YAQUI: A DOUBLE ALIGNED TROCHAIC FEET LANGUAGE

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1 INTRODUCTION

In this work we will be concerned with the acoustic realization of lexical level prominence in Yaqui, a language spoken in Sonora, as well as in Arizona. It has been said that Yaqui is a stress accent language (Langendoen & Munguía, 1996). Other researches hold that it is a pitch language (Demers et al. 1999). However our work shows that both single affiliations lack precision. Our analysis indicates that the data provide support for classifying Yaqui as a **mixed system language:** at foot level, the unmarked rhythm consists of a syllabic trochee [S W] and at pitch level, the unmarked pattern is [L H]. In that sense, we claim that the unmarked pattern of a lexical item consist of a **double aligned trochaic foot** requiring strong stress in the first syllable and a high tone in the second syllable. Under affixation, sometimes the double aligned trochaic foot is preserved, but sometimes it is realigned given rise to single aligned iambic feet or to single aligned trochaic feet. Therefore, Yaqui must be classified as a lexical stress-pitch language.

The term <<pitch>> accent, firstly proposed by Bolinger (1958), refers to the actual prominence in an utterance and a major cue to perception of stress. Gussenhoven (2004) (citing Beckman, 1986) argued that pitch accent (that is, a melodic accent) and stress accent (a dynamic accent) are different types of accent. Stress accent languages, as English or Spanish, use duration, intensity and vowel quality besides pitch height in order to differentiate stressed syllables from unstressed ones; in pitch accent languages, like Japanese, pitch change is the only acoustic cue to accent. Yaqui combines stress accent and pitch accent in lexical word formation.

The reminder of this paper is organized as follows: section 2 is a background about two previous alternative analyses for Yaqui (stress vs. pitch) accent prominences. Section 3 describes the methodology used in this study and the section 4 reviews its results. Section 5 discusses the acoustic realization of Yaqui prominence, and the way in which the current data provide support for classifying Yaqui as a mixed system language. Section 6 introduces some issues that must be investigated and section 7 presents the conclusions.

2. PREVIOUS STUDIES OF YAQUI PROMINENCE

Langendoen and Munguía (1996) proposed a stress accent analysis. They claim that lexical words always bear stress either on the first or second mora. They argue that a single bimoraic left headed foot is built from the left edge of Yaqui stems; i. e. a **trochaic foot**. And, for those words with stress on the second mora, they assumed an underlying iambic foot.

(1) Left edge stressed stems (trochaic feet)

káa	'not'
yúke	'rain'
tíwe	'to feel shame'.

(2) Right edge stressed stems (iambic feet)

biká	'rotten'
b^{w}ičía	'smoke'
taká	'body'

An identical analysis is assumed for tri-syllabic forms.

(3) First mora stress (trochaic feet)

táhori	'cloths'
námuke	'drunk'
húbare	'bat'

(4) Second Mora stress (iambic feet)

etého	'talk'
yoréme	'native person'
beméla	'young woman'

Finally, minimal pairs as those in (5a, b) are also assumed under the trochee and underlying iambic foot analysis.

(5) Minimal pairs

a.

káate	'build a house'
yóoko	'spotted'
téeka	'sky'

b.

kaáte	'go:PL'
yoóko	'tomorrow'
teéka	'lay down'

Demers, et al. (1999) proposed that high tone marks prosodic prominence in Yaqui words. They also claim that duration and loudness are of secondary importance. Their analysis maintain that a high tone occurs either on the first or second syllable of a word; when high tone is on the first, in isolated words, it spreads to the following vowels, when high tone is on the second syllable a low tone is present on the first.

(6) Initial vowel high tone — Second vowel high tone

a. bisyllabics

yécha	"wake someone up"	yená	"smoking"
kóche	"sleep"	tuká	"night"
táse	"coughing"	ye'é	"dance"
kári	"house"	hamút	"woman"

b. Trisyllabics and Longer

wásuktia	"year"	betchí'ibo	"for"
lóttila	"tired"	alléa	"happy"
híokole	"sorry"	hiápsi	"heart"

They also include classic minimal pairs to support their analysis.

(7) Initial vowel high tone — Second vowel high tone

téeka	"sky"	teéka	"lay down"
káate	"build a house"	kaáte	"walk"
yóoko	"spotted"	yoóko	"tomorrow"
wáate	"remember"	waáte	"others"

Summarizing, both analyses account for the same data. However, the difference is that the first authors consider, that Yaqui is a stress accent language and that duration and intensity are basic for foot formation; Demers et al (1999), on the other hand, assumed a pitch accent analysis where high tone is the principal cue for accent. In what follows, we will show that both analyses have some reason but both of them are missing something important that its opposite analysis has.

3. METHODOLOGY

3.1 Stimulus materials

The chosen words for this study contain the following syllable structures CV.CV, CV.CVC, CVV.CV, CVV.CVC and CV.CVC.CV. The target words were recorded in isolation and they also were embedded in sentences. Most of the recorded data consist of nouns and verbs, but sometimes adjectives and adverbs were considered.

3.2 Participants

The data were obtained from two native speakers (male and female). They are 20 and 25 years old respectively. Most of the data shown in this talk come from the male native speaker. He was born in Vicam and she is from Torim, both communities in Sonora, México. Both of them speak a fluent Spanish and they are students at the Universidad de Sonora and at the Escuela Normal del Estado, respectively.

3.3 Recording

Participants were recorded in the phonetic lab at the Universidad de Sonora using the Kay Elemetric Computerized Speech Lab (CSL) 4500 with a Shure SM10A professional unidirectional microphone.

The participants were asked to pronounce a given word three times in a natural rate with an interval of 5 seconds approximately between each repetition. Then they were asked to use that word in a given context.

3.4 Measurements.

Length of the vowel, energy or intensity and fundamental frequency were considered for this analysis.

4. DATA

4.1 The vocalic segments

It has been assumed that Yaqui has the following vowel system (D&C:

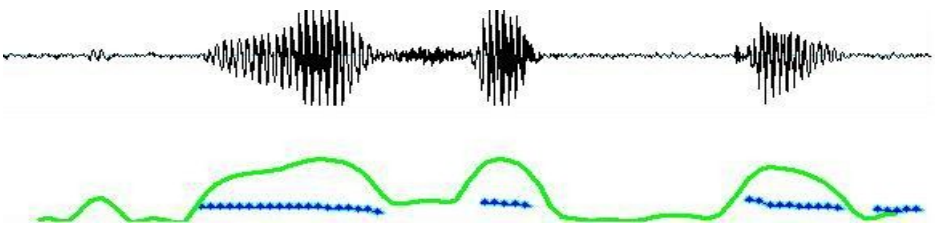
i i: u u:

e e: o o:

a a

However, phonetically we can speak of the 4 different length-size vowels.

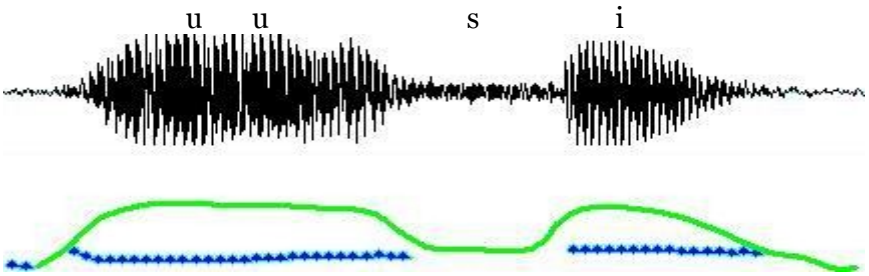
A typical short vowel as shown in figure [1] for *musukte* "bend down" (0.078 msc, for the first vowel).



Length	0.078	0.065	0.080
Hz	126.8	**143.07**	132.5
Db	**77.13**	76.68	72.11

Figure [1] Waveform intensity and F0 track spectrogram of *musukte* "bend down"

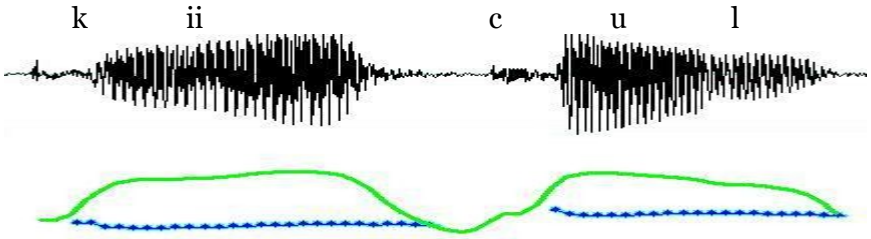
A typical long vowel, as in *uusi* "boy" (length 0.256 msc):



Length	0.256	0.143
Hz	133.1	**159.9**
Db	**77.45**	75.65

Figure [2] Waveform intensity and F0 track spectrogram of *uusi* "boy"

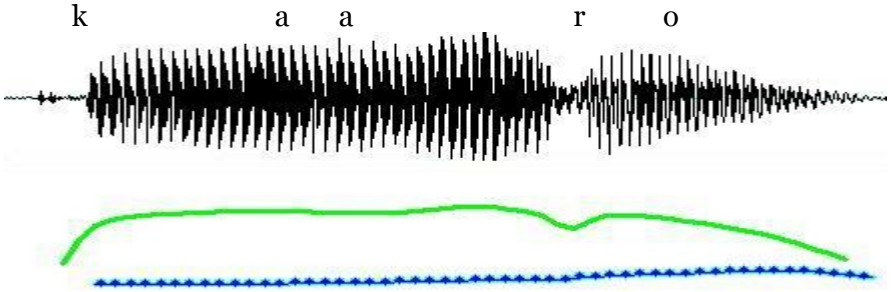
However, there are also some semi-long vowels which are longer than phonemic short vowels but shorter than the long ones, as the *i* in *kiicul* "cricket" (0.179 msc).



Length	0.179	0.085
Hz	144.23	**191.98**
Db	81.83	**81.98**

Figure [3] Waveform intensity and F0 track spectogram of *kiicul* "cricket"

Furthermore, in borrowed words, the first vowel of disyllabic words is longer than phonemic long vowels, as we can see in the graph for "car". This can be considered an extra-long vowel (0.305 msc).



Length	0.305	0.137
Hz	130.6	**159.4**
Db	**82.4**	78.8

Figure [4] Waveform intensity and F0 track spectogram of *kaaro* "car"

In spite of those differences in length, we did not found evidence by now that lengthiness is an important cue for accent. If we look at the Db and Hz values in fig. 1,

2, and 4, in the previous examples, we can see that all they have the same accent pattern: SW at the stress (Db) tier and LH at the pitch (Hz) tier. The figure 3 has a different pattern (iambic foot), but we are going to see in the analysis that it is not related to lengthness.

4.2 The prosodic prominences.

At the beginning, the recording data was selected based on its structure. We choose nouns and verbs with similar structures. However, after an initial analysis the organization of data took a different form: they were classified according to two different constraints over prosodic prominence: the [S W] or [WS] stress and the [HL] or [LH] tone requirement. For that reason, the data shown through this paper will be described considering stress prominence (based on energy/intensity) and pitch accent prominence (based on F0 track). The kind of lexical representation that we will use in this work appeal to these two tiers, as shown in (8)

(8)
[S W] foot tier
CVCV
[L H] pitch tier

5. ANALYSIS

The following table is a summary of the findings in the analysis of Yaqui lexical words. It indicates the kind of analyzed structures and the type of word category that the items belong to. It also shows the type of required foot considering both: stress and pitch. The first column is most abundant than others, it contains verbs and nouns and can be considered the unmarked pattern of Yaqui lexical words. These words align S to the left edge and H to the right edge, forming what we call **double aligned trochaic feet** (see the representation in (8)). The second column contains only nouns. They have aligned to the right edge both prominences (S and H). Therefore, they are called **single aligned iambic feet**. The third column contains few verbs and one adjective. All have aligned both prominences (S and H) to the left edge and consist of **single aligned trochaic feet**. The fourth column is empty because we did not attest any form fixing that logical possibility: **double aligned iambic feet**. The glosses are given along the sections of analysis.

PROMINENCES								
	Double aligned trochaic foot **S W** **L H**		**Single aligned iambic foot** **W S** **L H**		**Single aligned trochaic foot** **S W** **H L**		**Double aligned iambic foot** **W S** **H L**	
STRUCTURES	VERBS	NOUNS	VERBS	NOUNS	VERBS	NOUNS/ADJ	VERBS	NOUNS
CVCV	koce tase yena	teta heka		yeka				
CVCVC	nenka			batat teput				
(C) V_1V_1CV	miika yeewe	kaari		uusi aaki naamu	beete			
CV_1V_1CVC		haamut wiikit		kiicul baakot				
(C) V_1V_2CV					euse	siari		
C V_1V_2CCV		hiapsi			hioste			
CVCVCCV	tohakta musukte							
CV'V	ke'e he'e ye'e							

Table (1). A summary of the data and their respective prominences.

The above lexical items show that there are two important facts to consider in a relevant analysis of word structure formation: the rhythm of the language and the central role of pitch.

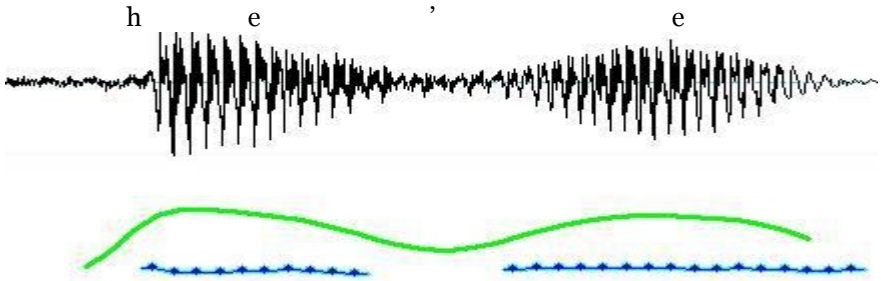
5.1 The double aligned trochaic foot pattern:

The analysis of bi-syllabic words indicates that most of them have a dual requirement: At foot level the unmarked rhythm of the language is trochaic: therefore a [S W] foot is required. At pitch level a sequence L H is demanded. So, a Yaqui single verb can be represented as seen in (9). On the representation there is a foot tier and a pitch tier. The structure represents what we call a double aligned trochaic foot. The left edge must contain a stressed syllable and the right edge must contain a syllable with a high tone. In other words, both edges are prominent:

(9) [S W] foot tier
he'e 'drink'
[L H] pitch tier

The following spectrogram of the word in (9) shows this double requirement. In the representation, the upper (green) line indicates energy, the acoustic correlate for stress in Yaqui, whereas the lower (blue) line indicates F0 track, the acoustic correlate of

pitch. The measures correspond to the nucleus of each syllable. In this case, stress prominence is found in the first syllable (79.1 Db) whereas the pitch prominence is located in the second syllable (151.5 Hz). This pattern, being the most common in Yaqui lexical words, can be considered the unmarked one:



Length	0.093	0.104
Hz	142.1	**151.5**
Db	**79.1**	77.5

Figure [5] Waveform intensity and F0 track spectrogram of *he'e* 'drink'

The analysis of lexical words in this group shows that we can find several structures (see table 1). The obtained measures indicate that vowels in (10a) are short, their length is among .060 and .090 ms, whereas those in (10b) are longer than those in (10a), they are around 0.150-200ms long. The examples in (10c) are cases of words which bear a frozen, unproductive, affix; the first syllable vowel is long, they are among 0.120 and 0.140ms. We consider important to observe that in these two particular cases the last consonant of the word is almost unperceived for hearers. Finally, in (10d, e) are verbs with clearly short vowels. Given these measurements, we conclude that length is not relevant for a double aligned trochaic foot formation.

(10) Words with the double align foot pattern:

	Verbs		Nouns	
a.	koce	'sleep'	teta	'rock'
	tase	'cough'	heka	'wind'
	yena	'smoke'		
b.	miika	'give'	kaari	'house'
	yeewe	'play'		
c.			haamut	'woman'
			wiikit	'bird'
d.	ye'e	'dance'		
	ke'e	'bite'		
	he'e	'drink'		
e.	tohakta	'rebound'		
	musukte	'bend down'		

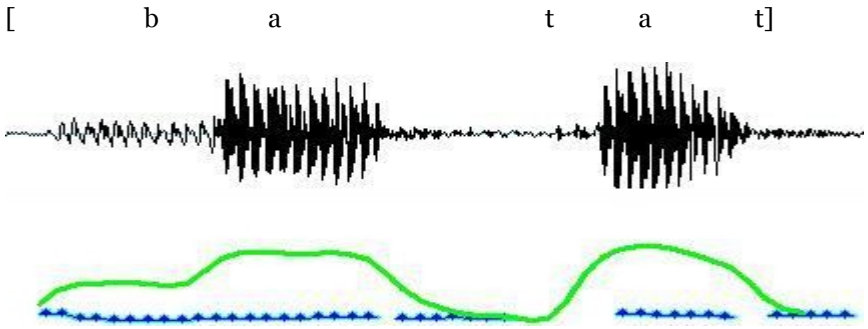
Other disyllabic words with a double aligned foot pattern are verbs like *chepte* "to jump", *noka* "to talk", *cae* "to shout", among others.

5.2 The single aligned iambic foot pattern.

On the other hand, only some lexical words have single aligned iambic structures, as indicated in (11). We can see that they are nouns and adverbs, as seen in the examples on table (1). We did not attest any verb with this lexical pattern.

	[W S]	foot tier	
(11)	b a t a t		'frog'
	[L H]	pitch tier	

The next spectrogram illustrates the stress prominence, indicated by an intensity of 79.58 db, and pitch prominence, indicated by F0 which has a value of 132.65 hz. Both prominences are aligned to the right edge of the lexical word.



Length	0.095	0.082
Hz	124.65	**132.65**
Db	78.78	**79.58**

Figure [6] Waveform intensity and F0 track spectrogram of *batat* 'frog'

The analysis of words with this iambic pattern gave the following results. As we can perceive in (12), the first syllable vowel for examples in (12a,b) is short, but for examples in (12c,d) the vowel is long. However the long vowels in (12c) are longer than those in (12d); the first ones are around 0.240-0.260 ms long whereas the vowels in (12d) are 0.170-0.190 ms long. At this point, and considering this result we reaffirm the view that intensity and pitch but not lengthening is important for stress placement.

(12) Words with strong syllable at the right edge (iambic feet)

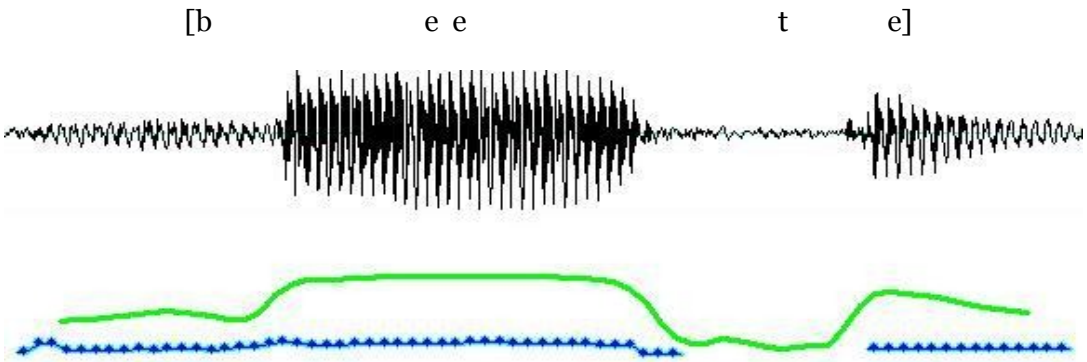
a.	yeka	'nose'
b.	batat	'frog'
	teput	'louse'
c.	uusi	'boy'
	aaki	'pithaya'
	naamu	'cloud'
d.	kiicul	'cricket'
	baakot	'snake'

5.3 The single aligned trochaic foot pattern

As seen in the examples in table (1), there are some structures which have single aligned trochaic feet. Although the attested words are now lexicalized, they seem to be historically derived. They end in the suffix *–te* wich is a verbalizer, the suffix *–se* which is an andative (SG) and the suffix *-ri* which is a nominalizer. In that sense, we can claim that most words following this pattern are derived in the language. The evidence for this claim will be shown in the section about minimal pairs. The representation of a word with a single aligned trochaic foot is given in (13).

	[S W]	foot tier	
(13)	b e e t e		"burn"
	[H L]	pitch tier	

The spectrogram of this word shows that stress prominence (78.97 db) and high pitch prominence (133.4 hz) are located in the first syllable.



Length	0.228	0.074
Hz	**133.4**	120.4
Db	**78.91**	72.51

Figure [7] Waveform intensity and Fo track spectrogram of *beete* "burn"

The other attested examples under the same pattern are verbs like *hioste* 'write' and *euse* 'hide' and the adjective *siari* 'green'. All these cases have either a long vowel or two different vowels in the same syllable.

5.4 The Double aligned iambic foot pattern.

The fourth logical possibility, the mirror image of the double aligned trochaic foot seen in (9), was not attested. In other words, we did not attest any structure with a stressed syllable in the right edge and a left syllable containing a H tone: a double aligned iambic foot. The representation is indicated in (14).

	[W S]	foot tier
(14)	*CVCV	
	[H L]	pitch tier

5.5 The double aligned trochaic foot under affixation.

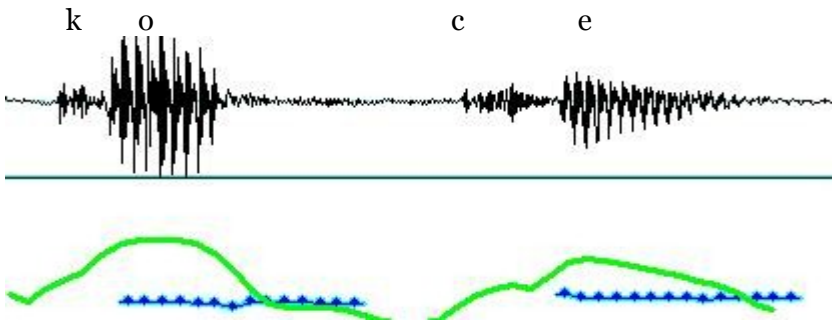
In this section we show the effect of affixation over some lexical Yaqui words containing double aligned trochaic feet. We give evidence here that a double aligned trochaic foot can be preserved, can become a single aligned trochaic feet (with stress and high pitch in the first syllable) or can become a single aligned iambic feet (with stress and high pitch in the second syllable).

5.5.1 Preservation of a double aligned trochaic foot.

Under affixation, some lexical words formed by a double aligned trochaic foot tend to preserve the double aligned trochaic foot by dropping a root final vowel. In such a case, stress is in the first syllable and the high pitch is in the second, as indicated in the next representation:

	[S W]		[S W]	foot tier
(15)	k o c e	→	kot-ne	
	[L H]		[L H]	pitch tier
	'sleep'		'will sleep'	

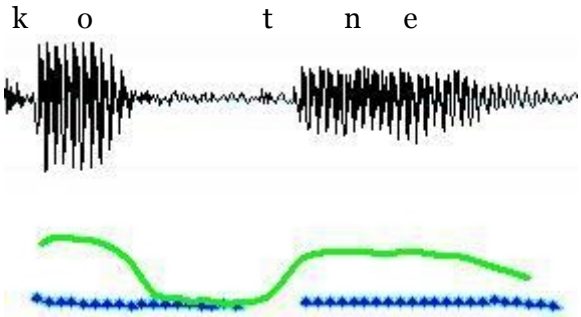
The spectrograms of these forms are shown in what follows. The spectrogram of *koce* 'sleep' has a first syllable with 77.89 db and a second syllable with 149.8 hz. It is clearly a double aligned trochaic foot.



Length	0.059	0.065
Hz	136.2	**149.8**
Db	**77.89**	70.22

Figure [8] Waveform intensity and F0 track spectrogram of *koce* "sleep"

By other hand, the spectrogram of *kotne* 'will sleep' shows that the double aligned trochaic foot is preserved: the first syllable has a stress of 77.84 db and the second one a pitch of 130.86 hz.



Length	0.089	0.096
Hz	127.93	**130.86**
Db	**77.84**	72.94

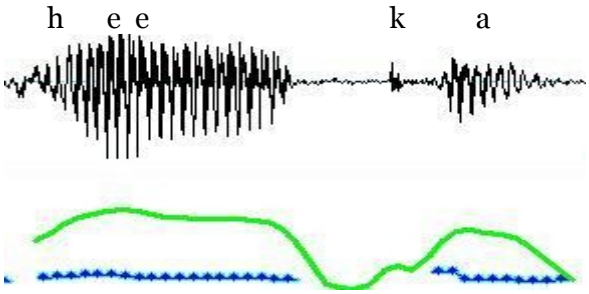
Figure [9] Waveform intensity and F0 track spectrogram of *kotne* "will sleep"

5.5.2 Derivation of a single aligned trochaic foot.

However, there are cases where the prominences of a double aligned trochaic foot are realigned and result in a single aligned trochaic foot. In the following example what is lost is the glottal consonant. The high tone remains in the root. And the result is a trochaic foot with stress and high tone in the fist syllable.

	[S W]		[S W]	foot tier
(16)	he'e	→	heeka	
	[L H]		[H L]	pitch tier
	'drink'		'drank'	

The spectrogram of *he'e* 'drink' was given in the figure 5. The spectrogram of *heeka* 'drank' is shown below (figure 10). The measures indicate that the first syllable has both prominences: 79.50 Db and 125.27 Hz. It is a single aligned trochaic foot.



Length	0.147	0.066
Hz	**125.27**	119.88
Db	**79.50**	72.27

Figure [10] Waveform intensity and F0 track spectrogram of *heeka* 'drank'.

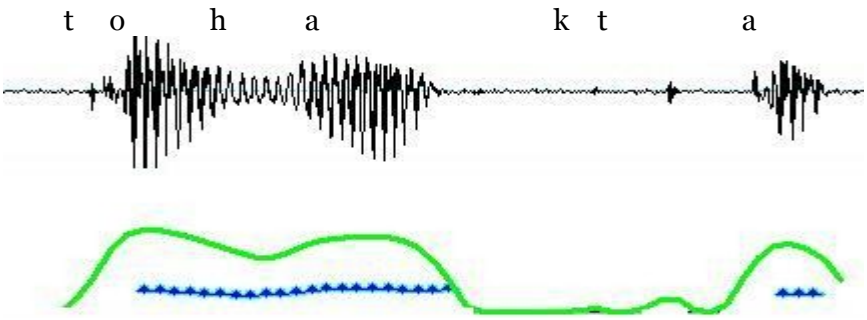
5.5.3 Derivation of a single aligned iambic foot.

The double aligned trochaic foot, under affixation, can give rise to single aligned iambic feet. We use reduplication as evidence for this claim and as a support that the language appeals to feet in some lexical processes. There are some tri-syllabic words that require

the reduplication of a CVCV foot for marking habitual. The analysis of the following example indicates that the prominences realign producing single aligned iambic feet, as indicated in the representation in (17)

	[S W] W		[WS]-[W S] W	foot tier
(17)	tohakta	→	toha- tohakta	
	[L H] L		[LH]-[L H] L	pitch tier
	'rebound'		'rebound habitually'	

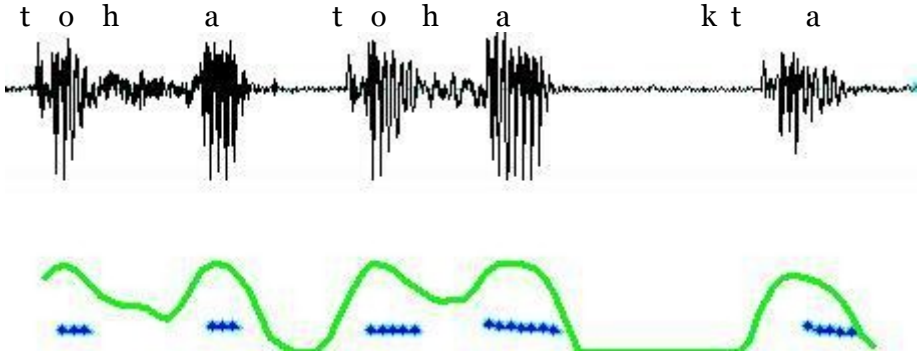
The spectrogram for *tohakta* 'rebound' shows the stress prominence in the first syllable (76.82 Db) and the higher pitch prominence in the second syllable (142.3 Hz). The final syllable has the lower measures in Db (72.26) and in Hz (127.19). Therefore, the structure of this try-syllabic word is based in a double aligned trochaic foot.



Length	0.077	0.072	0.047
Hz	130.6	**142.3**	127.19
Db	**76.82**	76.1	72.26

Figure [11] Waveform intensity and F0 track spectrogram of *tohakta* "rebound"

When reduplicated, the prominences in *toha-tohakta* 'habitually rebound' realign as shown in the spectrogram. The measures indicate that we have single aligned iambic feet: the first syllable has lower values (74 Db, 126.5 Hz) than the second one (75.28 Db, 136.8 Hz) and the third has lower values (74.64 Db, 127.98 Hz) than the fourth 75.86 Db, 133.69 Hz). The final syllable has low values (71.86 Db and 129.02 Hz) and it is left unparsed. Note that if we parse the syllables from right to left we can suggest that the language build single aligned trochaic feet, leaving unparsed the first syllable. However, the evidence that it is the final syllable and not the first one which is left unparsed comes from the reduplication of CV that we are going to see in the analysis of the minimal pairs in the next section and the analysis of tri-syllabic words like *tohakta* 'rebound' above which left unparsed the last syllable.



Length	0.045	0.053	0.057	0.064	0.063
Hz	126.5	**136.8**	127.98	**133.69**	129.02
Db	74.31	**75.28**	74.64	**75.86**	71.86

Figure [12] Waveform intensity and Fo track spectrogram of *tohatohakta* "habitually rebound"

5.6 The Minimal Pairs in Yaqui.

As seen before, there are Yaqui classic minimal pairs and it is worth to analyze them. The results indicate that pitch is central in the understanding of Yaqui prosody. The spectrograms show that the set A is conformed by double aligned trochaic feet (the unmarked pattern in Table (1)), whereas the set B adjusts its structure to single aligned trochaic feet. The traditional way to mark the difference is indicated in (18) (although the spectrogram indicates that the difference is found in the final syllable, not in the first one).

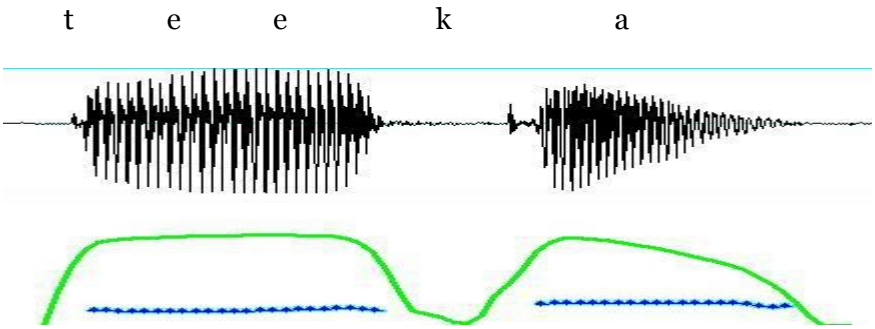
(18) Minimal Pairs

Set A		Set B	
kaáte	'go:PL'	káate	'build a house'
waáte	'others'	wáate	'remember'
yoóko	'tomorrow	yóoko	'tiger/spotted'
teéka	'lay down'	téeka	'sky'

The spectrograms below show that the difference in meaning is given by the location of high pitch. In that sense, pitch is phonological and stress is only part of a rhythm device. Both spectrograms have a similar [S W] tier. Their representations are given in (19):

	Set A		Set B	
	[S W]	foot tier	[S W]	foot tier
(19)	teeka	'lay down'	teeka	'sky'
	[L H]	pitch tier	[H L]	pitch tier

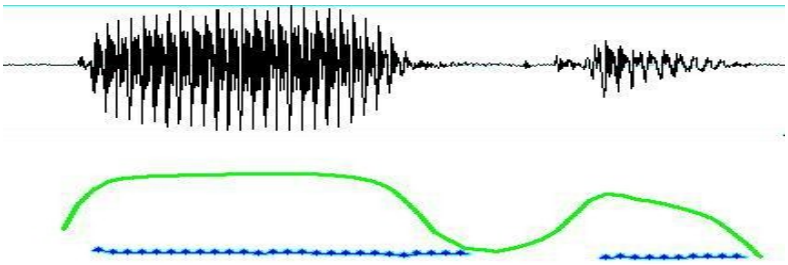
The spectrogram of *teeka* 'lay down' indicates that the first syllable has the stress prominence (84.25 Db) whereas the second syllable contains the pitch prominence (147.38 Hz). Therefore it is a double aligned trochaic foot.



Length	0.209	0.137
Hz	122.94	**147.38**
Db	**84.25**	81.17

Figure [13] Waveform intensity and F0 track spectrogram of *teéka* 'lay down'

By other hand, the spectrogram of *teeka* 'sky' indicates that the first syllable has both prominences (84.25 Db) and (117.78 Hz). Therefore, it is a single aligned trochaic foot.



Length	0.212	0.085
Hz	**117.78**	103.92
Db	**84.25**	74.76

Figure [14] Waveform intensity and F0 track spectrogram of *téeka* 'sky'

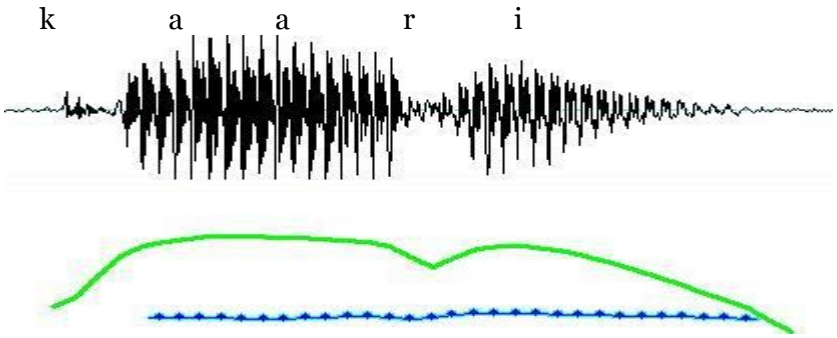
5.6.1. Some minimal pairs in the set B are derived.

Our analysis of minimal pairs gives evidence that at least some words in the set B are derived. A derivation is represented in (20): a double aligned trochaic foot becomes a single aligned trochaic foot, the spectrograms of (20b) were shown in figures (5) and (10) and the spectrograms of (20a) are shown below in Figures (15) and (16).

		[S W]	[S W]
(20)	a)	kaar i →	kaate
		[L H]	[H L]
		'house'	'build a house'

	[S W]	[S W]
b)	he'e →	heeka
	[L H]	[H L]
	'drink'	'drank'

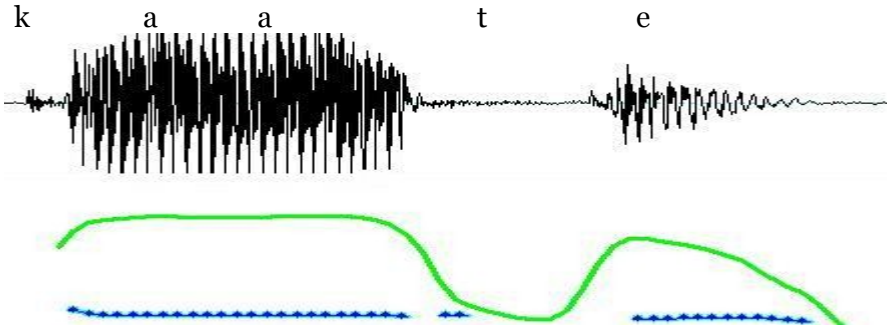
The spectrogram of kaari 'house' indicates that the first syllable contains the higher stress prominence (81.76 Db) whereas the second syllable has the higher pitch prominence (135.7 Hz). It is what we call a double aligned trochaic foot.



Length	0.130	0.085
Hz	126.73	**135.7**
Db	**81.76**	77.66

Figure [15] Waveform intensity and F0 track spectrogram of *kaari* 'house'

When affixed, by the suffix *–te* 'verbalizer', the verb becomes a single aligned trochaic foot. Both prominences are in the first syllable (86.88 Db and 117.17 Hz).



Length	0.230	0.121
Hz	**117.17**	107.73
Db	**86.88**	76.67

Figure [16] Waveform intensity and F0 track spectrogram of *kaate* 'build a house'

The fact that some minimal pairs are derived in the language explains why they behave different under reduplication. Next section focuses those differences.

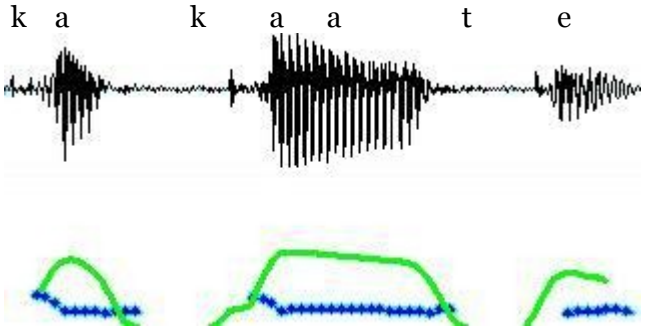
5.6.2. The reduplication of minimal pairs.

In the figure (16) we saw that the derived verb becomes a single aligned trochaic foot. The analysis of CV reduplication (it indicates habitual) applied to this stems indicates

that reduplication preserves the trochaicity of the derived verb. In such a case we can see that the CV reduplicant bears low tone and weak stress. The representation is given in (21).

	[S W]		W [S W]
(21)	kaate	→	ka-kaate
	[H L]		L [H L]
	'build a house'		'habitually build houses'

The spectrogram of *kakaate* 'habitually make houses' is shown below. All these words (set B) have the same reduplication pattern. The root has the same single aligned trochaic feet than the non reduplicated form (see (21)). The reduplicant has weak stress (69.65 Db) and low pitch (117.6 Hz). The initial syllable of the base is stressed (73.31 Db) and contains high pitch (121.84 Hz). The base preserves the long vowel. The structure is not a single aligned iambic feet (formed by the reduplicant and the initial syllable of the base) because examples like (22) indicate that the reduplicant CV in these verbal structures does not count for foot formation.



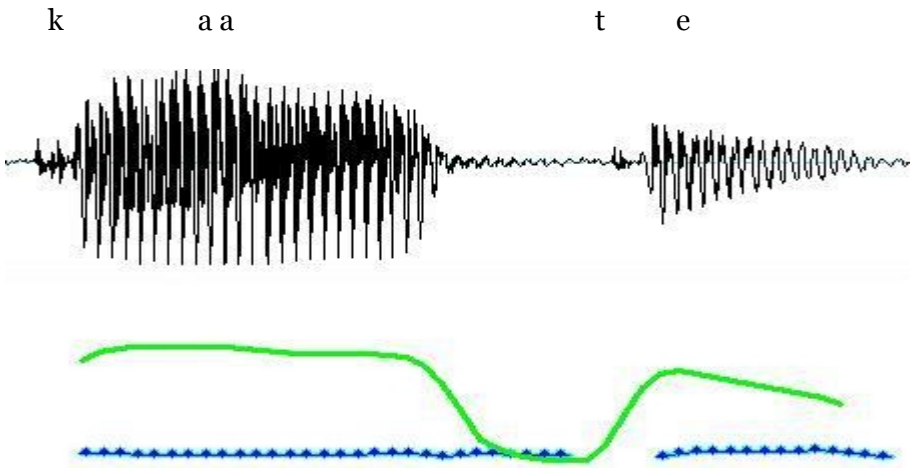
Length	0.570	0.154	0.063
Hz	117.6	**121.48**	119.05
Db	69.65	**73.31**	67.27

Figure [17] Waveform intensity and F0 track spectrogram of *kakaate* 'habitually build a house'.

By the other hand, the reduplication of words in the set A shortens the long vowel of the base. The non reduplicated verb consists a double aligned trochaic foot. The reduplication process forces the realignment of prominences and we get in this case a single aligned iambic feet. The representation of the change is given in (22). Observe that the sequence of two week syllables in the reduplicated form tells us that the foot is formed over the base.

	[S W]		W [W S]
(22)	kaate	→	ka-kate
	[L H]		H-[L H]
	'go:PL'		'HAB-go:PL'

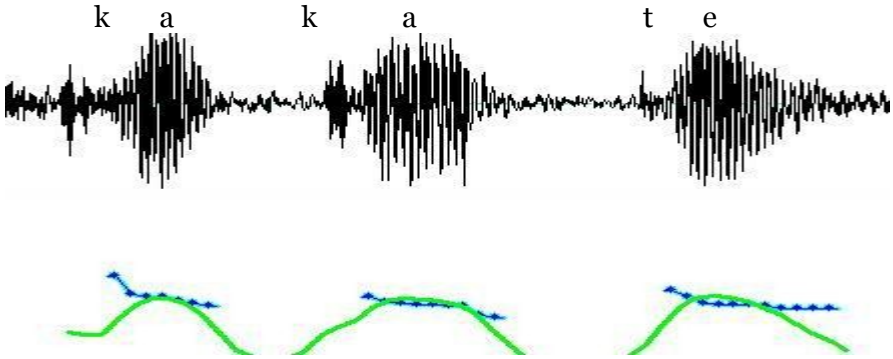
The spectrograms are the following. *kaate* 'go: PL' shows stress in the first syllable (80.71) and high pitch in the second (126.52). It is a double aligned trochaic feet.



Length	0.157	0.122
Hz	120.96	**126.52**
Db	**80.71**	72.99

Figure [18] Waveform intensity and F0 track spectrograms of *kaate* 'go:PL' and

However, the measurements in the reduplicated form kakate 'habitually go:PL' indicates how the interaction of pitch and foot formation produces iambic feet where the stress and the high tone coincide in the final syllable of the base syllable (67.06 Db) and (214.79 Hz).



Length	0.059	0.067	0.065
Hz	**225.27**	213.89	**214.79**
Db	66.14	66.23	67**.06**

Figure [19] Waveform intensity and F0 track spectogram of *ka-kate* 'Habitually go:PL'

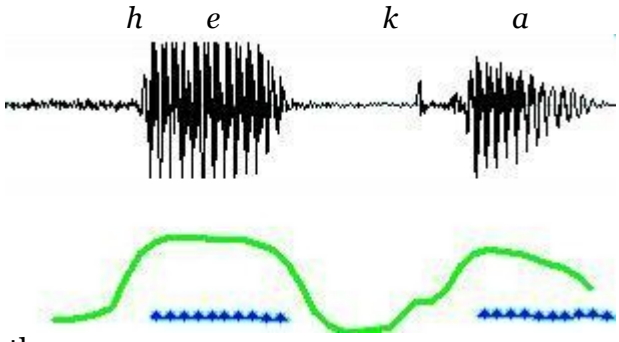
5.7 Some predictions within the language.

In this section we introduce additional examples that support our analysis and that indicate that footing is important in the language. We have seen in (16) and in figure

(10) that *heeka* 'drank' (set B) is a derived single aligned trochaic foot. Therefore, it must contrast with *heka* 'wind' (set A) which must be a double aligned trochaic foot. The representation of *heka* 'wind' is shown in (23) and its spectrogram in figure (18). It indicates that the prediction is correct.

	[S W]	
(23)	heka	'wind'
	[L H]	

The spectrogram shows that the first syllable is stressed (81.65 Db) and that the second has a high tone (132.41 Hz).



Length	0.094	0.075
Hz	127.33	**132.41**
Db	**81.65**	76.19

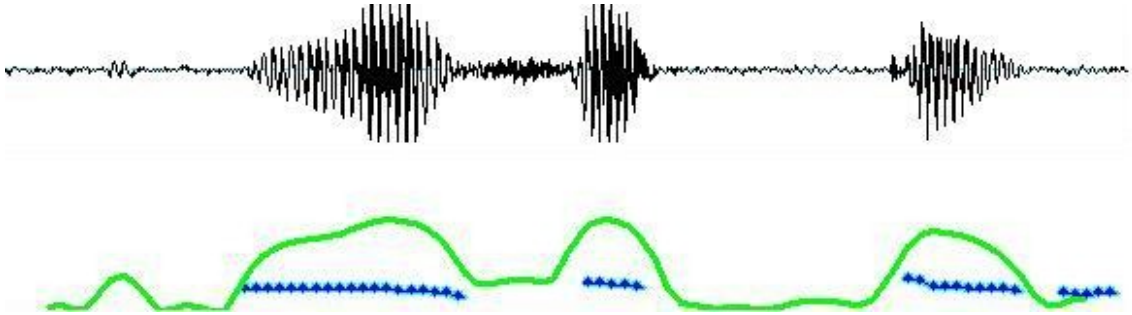
Figure [20] Waveform intensity and F0 track spectrogram of *heka* 'wind'

However, from the structure of words such as *tohakta* 'rebound' and its reduplication toha-tohakta 'habitually rebound' analyzed in (17) and its spectrograms in figures (21) and (22), we predict that a word like *musukte* 'bend down', will have the same behavior when reduplicated. Although the base consists of a double aligned trochaic feet, the reduplication does not change to a chain of single aligned iambic feet. Instead, we can observe that the reduplicated form consist of two double aligned trochaic feet. In addition the last syllable is the weaker one (Db), but it has the higher pitch in the row. Therefore, we need to study carefully the conditions that produce this different pattern. By now is important to point out that the pitch tier goes up and down showing that foot formation is playing a role in the language.

	[S W] W	[S W] [S W] W
(24)	musukte →	musu-musukte
	[L H] L	[L H]-[L H] H
	'bend down'	'habitually bend down'

The spectrogram of *musukte* 'bend down' confirms that it is a double aligned trochaic foot (first syllable (77.13 Db), second syllable (143.07 Hz)).

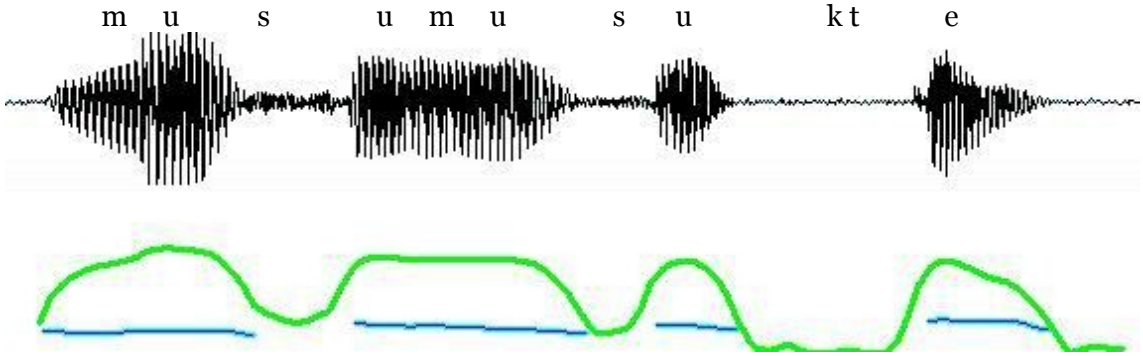
m u s u k t e



Length	0.078	0.065	0.080
Hz	126.8	**143.07**	132.5
Db	**77.13**	76.68	72.11

Figure [21] Waveform intensity and Fo track spectrogram of *musukte* 'bend down'

The spectrogram of *musu-musukte* 'habitually bend down' indicates that the higher stress is in the initial syllable of the reduplicant. The values in Db go down until the last syllable. However, we can think that footing is taking place because the pitch goes up and down and the syllable in the left edge of a foot is strong compared with the second syllable in the same foot.



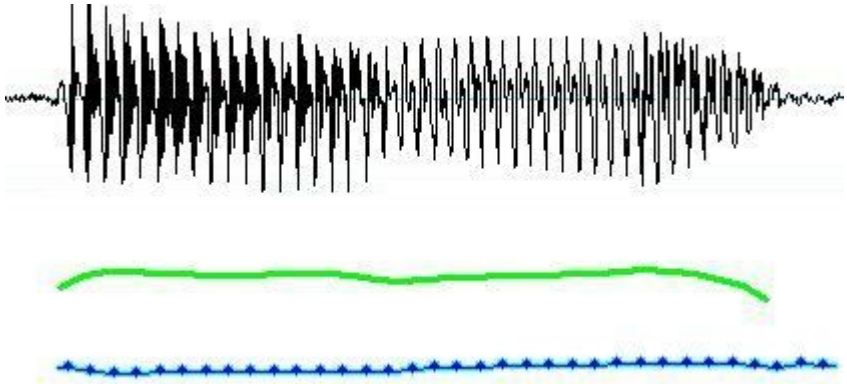
Length	0.071	0.063	0.087	0.067	0.075
Hz	131.54	**147.28**	135.36	**144.48**	**158.85**
Db	**81.5**	78.57	**77.55**	76.57	75.18

Figure [22] Waveform intensity and Fo track spectrogram of *musumusukte* "habitually bend down"

6 Some final notes.

At this point we want to make some observations. First, some words like *hamut* 'woman' seem to be in a process of readjustment. We get it from our female consultant with stress and high pitch in the final syllable (single aligned iambic foot). However, it is a double aligned trochaic feet with our male consultant. But in this case, as we can see in the spectrogram, the difference in Db is really small. This type of words contain an historical suffix. So the hypothesis is that they were affixed with the suffix –t 'absolutive' became single aligned iambic feet and now are in process of change to the unmarked double aligned trochaic feet. We leave this for future research.

h a a m u **t**



Length	0.121	0.068
Hz	131.27	**147.59**
Db	**80.96**	80.77

Figure [23] Waveform intensity and F0 track spectogram for *hamut* "woman"

Second, our overall analysis of the language makes us to fell the need of more deeper studies on vowel duration. From words like those in (25) we know that lengthening is distinctive in the language, but it is possible that it may be relevant for stress and tone distribution beyond lexical level.

(25)

Short vowel		Long vowel	
ta'a	"to know"	taa'a	"sun"
sawa	"leaf"	saawa	"root (of a plant)"

7 CONCLUSIONS

In this work we have shown that stress prominence and pitch prominence are both relevant in Yaqui. Stress prominence is basic at morphological level because the prominences readjust according to principles of foot formation. Pitch prominence is important also because it is a distinctive feature in the language, as indicated by the classical Yaqui minimal pairs seen in (18).

We are proposing, and presenting evidence, that there are three different patterns for these two prominences. An unmarked and non-derived pattern, where most of the Yaqui words fall in. We have called it a double aligned trochaic foot. There are two marked patterns: a single aligned trochaic foot and a single aligned iambic foot. The fourth logical possibility: the double aligned iambic foot was not attested in the language. The next table summarizes the proposal and the findings.

UNMARKED	MARKED	UNATESTED
DOUBLE ALIGNED TROCHAIC FOOT S W L H	**SINGLE ALIGNED TROCHAIC FOOT** S W H L	**DOUBLE ALIGNED IAMBIC FOOT** W S H L

	SINGLE ALIGNED IAMBIC FOOT W S L H	

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