow, a pitch accent language (C. Golston, personal communication, November 20, 2016.) and Lakota where F0 is a primary marker for stress along with other phonetic properties (Mirzayan, 2010).

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August 2017

METRICAL PROMINENCE IN HIDATSA: AN ACOUSTIC AND PHONOLOGICAL ANALYSIS

by
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A thesis

submitted in partial

fulfillment of the requirements for the degree of

Master of Arts in Linguistics

in the College of Arts and Humanities

California State University, Fresno

August 2017

APPROVED

For the Department of Linguistics:

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ACKNOWLEDGMENTS

First I'd like to thank John Boyle who took me under his wing and guided me through this entire project. John Boyle bestowed his knowledge of field research onto me and gave me a chance to see first hand what documenting a language is all about. I will never forget my time at the Fort Berthold Reservation and your unwavering passion for Hidatsa. I'd also like to thank Michael Shepherd for helping me with the statistical analysis of this research; without him, this thesis would not have been possible. I want to thank Sean Fulop for always wanting this thesis to be the best it could be and pushing me to think outside the box. I want to thank Chris Golston for teaching me all that I know about phonology and your great knowledge of past and current research. I want to thank Brian Moran, a colleague and dear friend of mine, who stood behind me through all the obstacles I faced when undergoing this project. Lastly, I would like to thank my parents who have always supported me in all my endeavors. I have only ever wanted to be a daughter you can be proud of.

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CHAPTER 1: INTRODUCTION

In this thesis I analyze the phonological and acoustic correlates of syllable prominence in Hidatsa, a Siouan Language. Various researchers have claimed that Hidatsa is a pitch-accent language or a stress-accent language. Park (2012) claimed that Hidatsa is a pitch-accent language and that the "high pitch (tone) is inserted at the left edge of a phonological word whence it spreads until it hits an accented mora (which also has a high pitch). Low pitch is inserted after the accented mora and spreads until the end of the phonological word" (Park, 2012, p. 38). Boyle et al. (2016) claimed that stress does not correlate with pitch (F0) but rather that stress is marked in long vowels via lengthening (duration); in short vowels via vowel quality such as formant values and that intensity (amplitude) is also a marker for stress. I will conduct an empirical investigation of both phonetic and phonological cues to accent in order to resolve the above claims.

Objectives and Goals

My main goal in this thesis is to use phonetic instrumentation to establish the phonetic differences between accented and unaccented vowels in Hidatsa, as well as to determine what phonetic properties (F0, amplitude, and duration) are revealed and if they coincide with the patterns of metrical prominence that Hidatsa exhibits. Lastly this investigation will allow me to either refute or support the hypothesis of pitch spread (Park, 2012).

CHAPTER 2: LITERATURE REVIEW

Crow

Graczyk (2007) and Wallace (1993) have shown that Crow, which is closely related to Hidatsa, has a pitch accent system. In this system, tone can be predicted once the position of the accent [´] is known. The rules are as follows along with examples that are shown below; high F0 is marked by H, low F0 is marked by L (Graczyk, 2007, p. 21).

- Accented vowels are high in pitch.
- All vowels to the right of the accented vowel are low in pitch.
- All short vowels to the left of the accented vowel are low in pitch.
- All long vowels to the left of the accented vowel are high in pitch.
- Short vowels that intervene between a long vowel and the accented vowel assimilate to high pitch

(6A)*ammaachimmúaau* ‘school’ (6B) *alachiwakáau*‘church’

L HH H HLLL L L L L HLL

Golston (personal communication, November, 20, 2016) has also shown that Crow has a pitch accent system. He proposes that “all Crow words are stressed on the initial iamb and that they fall into one of two tonal classes: *H*L*, and *L* H*.” Examples of these classes are shown below.

*H*L* *(a ˈlá)(sàlee)* ‘blaring sound’

(a ˈlá)(pàa)pi ‘smart, burn’

L H* *(a ˈlá)(páa)pi* ‘buttock’

(a ˈlà)(páa)šu ‘corner’

Swedish

The former, *H*L*, was first shown in Riad (2014) where Swedish, a pitch accent language, was discussed. He showed that Swedish differentiates between two prominence levels of accent (Bruce 1977; Heldner 2001). Each level of prominence has two different accent 'melodies'; *Accent 1* (*HL* *) and *Accent 2* (*H* **L*) (Bruce 1977; Heldner 2001) where the (*H*) represents the high tone (high F0) and (*L*) represents the low tone (low F0). *Accent 1* is considered solely as intonation and *Accent 2* actually carries a lexical tone. More specifically, the former leads into the association point, which is the primary stress, and the latter tone actually associates with the primary stress. Tonal word accent is realized by the intonation contour where a stressed syllable/foot can only bear a single tone. Stressed feet in Swedish are minimally bimoraic and the default stress is on the penultimate syllable. "Stressed syllables must be heavy in Swedish" (Riad, 2014, p. 6). A heavy syllable in Swedish includes either a long vowel or a short vowel with a long consonant.

Previous Studies on Hidatsa

Park (2012) described Hidatsa as having a lexical word-level pitch accent but does not provide any phonetic instrumentation to support his claim. Park stated that "high pitch is inserted at the left edge of a phonological word whence it spreads until it hits an accented μ (mora) (which also has high pitch). Low tone is inserted after the accented mora and spreads until the end of the phonological word. All morae to the right of the mora bearing the pitch accent are low tones" (Park 2012:38). An example of this is shown below.

giwiiwaacigúahgeec 'I became diabetic' (Park, 2012, p. 39).

HHH HHHHL LL

A competing view by Boyle et al (2016) investigated Park's (2012) analysis by using phonetic instrumentation to examine the behavior of word-level pitch in Hidatsa. Boyle et al. proposed that "metrical prominence is restricted to no more and no less than one syllable, contra Park (2012)" (Boyle et al., personal communication, January, 9, 2016). Furthermore, Boyle et al. stated that "primary stress is predictable and falls on the second syllable unless the initial syllable is heavy (i.e., (C)VV, (C)Vh, (C)Vʔ) or the third syllable is heavy and the first two are light" (Boyle et al., 2016). Note that only (C)Vh and (C)Vʔ are heavy (implying that syllables with other coda consonants are light). My analysis is based on the idea that all codas supply a mora, which means every CVC is heavy whether the coda is *ʔ*, or *h*, or any other consonant (C. Golston personal communication, June 9, 2016).

CHAPTER 3: STRESS AND PITCH-ACCENT

Stress Accent Systems

Depending on the language, word stress can be characterized by the emphasis on one or more syllables in a word. Some languages carry one stressed syllable in a word, whereas others carry two (i.e., primary and secondary stress). From a phonetic perspective, prominence in stressed syllables is usually indicated with one or more acoustic properties such as duration, amplitude, F0 and vowel quality. From a phonological perspective, Hyman stated that a stress accent "is an indication of word-level metrical structure meeting the following two central criteria" (Hyman, 2006, p. 168).

Obligatoriness: every lexical word has AT LEAST one syllable marked for the highest degree of metrical prominence (primary stress).

Culminativity: every lexical word has AT MOST one syllable marked for the highest degree of metrical prominence. (Hyman, 2006, p. 168).

Fry (1958) found that fundamental frequency (F0) is the most important acoustic correlate when determining prominence, but Gordon (2014) stated that a limitation in Fry's study is that only words in the focus position of an utterance were considered. This position "conflates word level stress and phrase level prominence and that the said levels can be realized through different phonetic means" (Gordon, 2014, p. 2). From the above discussion, I assume that stress involves prominence in one or more syllables and that certain phonetic properties coincide with that prominence.

Pitch Accent Systems

A *pitch accent system* can incorporate the phonetic and phonological parameters of both tone (F0) and stress systems. Hyman (2009) stated that "pitch accent systems freely pick-and-choose properties from the tone and stress prototypes, producing mixed, ambiguous, and sometimes analytically indeterminate systems which appear to be intermediate" (Hyman, 2009, p. 213). He stated that pitch accent refers to a "defective tone system whose tone is obligatory, culminative, privative, metrical, and/or restricted in distribution" (Hyman, 2009, p. 213). Gordon stated that pitch-accent is "primarily cued through fundamental frequency, whereas stress may be signaled through a variety of properties, including duration, intensity (amplitude), fundamental frequency (F0) and various segmental processes" (Gordon, 2014, p. 11). From the above discussion, I can infer that F0 is a primary correlate for pitch-accent languages along with an addition of one or more other acoustic properties such as the above discussed. Therefore, in this thesis I will not only establish whether or not Hidatsa is a pitch accent or stress accent language but more specifically reveal which phonetic properties are at work here.

Typology of Prominence Systems

Gordon (2014) discussed the importance of languages and their categorization according to how their prominence patterns correlate with different prosodic units, and not just based on the classifications of tone, stress, or pitch accent languages. "A further benefit of developing a typology of prominence at different levels is its potential for enriching the phonological literature on metrical stress theory" (Gordon, 2014, p. 2). Gordon summarized the typology of prominence systems. He divides them into two types. The first type of system is *Symmetrical* which includes the languages: English, Egyptian, Arabic, Hebrew,

and Farsi. In this system, prominence is found on the same syllable at the word and phrase levels. Language with this system can be subdivided based on the prominence falling on a peripheral syllable (initial or final syllables) or a non-peripheral syllable (peninitial, antepenultimate, penultimate, etc.). In keeping with the objective of the current paper, I find it is important to shed light on how stress and tone (F0), in other languages, are found to coincide and/or go their separate ways. Becker (2003) stated that stressed syllables in Hebrew are marked by the high tone:

> The high tone appears on the stressed syllable when it is final or penult in the phrase (1a). When the stress is farther to the left in the phrase, the high tone appears one syllable after the stress (1b). This is a fully productive post-lexical phenomenon, as can be seen in (1c) (p. 47).

In the examples shown below, note that the acute accent (´) marks the high tone and the underline (_) marks the stressed syllable)

a. *ba<u>ló:n</u>* ‘balloon’
<u>yé:</u>led ‘boy’

b. <u>a:m</u>búlans ‘ambulance’
<u>be:y</u>bísiter ‘babysitter’

c. <u>yé:</u>led ‘boy’
<u>yé:</u>led ma<u>tó:k</u> ‘a sweet boy’

The second type of system is *Asymmetrical* and includes: Chickasaw, Cayuga, Seneca, Central Alaskan Yup’ik, Onondaga and Wolof. In this system,

prominence is found on different syllables at the word and phrase levels. Languages in this system can be subdivided into 4 types based on whether prominence repulsion occurs at the word or phrase level. The first subtype includes *edge repulsion,* which is exhibited at the phrase-level but not the word-level. The second type includes stress falling on a peripheral syllable at the word-level but with no phrase-level pitch accent. In the last two subtypes, *edge repulsion* is exhibited at the word level but not the phrase-level, with no pitch accent (PA) at the phrase-level. The typology of prominence systems is shown in Table 1.

Table 1

Typology of Prominence Systems (Gordon, 2014)

Symmetricality	Word	Phrase	Languages
Symmetrical	Yes	Yes	English, Egyptian Arabic
	No	No	Hebrew, Farsi
Asymmetrical	No	Yes	Chickasaw, Cayuga, Seneca, Central Alaskan Yup'ik, Onondaga
	No	No PA	Wolof
	Yes	No	Unattested?
	Yes	No PA	Unattested?

Similar to Hebrew (symmetrical), in Chickasaw (asymmetrical), stress and pitch do not coincide in some cases. Lehnert-LeHouillier (2005) found that "the percentage of words where the highest F0 peak and the stressed syllable do not coincide increases with the number of syllables in a word. For example, in the Onondaga word /*onihnotákwaʔ*/ 'apron' the highest F0 falls on the antepenultlimate syllable and the penultimate syllable (stressed syllable) "has its own, less prominent F0 peak" (Lehnert-LeHouillier, 2005, p. 435). Note that in the

example above, the underline (_) marks the high F0 and the acute accent (´) marks the stressed syllable.

CHAPTER 4: OUTLINE OF HIDATSA PHONOLOGY

Hidatsa Consonantal Inventory

The consonantal inventory of Hidatsa is shown in Table 2.

Table 2

Consonantal Inventory (Harris & Voegelin, 1939)

Articulation	Labial	Alveolar	alveopalatal	velar	glottal
stops	p p:	t t:		k k:	ʔ
fricatives			š š:	x x:	
affricates		ʦ ʦ:			
sonorants	w	r			h

The glottal stop in Hidatsa can appear inter-vocalically to prevent hiatus. There is an epenthetic glottal stop that appears as an onset and a phonemic glottal stop that appears in the coda positon. The voiceless stops [p,t,k], when positioned inter-vocalically, are realized as voiced [b,d,g]. The glide [w] and the liquid [r] are sonorous and and are sometimes realized as /m,n/ in pause initial positions (i.e the beginning of a sentence or a word when elicited in isolation). The affricate [ʦ] is voiced and is written as “c” in the orthography[1]. Hidatsa also has a voiceless alveopalatal fricative, which is written as “sh” in the orthography and a voiceless velar fricative [x]. Furthermore, Harris and Voegelin (1939) stated that there are a series of “lenis” (henceforth singleton) consonants and “fortis” (henceforth geminate) consonants and claim that only obstruents can be geminated. Evidence for this is seen in the intervocalic position, where geminates become ambisyllabic

[1] This refers to The Standard Hidatsa Orthography, which has been adopted for standardized teaching materials by The Three Affiliate Tribes.

(meaning syllable final and syllable initial). They also claimed that the geminated series are rare word initially and infrequent in the word-final environment. Harris and Voegelin stated that the geminate stops [pː tː kː] appear in the word medial (intervocalic) position and the singleton stops [p, t, k], occur in word initially, word finally, and are slightly voiced [b, d, g] in intervocalic position. The singleton fricatives [š x] and singleton affricate [ʦ] have geminate counterparts [šː xː], [ʦː] respectively. [2]

Hidatsa Vocalic Inventory

Hidatsa has a five vowel system, and for each short vowel there is a long counterpart. The long vowels are written in the orthography as double vowels, e.g., "aa" for [aː].[3] In addition, there are two diphthongs[4]. The vowel inventory of Hidatsa is shown in Figure 1.

Vowels					
	high	i iː			u uː
	mid	e eː		o oː	
	low		a aː		
diphthongs		ia		ua	

Figure 1. Vowel inventory (Boyle, 2007)

2 All other researchers have followed Robinett (1955) who analyzed the geminates and assumed they were clusters of Ch.

3 Park (2012) stated that there are three short high and low vowels [i, a, u]; the mid vowels only have long segments [ee,oo] in addition to three long, high and low vowels [ii, aa, uu].

4 Harris & Voegelin (1939) claimed there are actually three diphthongs with the third one being [ui] in the word /ruxːaparui/ 'shaft' as in 'arrow shaft'. Boyle (2007) suggests that "this is perhaps a loan word since diphthongs like [ui] don't exist in Crow/Hidatsa (Missouri Valley)" (Boyle, pc.)

Syllable Weight & Syllable Structure

The segmental phonology of Hidatsa is relatively well-understood, as is some of the metrical phonology. Specifically, heavy syllables in Hidatsa include any long vowel, diphthong or any syllable that carries a coda. Also, any syllable in a word can be light (V, CV) or heavy (VC, CVV, VV, or CVC) and super heavy (CVVC). However, I show here that metrical prominence in Hidatsa is unpredictable because accent [´][5] in a word, which always coincides with high tone (H), (henceforth F0) may or may not coincide with the default stress, which lands on an iambic foot that is aligned with the left edge of a word (L´L), (L´H) or (´H). The term accent [´] in this paper is not used in reference to stress accent nor pitch accent because the phonetic properties have yet to be revealed. The term accent [´] in this thesis represents the high tone in a word and/or the default stress. In Hidatsa, every vowel carries a mora and I presume that coda consonants also hold moraic weight. More specifically, a light syllable carries only one mora (CV=Cμ, V= μ) and a heavy syllable can carry as many as three morae (CVVC = Cμμμ). What remains to be investigated is another aspect of metrical prominence; specifically, which phonetic cues (F0, amplitude, duration) coincide with the accent [´] in Hidatsa, and do these phonetic cues part ways with the iambic foot (henceforth default stress)?

[5] Throughout this thesis the acute accent (´) is reserved for high tone (H) and/or default stress.

CHAPTER 5: ACOUSTIC INVESTIGATIONS

Procedure

The data for this paper are based on recordings of three fluent speakers of Hidatsa: Martha Birdbear (MB), Mary Gachupin (MG) and Arvella White (AW). The recordings are of words in isolation, recorded between 2015 and 2016 in a foam-padded, quiet, isolated room. Equipment included a Shure microphone, pre-amplifier, and an AD conversion device to record directly onto a computer. Sessions were recorded using Audacity, set to a minimum sampling rate of 44.1 kHz. The phonological analysis consisted of analyzing only three syllable verb and noun roots in a 6000-word Hidatsa dictionary (Boyle & Gwin, 2006), to determine their patterns of metrical prominence. I found 861 roots (both verbs and nouns) and text grids were created using Praat (Boersma & Weenik, 2015). I used a Praat script (Styler, 2012) to measure F0, duration, and amplitude of each vowel in a root simultaneously in order to see which phonetic cues coincide with accent and/or default stress.

The 6000-word Hidatsa dictionary consists of words already marked with an accent [´] by Siouan linguists. Researchers working for The Language Conservancy[6] recorded these words over the span of two years. I organized the 861 roots into categories based on the accent placement. The majority of the words fell into the default category (iambic-´H, L´H, L´L) where accent is placed on the left-aligning iamb in a word. However, accent [´] is found in other places as well; these include on the initial mora in a word where a light syllable is, on the first mora to the right of an initial iamb (regardless of syllable weight), and on the last mora of a word. I listened to the recordings to determine if the accent [´]

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6 The Language Conservancy is a non-profit organization that works with the Three Affiliated Tribes to develop teaching materials for their language programs throughout the reservation.

coincided with the emphasized syllable. The majority of the words had the correct accent placement but if any were incorrect, I then placed them in the appropriate category. These classes are described in Figure 2.

Class I Iambic

(´H) Accent falls on the first mora of the heavy syllable

(L´H) Accent falls on the first mora of the heavy syllable

(L´L) Accent falls on the mora of the second light syllable

Class II Accent on the initial mora of a word, which is a light syllable

ĹHH

ĹLL

ĹL

ĹHL

ĹH

ĹLH

Class III Accent on the 1st mora to the right of the initial iamb

HḾ
HĹ
LHĹ
LLĹ
LLḾ
LHḾ

Other pattern

HLḾ

Figure 2. Classes of accent placement

Of the 861 roots, 779 fell into the default class, Class I (Iambic), 32 fell into Class II (Accent on the initial mora of a word, which is a light syllable), 39 fell into Class III (Accent on the first mora to the right of the initial iamb), and 10 fell into neither class because the words either included an indefinite marker /maa-/ or the prefix /naga/ 'by sudden motion or inner force'. One verb fell into another pattern of metrical prominence, HLḦ. [7]

Golston (2016) proposed that two of the three classes in Hidatsa are similar to the Accents 1 and 2 in Swedish. In Hidatsa, the default class (Iambic) is H **L* (*Accent 2* in Swedish), where the high tone associates with the accent on the initial iamb (´H, L´H, L´L). This is where the stressed syllable is expected to be. The second class is H *L** (*Accent 1* in Swedish), where the high tone associates with the accent on the initial mora, which is an unstressed syllable; and then tone leads into the adjacent stressed syllable, which carries the low tone. In addition to these two classes, Golston (2016) proposed a third class *L** H, where the high tone associates with the accent on the initial mora to the right of an iamb, regardless of syllable weight. In accented long vowels in the first or third class, the high tone (H) always falls on the first mora of the long vowel. Examples and glosses[8] of each class are shown in Figures 3 through 6, along with a waveform.

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7 ookácia 'to soar'

8 See Appendix.

<u>$\mathcal{H}$*L (Default Class)</u>

ad<u>á</u>ate – ‘to let someone out’

ab<u>í</u>cga – ‘moustache’

ad<u>é</u>ʔ - ‘to stick out’

ab<u>á</u> – ‘nose’

ad<u>í</u>shi – ‘smoke hole’

ag<u>á</u>gi – ‘to be able’

<u>á</u>agashi – ‘to write; to draw’

<u>á</u>agciishi – ‘to peek in to peer’

b<u>á</u>ahi – ‘to sing’

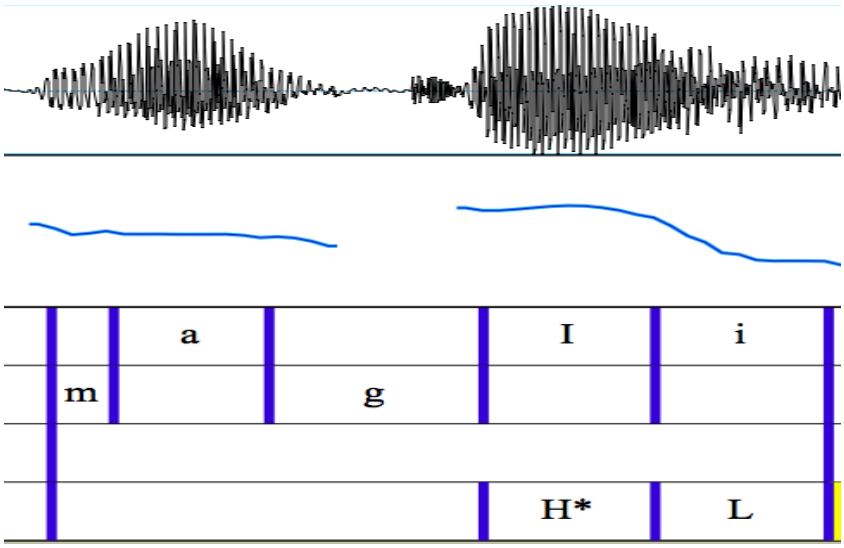

Figure 3. $\mathcal{H}$*L magíi

<u>ℋ 𝕃* (Class II initial mora)</u>

ákaahi – ‘to’

ákahi – ‘bring; to deliver’

árashigia – ‘curly hair’

áwashi – ‘cave; cellar’

gácia – ‘bloated’

géʔe – ‘scratch an itch’

gírada – ‘to like’

gírashi – ‘to love’

gírura – ‘go back after’

gíʔiria – ‘to ride horseback’

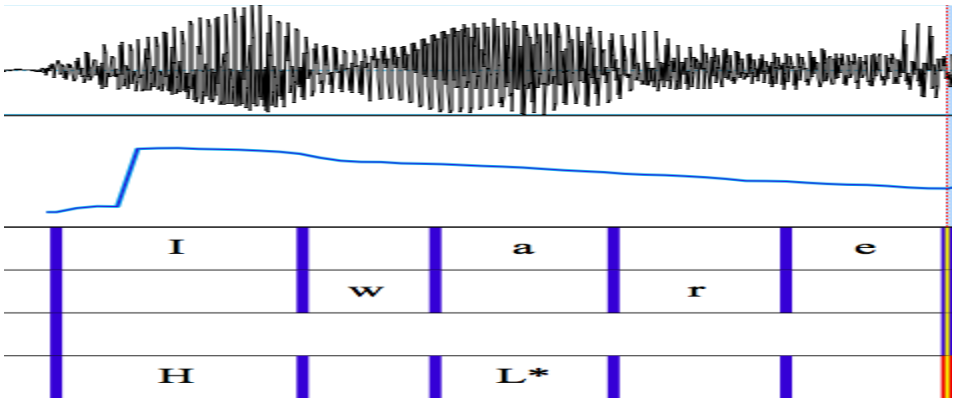

Figure 4. ℋ 𝕃* íware

<u>*L* ℋ* (Class III Accent on the first mora to the right on an initial iamb)</u>

HH́

agshí – ‘to capture’

ashgóo – ‘to limp’

aʔrée – ‘get after someone’

HL

abcá – ‘to be sharp’

agshí – ‘to catch’

bishdá – ‘eye’

LLL

gicibí – ‘to dive back’

garapé – ‘to remind’

garawí – ‘to remember’

LLH

adarúu – ‘to get hurt’

agubáa – ‘announcer’

gadabáa – ‘to be gentle; to be kind’

LHL

dadaxxí – ‘to make a clicking or tapping sound’

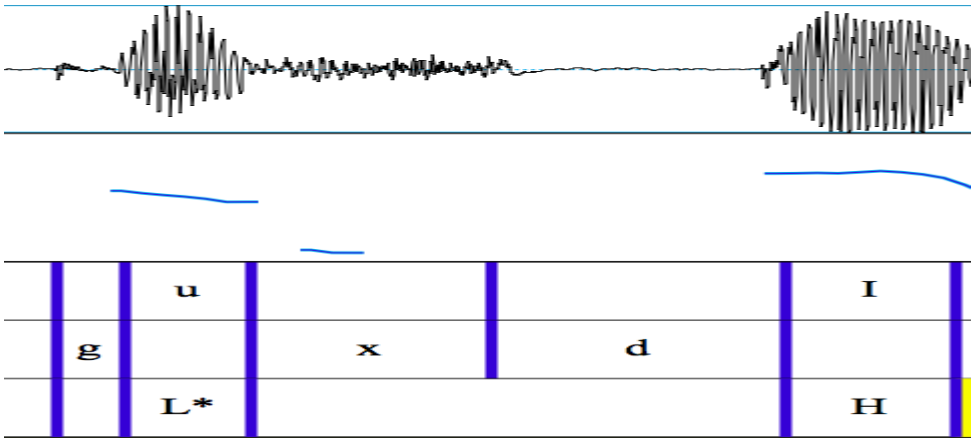

Figure 5. L* *ℋ* guxdí

<u>Other pattern *ookacía*</u>

HLḾ *ookacía* ‘to soar’

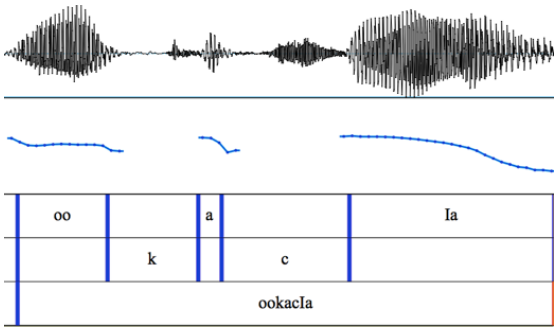

Figure 6. Other pattern

CHAPTER 6: RESULTS

I measured the F0, amplitude and duration of accented vs. unaccented vowels to see if they differ systematically. In this study, I conducted three paired *t*-tests for the first three classes (H**L*, H*L**, *L**H), testing whether F0, duration, and amplitude align with the accent [´] in a word.

For the H**L* (default) class, the accented vowel of an iamb was compared to the adjacent, unaccented vowel. In the case of long vowels and diphthongs, I compared the first half of the vowel to the second half. I analyzed one hundred forty-three pairs of vowels (one accented, one unaccented from within the same word token), comparing variables of F0, amplitude and duration. In the paired *t*-tests, there was a significant difference between the mean F0, $t(142) = 7.49$, $p < .001$, and mean amplitude, $t(142) = 5.79$, $p < .001$, (but not mean duration) of accented vs. unaccented vowels. In the H**L* class, both F0 and amplitude correlate with the default stressed syllable, as expected. Accented vowels average 17Hz higher in F0 and 1.73 dB higher in amplitude than their unaccented counterparts, as shown in Figures 7 and 8. Duration was not related to stress.

For the $\mathcal{HL}$*, (initial mora) class, I compared the accented vowel to the adjacent vowel, which was within the default stressed syllable. The F0, amplitude, and duration of 20 pairs of vowels (one accented, one unaccented from within the same word token) were analyzed, comparing variables of F0, amplitude and duration. The paired *t*-tests showed significant differences between the mean F0, $t(19) = 2.31$, $p = .032$, and mean amplitude, $t(20) = 4.42$, $p < .001$, of accented vs. unaccented (default stressed) vowels, such that the accented one was higher in F0 and amplitude. This finding shows that, in the $\mathcal{HL}$* class, neither F0 nor amplitude correlate with the default stress. Accented vowels averaged 9 Hz higher in F0 and 2.43 dB higher in amplitude than their unaccented counterparts, as shown in Figures 9 and 10. In addition, there was no significant difference in duration between the accented mora and the unaccented mora.

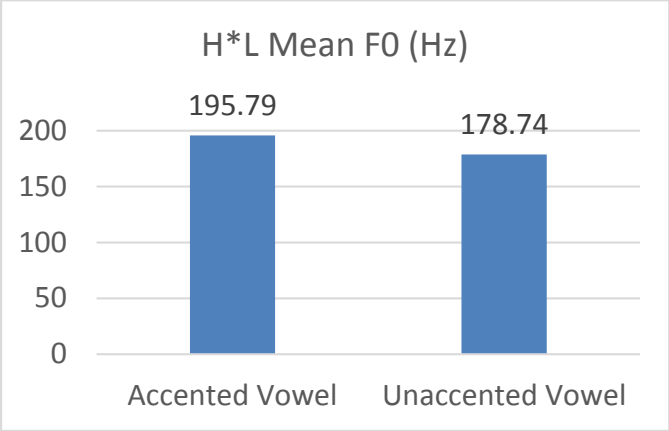

Figure 7. Mean F0 of vowels: $p < .001$

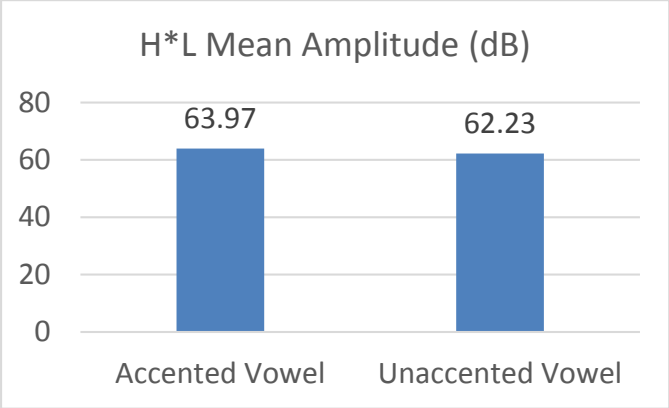

Figure 8. Mean amplitude of vowels: $p < .001$

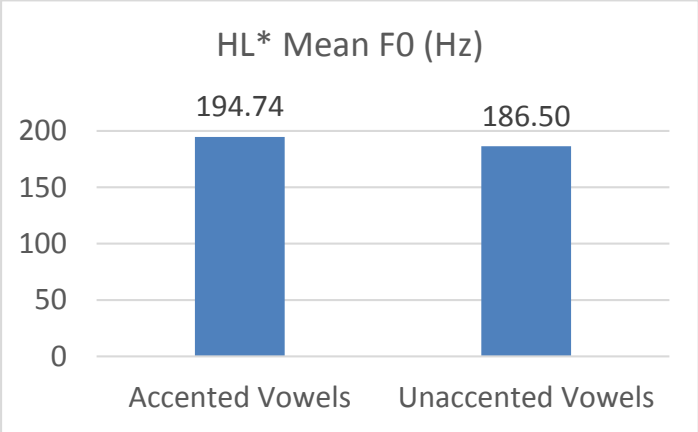

Figure 9. Mean F0 of vowels: $p = .032$

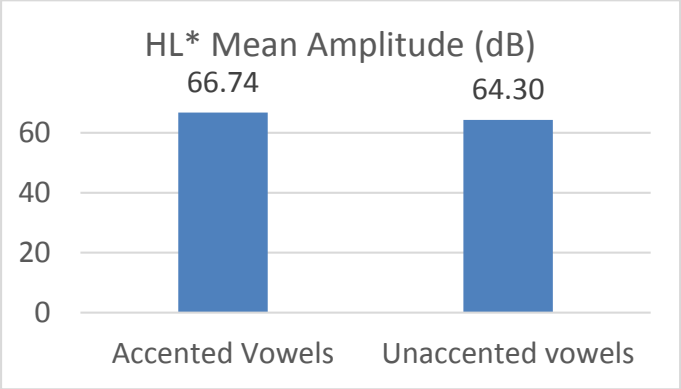

Figure 10. Mean amplitude of vowels: p <.001

For the L^*H (accent on the first mora to the right of an iamb) class, I compared the vowel of the default stress to the adjacent accented vowel. I then analyzed thirty-eight pairs of vowels (one unaccented, one accented from within the same word token), comparing variables of F0, amplitude and duration. The paired *t*-tests showed significant differences in the mean F0, $t(37) = 3.67$, $p < .001$, mean amplitude, $t(37) = 5.62$, $p < .001$, and mean duration, $t(37) = 6.13$, $p < .001$, of unaccented vs. accented vowels, as illustrated in Figures 11, 12, and 13. Therefore, in the L^*H class, F0, amplitude, and duration does not correlate with the default stressed syllable but rather the accented mora to the right of an iamb.

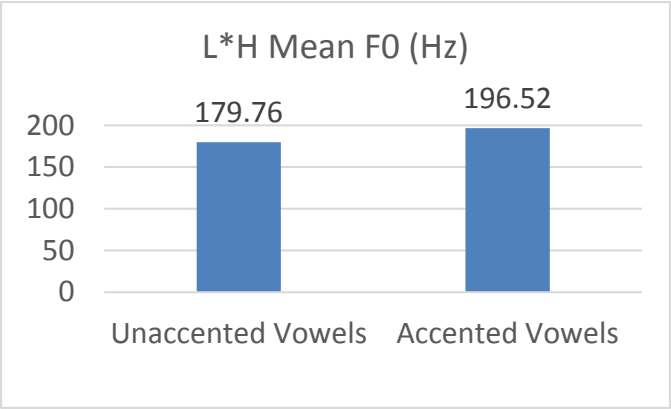

Figure 11. Mean F0 of vowels: $p < .001$

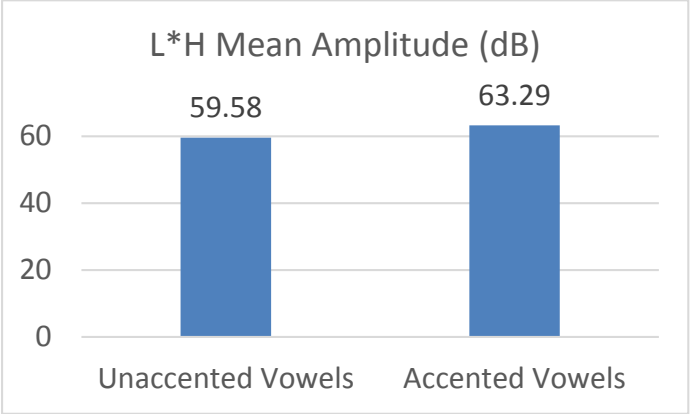

Figure 12. Mean amplitude of vowels: $p < .001$

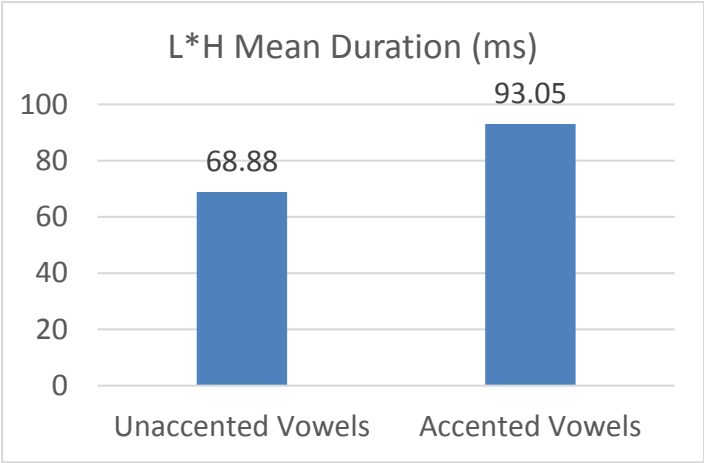

Figure 13. Mean duration of vowels: $p < .001$

In regard to past findings, I found that F0 does correlate with the default stressed syllable in the *H*L* (default) class, contra to the claims made by Boyle et.al (2016). However, in the *HL** (initial mora) class and the *L*H* class (accent on the first mora to the right of an initial iamb), F0 does not correlate with the default stressed syllable but rather the accented mora. Boyle et al. (2016) stated "stress is marked in long vowels via lengthening (duration)" (J. Boyle et al., personal communication, January, 9, 2016). My findings show that duration was only shown to be a marker for the accented mora in the *L*H* class, where long vowels occasionally showed up at the end of a word in the LL`H and H'H patterns.

Therefore, I argue that duration is not a marker for stress, contra to Boyle et al. (2016).

If the hypothesis of pitch spread, “high tone (F0) inserted at the left edge of a word and then spreads to the high tone bearing mora” (Park, 2012 p. 38), is correct then an unaccented mora to the left of an accented mora will carry the same high tone ($\mathcal{H}$) as the accented mora. It is also possible that pitch spread (high F0) works as it does in Crow; namely, it spreads to long vowels but not short vowels. To test if either of these hypotheses are correct, I conducted paired *t*-tests on three data sets: namely, 1) long vowels to the left of the accented mora, 2) light syllables (CV,V) to the left of the accented mora, and 3) other heavy syllables that carry a coda (VC, CVC) to the left of the accented mora. The data set for the long vowels and heavy (coda) syllables included 60 tokens from the HH́ and HĹ patterns of metrical prominence. The light syllables included 126 tokens from the LH́ and LĹ iambic patterns. My results show, in every case, that the unaccented first syllable was significantly lower in F0 than the accented second syllable, whether it was light, $t(125) = 6.22$, $p < .001$, coda-heavy, $t(43) = 7.26$, $p < .001$, or long-heavy, $t(15) = 2.23$, $p=.041$. In other words, high F0 in Hidatsa never spreads from the left edge of a word to the accented mora, counter to Park’s -claim. The mean and standard deviations for F0 and amplitude are shown in Tables 3 and 4.

Table 3

F0 (in Hertz)

Syllable	Syllb 1 mean (SD)	Syllb 2 mean (SD)	Difference
light initial syllable	181.57 (21.16)	194.86 (25.38)	-13.29
heavy (coda) initial syllable	173.43 (11.80)	193.08 (20.58)	-19.65
heavy (long vowel) initial syllable	179.43 (27.24)	191.28 (29.12)	-11.85

Table 4

Amplitude (in Decibels)

Syllable	Syllb 1 mean (SD)	Syllb 2 mean (SD)	Difference
light initial syllable	61.59 dB (7.53)	65.04 dB (7.03)	-3.45
heavy (coda) initial syllable	66.29 dB (7.85)	68.17 dB (5.55)	-1.88
Heavy (long vowel) initial syllable	66.97 dB (8.55)	69.36 dB (7.32)	-2.39

Furthermore, to address the possibility that partial pitch (F0) spread is taking place specifically to long vowels (such that unaccented long vowels become higher than unaccented short vowels without becoming as high as the accented vowel), I conducted a *t*-test comparing unaccented initial long vowels and unaccented initial short vowels. The results show that said vowels are not significantly different from each other in F0 or amplitude, further underscoring the lack of pitch (F0) spread in Hidatsa.

CHAPTER 7: DISCUSSION

Graczyk's (2007) rules are as follows: accented vowels are high in pitch, all vowels to the right of the accented vowel are low in pitch; all short vowels to the left of the accented vowel are low in pitch; all long vowels to the left of the accented vowel are high in pitch; and short vowels that intervene between a long vowel and the accented vowel assimilate to high pitch. The first, second and third rule stated above are the only rules that apply to Hidatsa. Accented vowels in Hidatsa are high in F0, and the vowels to the right of the accented mora are low in F0. Short vowels to the left of the accented mora were found to be low in F0. However, long vowels as well as other heavy syllables that carry a consonant in the coda were found to be low in F0. The fifth rule is ambiguous because it is not clear if the short vowel intervening between a long vowel and the accented vowel is a heavy syllable or a light syllable. At any rate, this rule could not apply in Hidatsa because it involves pitch spread, and this has been refuted thus far.

I have shown that high F0 does not spread in Hidatsa; rather, there is only one prominent high tone ($\mathcal{H}$) in Hidatsa, and the morae to the left and right of the high-tone-bearing mora carry low tones contra to Park (2012).

The findings of Boyle et al. (2016) revealed that F0 in Hidatsa does not correlate with stressed syllables; duration was found to be significant in long vowels; stress is marked in short vowels via vowel quality; and intensity (amplitude) is also a marker for stress. Boyle et al. claimed Hidatsa features a classic stress accent system, involving left-aligned, weight-sensitive iambs. Left-aligned iambs were found to be the default stress in Hidatsa, and the phonetic parameters (amplitude and F0) were found to coincide with the default stress in one of three classes. It was found that a rise in F0 does correlate with the accented

mora of the $\mathcal{H}$*$\mathcal{L}$ (default) class, which I show phonetically and statistically contra the findings of Boyle et al. In regards to the other phonetic cues (i.e., duration, amplitude) coinciding with accent, I show that amplitude does correlate with the accented mora of the $\mathcal{H}$*$\mathcal{L}$ (default) class. Amplitude was significantly higher in accented vowels than in their unaccented counterparts. Although, duration was not found to be significant in the $\mathcal{H}$*$\mathcal{L}$ (default) class. In the $\mathcal{H}\mathcal{L}$* (initial mora) class, F0 and amplitude coincides with the accented mora which is not the default stressed syllable. Lastly in the $\mathcal{L}$*$\mathcal{H}$(accent on the first mora to the right of an iamb) class, all three phonetic properties (F0, amplitude, and duration) coincide with the accented mora which is not the default stressed syllable. Overall, the phonetic cues (amplitude, F0, and duration) discussed above were found to part ways with the default stress (iambic foot) in two ($\mathcal{H}\mathcal{L}$* and $\mathcal{L}$*$\mathcal{H}$) of the three classes that I analyzed statistically but did not part ways in the default class ($\mathcal{H}$*$\mathcal{L}$) which includes the majority of the data. With that being said, I have shown phonetically and statistically that Hidatsa incorporates the phonetic properties of both stress and pitch, thus concluding that Hidatsa exhibits a lexical word-level pitch accent as stated in Park (2012). Furthermore, I show that pitch does not spread contra to Park.

CHAPTER 8: CONCLUSION

In this thesis, I have shown that Hidatsa does exhibit metrical prominence and is excluded to one syllable per word, similar to the findings of Boyle et al. (2016). Moreover, this study shows that metrical prominence in Hidatsa includes amplitude, F0, and duration to be markers for the accented mora of a word depending on the class. These findings have revealed that words in isolation incorporate the phonetic properties (F0, amplitude, and duration) of a pitch accent system. Future studies should involve an analysis at the phrase-level in order to further establish the rules of metrical prominence in Hidatsa and ultimately add to the typology of prominence systems for the linguistic community. The current findings of Hidatsa can now be tied into other closely related languages such as Crow which is also a pitch accent language (C. Golston, personal communication, November, 20, 2016). and Lakota which is known to use F0 as a marker for lexical stress along with other phonetic properties (Mirzayan, 2010).

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APPENDIX

L´H	Gloss
a.dáate	to let someone out
abícga	moustache
adéʔ	to stick out
agábcia	to be jealous
agábxi	to step over
akáaga	to be late
akáaga	to delay
aráxbi	get the better of someone
aríidi	to be hungry
awáagi	to sit down
bacáa	to lace up; string
biriá	to be wrinkled
gacáhcee	to show respect
gadáatec	to exile
gageéki	to creak
garáa	to run away
garácce	to believe
gigáagi	to sew
gigúa	to trap
gigúucgi	to learn, practice
giwía	to turn back
gurée	to chase
haxáaxi	to file
iʔáadi	to throw at
ibúa	to toss
icía	durable
icéec	to wake up
idáxpe	to make someone nervous
igáahi	glance at
igáhge	show something to someone
iigáaxdi	mistaken; to be wrong
igóogi	hang something up
igúcgi	imitate
igúucke	measure
iháadi	growl

iráake	to adopt
irábbi	to prick to stick
iréeʔe	to talk
iréʔtaa	to be mute
iríahi	to breath
iriígshi	to punish to scold
iróʔo	to exert force
irúʔta	disapprove
iruúhi	stand up
ixúaʔe	to be sick
ixúashi	to dress
iʔáadi	to throw at
magíi	to gamble
ob.xíc.he	to stub
oo.rée	to pass by; go beyond
abícga	moustache
abíiri	blood from the nose
agúxi	ears
apúhga	cap, hat
awáadi	sweat lodge
awáasha	beans
bashía	brace
baxuá	tan hides
biʔée	vapor
buʔée	steam
cagáaga	bird
caráa	grease
darúhdi	flatland
dibíhbi	marsh
garée	vomit
garée	rotten
gawíhga	sea gull
gogógshi	chipmunk
gogógshi	squirrel
idáaka	kettle
iráaxi	spirit
L´L	**Gloss**
a.bá	nose

a.dí.shi	smoke hole
a.gá.gi	to be able
agáhee	to accuse
a.gú.xaa	to be separated
a.hí.bi	to dig turnips
akú	bring something
a.rú.wi	notice
ca.gí.he	do skillfully
ca.gí.ria	to be particular
ci.gí.da	to be mushy
ci.xí	to threaten
ci.xí.hee	to frighten
cugí	to melt; to dissolve
cu.gí.hee	melt
cukée	to make something level
da.tá.he	to mistreat
dasháhi	slap
di.rí	to run
ga.cí	to cool off
ga.xú.kee	to fool
gi.dá.he	slaughter
gigúha	invite; call
giwéhe	to invoke
gixába	to go to bed
gu.ré	to keep
guréʔe	to keep
guká	about to happen
ha.shí.ce	infuriate
ha.shí.shi	to sting
hi.rá	to make
ho.bí.he	to cut a hole
igá	to jump
i.gú.ba	to be with someone
igupáa	to lay something flexible
i.rí.ci	to smell

i.rí.cii	to stink
i.shí.he	to ruin
idóhe	to disgrace
ixú	to be tired
ma.dú	to be
ma.kí	to get together
makíhe	to join
a.bí.sha	liver
a.dá.gi	corn (soft white)
abádaa	front of torso
adí	house
ará	hair
awá	earth
birága	ten
buxí	foam
dahú	thunder bird
gagíhi	circle
gagúwi	squash
hirú	bone
i.dí.pu	hill
icí	foot
irí	penis
irígi	leg
irú	flesh (meat)
ishdá	eye
xuh.dí	glove

´H	**Gloss**
áagashi	to write to draw
áag.cii.shi	to peek in to peer
ág.ci.xi	to jump at
ág.shua	to spit on
báa.hi	to sing
báh.xi.xi	to avoid
dáa.ri	to cross
ée.xe	to urinate
gáa.caa	to blow on
gáx.xee	to pile
gée.she	to look after
gíiria	to ride horseback
guúʔu	give
huá	to cough

húu	to come
iáka	Make fun
íhgeraa	to stretch ones limbs
ií.gaa	to see
íi.gi.gu	to hear
íi.gi.gua	hear; listen
íiguhba	to dislike hate
íirihee	borrow
íi.shi	to throw something away
íi.waa.re	to play a musical instrument
íigadia	to stretch out
íih.do	to be ashamed/to be embarrassed
íikaci	understand
íiwidia	to descend; to get on
íshge	to think about
maagaáhi	to pull on something
áa.ci.sha	udder
áakaahi	human ear
áashhi	horn; spoon
áa.shi	creek
áa.xuh.ga	kidney
ásh.shu	string
báx.xa	corner, bend
béeicga	raven bird
búa	rotten
búu.xa.ga	sand
búubudi	bubble
cáh.di	salve, ointment
cií.tac.gi	cougar
ciíc.ga	clan
éexe	urine
éʔgureʔ	brown bag
gíi.ra.bi	bull
góo.xaa.di	corn
gúu.wi.xi	wasp
hée.wi	vulture
íi.da	face
iídabaa	wildcat
íi.xa	a net

iígudi	wrist
íx.xi	forehead
bacgíria	cactus
´µ	**Gloss**
gíwahu	to ask a question
ákaahi	to take something with one
ákahi	bring to deliver
gácia	bloated
géʔe	scratch an itch
gírada	to like
gírashi	to love
gírura	go back after
háheeta	to divorce
hírami	to sleep
íhe	to apply paint
mí.da.ba	to tell a lie
mí.ri.di	fry; to broil
ná.ha.ree	to stand
ó.ka.daa	to get dressed
ópihe	catch an illness
ópe	influence
shhúwaa	slow
nudábi	to be tight
nadúxi	to break through ice
árashigia	curly hair
áwashi	cave; cellar
hú.ba	soup
LL´H	**Gloss**
adarúu	to get hurt
agadáari	to take out
agubáa	announcer
gadabáa	to be gentle; to be kind
gicawée	to become warm
girahíi	get up
giwaxúa	to drain
nagadáhdi	to be unstable
na.ga.shía	to be sheltered

a.wa.gáa	badger
a.wa.ría	ridge
a.wa.shíi	fog
gi.wa.géʔ	to invoke
ma.ci.dóo	awl
LL´L	**Gloss**
garapé	to remind
garawí	to remember
gicibí	to dive back
awadí	country
giruwí	count
ihobí	to be pleased
mashigá	gum
nagibí	to shave a stick
na.ga.pí	to pick out; to select
na.ha.ré	to stand
nah.gí.ci	to miss a shot/to strike and miss
miribí	bathe
mi.ra.bú	shrub
a.wa.dí	country
H´L	**Gloss**
abcá	to be sharp
agshí	to catch
bishdá	eye
gibcá	to skewer, not a needle
guxdí	to help someone
haxpí	to sneeze
ihgá	egg
iixí	forehead
ishdábi	eyebrow
ishgí	scale
ixbá	wing
ihcú	temple
noogdé	corpse
maapá	sunflower
nag.cá.daa	smash
nag.cá.rua	to skate; to slide
nag.dá.ree	to pound in; to get stuck
nah.xá.raa	to thresh

nah.xí.bi	to skin
nash.bí	finish talking
nash.kí	to weave
nax.pí	to knock down from a high place
nax.tí	crush
nuh.bí	to break off a part
nuh.cí	to get
nag.cú.di	to braid; to whip
nag.shá.gi	to split
nag.shú.di	slip out of place and drop
uuwági	bedding
maa.pí	cornball
nah.xúxi	to scrape; to shave
nuu.dí	to eat
nuu.gí.bi	to scrape

H´H	**Gloss**
agshiá	to capture
ashgóo	to limp
aʔrée	get after someone
gibcáa	lace
icxúugi	feather
ihcú	temple
iidáada	cheek
iishúudi	gums
iiʔóohi	accustomed to; used to
iiʔóowia	aim at
maa.ʔíi	fur
maa.ʔóo.tee	roach
maab.cúu	cholesterol bread
maah.shía	garbage
mag.shía	catch; trap
nacgíidi	to clip off
nag.cúa	mink
nag.cúu.di	to slip; to slide
nag.cúu.xi	to crush the hand
nag.shúu.gi	clear a field
nagcáa	shatter; to shatter
nagdíiwi	to ricochet

nagshía	to hook; to trap
nagshúa	dent
nagshúahe	to dent
nah.xáa	to sweep
nah.xóo.gi	to paddle
nah.xúa	to knock down
nii.sháb	to tell someone to hurry
nux.báa.ga	friend; people
nag.shíi.haa	to gush out
nah.xáh.xi	hump
maa.cáh.gi	window screen

LH´L	**Gloss**
dadaxxí	to make a clicking or tapping sound