A study of stress in connected speech in Banawá, a language of the Amazon

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1. Introduction

In this paper I argue that stress patterns in connected speech in Banawá do not correlate precisely with those illustrated by Buller, Buller & Everett (1993) in which isolated words were studied. It is important to note that the purpose of this paper is not to propose a new overall analysis but to describe in more detail the acoustic correlates of stress and to look at, in more depth, stress in connected speech using the conclusions already established by Buller, Buller & Everett (1993). Should the hypothesis proposed above be proved it will have interesting implications for future comparisons of stress patterns in connected and isolated speech both in Banawá and other languages. It will also give linguists working on Banawá a greater insight into the way in which the language is structured and the way in which listeners process speech. I also hope to gain a greater understanding of the role played by stress in speech processing. Finally, I intend to give an overview of the phonological constraints regarding stress placement in Banawá using Optimality Theory, a brief description of this theory is given in section 4.

This paper will be organised into several sections. Section 2 will describe the methodology used in researching the paper and give some background information regarding the study of stress patterns in Banawá. An overview of the language and culture of the tribe will also be presented. The acoustic analysis in section 3 will look at stress patterns within the data in relation to the duration of sound, pitch, amplitude and vowel quality. In section 4 the apparent phonological constraints regarding stress placement in Banawá will be analysed using Optimality Theory. The paper will be concluded in section 5 in which I shall give an overview of the findings, their implications and discuss any work that could be carried out in light of this paper.
2. Background and Methodology

Banawá is an endangered language that is spoken in the Brazilian Amazon by approximately 70 people (1994 SIL ethnologue). The language is a member of the Arawak family and is a dialect of Madi. The three Madi dialects, Jarawara, Jamamadi and Banawá share approximately 95% of their vocabulary, have similar grammars and consequently are mutually intelligible. Some speakers of Banawá are bilingual in Brazilian Portuguese and Jamamadi; however in general the Banawá prefer to use their own language (SIL ethnologue). Despite this preference, Banawá is still considered to be an endangered language.

Investigations into the syllable structure and stress patterns of Banawá have been carried out, most notably by Boiler, Buller & Everett (1993) and Ladefoged.
Ladeoged & Everett (1997). By analysing isolated words, these papers established that Banawâ only allows 2 types of syllables, CV and CVV. Each vowel is associated with one mora and therefore each syllable contains either one or two moras. This also demonstrates that there are no consonant clusters found in the language (Ladeoged, Ladeoged & Everett 1997:105-106). Since Banawâ only uses CV and CVV syllables, all syllables in Banawâ are open and, consequently, there are no syllable codas found in the language (Everett 1996:29). Onsets are obligatory and therefore there are no word initial vowels, except where extraprosodically occurs (see below).

The work of Halle & Vergnaud (1987) is particularly useful when studying Banawâ foot constructions and stress assignment. The model proposed in their work assigns a metrical grid to a word or phrase and then assigns stress at the first level and groups these stressed syllables into feet on the next level, if the word contains more than two syllables. This continues until the entire word or phrase is parsed as can be seen in example 1:

1. *line*rifai'bu**ne* "you are going to work"
   (*)(**)(*) Line ø
   *     * Line 1

From this example it is possible to derive a stress algorithm (Bullier, Buller & Everett 1993:288-289).

a. For each segment dominated by a vowel mark a * in line ø
b. From left to right group line ø *s into binary left headed feet (a trochaic pattern).
c. (If required project the heads of the pattern in line ø to line 1).
All syllables are constrained by a sonority sequence, which dictates that “adjacent segments must not have the same sonority value” (Bulter, Bulter & Everett 1993:262). The sonority sequence is based on the following hierarchy:

2. [+high -cons] > [+high -cons] > [+cons]

Within isolated words stress is binary and uniquely trochaic, meaning that every other vowel is stressed from left to right in a ‘strong weak’ pattern. Extraprosodic sounds, by definition, are not stressed and are not included in this stress pattern, for example if a word begins with an extraprosodic vowel then this syllable is not counted and stress is applied to the second syllable and every other syllable after that (Bulter, Bulter & Everett 1993:287).

3. u’dainu’ku u’dainu’ku hana “She picks up the seed that is open”

There are two types of extraprosodicity in Banawá, word final /* and word initial vowels when words are more than three moras in length (Ladevoged, Ladefoged & Everett 1997:107). As a result of this extraprosodicity, CVVV syllables can occur in word final position as long as the final vowel of the syllable is */ and V syllables are also possible in word initial position. It is these word initial vowels that will be focused on in this paper. Stress is unaffected by these phenomena because of them being extraprosodic. Extraprosodicity can be described by the following equation:


However this equation does not account for the rules surrounding minimality (see below).
No conclusions have been drawn regarding possible maximum word length however it has been noted that minimality applies in Banawá because ‘all Banawá words have at least two moras’ which can be stated as:

5. Word Minimality (WoMIN): Words are minimally bimoraic (Everett 1996:10)

“The minimal word in Banawá is equivalent to the maximal foot” which is bi-syllabic and bi-moraic (Everett 1996:30). Only vowels map to moras rather than vowels and consonants and therefore word length is only constrained by vowels (Everett 1996:29). This claim is supported by evidence, which shows Banawá lacks monomoraic words, long vowels are restricted to bi-moraic words and finally verb roots that take inflectional morphology can be monomoraic, however “verbs which take an auxiliary must be at least bi-moraic, since inflection must appear on the auxiliary, not the verb directly” (Everett 1996:10). This means that words can have one or more syllable but monosyllabic words must contain two vowels (Ladefoged, Ladefoged & Everett 1997:109).

As previously mentioned, all the work to date on Banawá stress patterns has been carried out using isolated words. Buller, Buller & Everett commented that “further work remains to be done in studying stress patterns in connected text” (1993:293) which is the purpose of this paper. Using my own transcriptions I will analyse and describe the stress patterns of Banawá and draw conclusions on the acoustic effects of stress assignment in connected speech. I also hope to assess the role stress plays in Banawá and formulate an analysis using Optimality Theory to help predict where stress will be assigned.
There are two possibilities that can be predicted from the literature. Either all words show a trochaic system and stress in connected speech is no different to stress in isolated words, or secondly stress patterns in connected speech are unaffected by word boundaries and continue in a (strong weak) pattern throughout the passage. A brief look at the data, however, shows that neither of these theories can be applied satisfactorily.

The claims made by Buller, Buller & Everett (1993) do not always apply to words in passages of connected speech:

6. udadusi kuma udadusi te:ne bisa:
   a. u’dadu’si ku:ma u’dadu’si te:ne bi’sa:
   b. u’dadu’si kuma u’dadu’si te:ne bisa:

The expected analysis derived from theories put forward by Buller, Buller & Everett (1993) as seen in 6a does not reflect the reality of stress patterns illustrated in 6b, if we assume that stress assignment ignores word boundaries. 6b appears to illustrate an example of stress shift in which one would expect the speaker to stress both word initial vowels to fit with the trochaic stress assignment pattern, however this is avoided in Banawá and consequently stress shifts to the next syllable. However, some passages do follow the predictions formulated from Buller, Buller & Everett’s (1993) findings.

7. "hashi ‘habo’tu a’wisa “need to pound the root into salt”

It should be noted that all syllable constraints proposed by Buller, Buller & Everett (1993) can be related to the passage of speech used as data for this paper to explain stress patterns, as well as explaining stress assignment in isolated words. It is only
the stress patterns that are altered in connected speech. The theories proposed by Buller, Buller & Everett (1993) are confirmed by Ladefoged, Ladefoged & Everett (1997) so the facts proposed in this article are not disputable. The claims and theories previously proposed by these articles consistently apply to words in isolation.

Extraprosodic rules are also violated in passages of speech. According to Buller, Buller & Everett (1993) no extraprosodic sound should carry stress, however within the passage there are examples of word initial vowels occurring in words of three or more moras and being stressed.

8. jama ekija:
   a. jama e'kjia:
   b. jama e'kijia:

Example 8a shows the analysis predicted using the theories proposed by Buller, Buller & Everett (1993) however it can be seen in 8b that these predictions are violated in reality because the word initial syllable /e/ carries stress (see section 2.1.1 below). A possible explanation for this is proposed by Buller, Buller & Everett (1993) who note that word initial vowels are only stressed when they occur at the left boundary. From the example above it is possible to argue that this must be the left boundary of the phonological word.

The data used to research this paper was collected in the field by Prof Daniel Everett. I then transcribed the data and proceeded to carry out experimental phonetic analysis on it using the Praat computer programme. By analysing the resulting waveforms and spectrograms it has been possible for me to establish patterns within the data and use these patterns to formulate acoustic correlates regarding the
placement and effects of stress in connected speech within Banawá. Throughout the paper the data used to analyse these phenomena is referred to as 'the passage'.
3 Acoustic Analysis

Hayward claims that "other things being equal, stressed syllables may have longer duration, higher pitch, greater acoustic intensity and more carefully articulated vowel and consonant sounds than unstressed syllables" (2900:274). This chapter will describe and analyse the role played by these features in marking stress and the effect stress has on these acoustic features within the passage. The findings will be presented as a series of acoustic stress correlates. Halle & Vergnaud argue that "in the case of words with multiple stresses, there appear to be three major principles of distribution: stressed and unstressed syllables alternate, stress falls on phonemes in particular environments [or] a combination of the preceding" (1987:3). By looking at Buller, Buller & Everett (1983) it is possible to conclude that stress assignment in Banawã can simply be explained by the first generalisation made by Halle & Vergnaud (1987) because stressed and unstressed syllable alternate, however in connected speech other factors also play a role. I intend to document the acoustic correlates of stress in connected speech with the aim of gaining a more comprehensive understanding of stress patterns in Banawã.

3.1 Duration of Sound

Duration is generally used to mark phonological phrasing and vowel length, which is a phonemic phenomenon in many languages. (Hayes 1995:7). Hayes consequently argues that "stress is parasitic, in the sense that it invokes phonetic resources that serve other phonological ends" (1995:7). From this we can establish that duration does not cause or attract stress but rather is caused by other factors such as phrase final position. Duration is then exploited by stress as an acoustic correlate. It has also been noted that length does not play any role in distinguishing words in Banawã (Ladefoged, Ladefoged & Everett 1997:107) however it is probable that it plays a role in sentence parsing, and therefore stress. Both vowel and syllable duration can be
used to mark stress as well as the length of voice onset time (VOT), each of which will be studied in this section.¹

3.1.1 Vowel Duration

As previously discussed, all monosyllabic words must contain two vowels in order to satisfy word minimality (Ladefoged, Ladefoged & Everett 1997:106). Therefore, by comparing long vowels in monosyllabic words within the passage, it is possible to determine the effects of stress on vowel length. Unstressed, long pure vowels such as those found in /kiː/ (Figure 1) and /daːz/ (Figure 2) vary between 0.086-0.085 seconds in length whereas stressed long pure vowels can be as long as 0.186 seconds as seen in /kiː/ (Figure 3).

9a. /jaːma kɪ/ "the jungle has"

Figure 1

[Image of a spectrogram showing vowel duration]

Duration = 0.450692 seconds

¹ It is important to note that duration will be affected by the speed of speech. Therefore duration of sound will be analysed by comparing neighbouring sounds and sounds in small passages rather than looking at the passage overall.
9b. /dze:'lta/

Figure 2

Duration = 0.536885 seconds

9c. /'jama'ki/ "the jungle has"

Figure 3

Duration = 0.756 seconds

The differences in stress patterns between Figures 1 and 3 occur as a result of surrounding sounds. In Figure 1 /ja/ is stressed because the previous syllable is also /ja/ and stressed (see 10 below). As is discussed in section 4 all neighbouring syllables that have the same onset must carry the same stress. The trochaic pattern then continues as predicted. In Figure 3 the context is different with neighbouring
syllables sharing the same vowels rather than consonants. This means that syllables must carry alternating stress (see section 4). The preceding CVV syllable /hai/ must be stressed and as a result of this /ja/ is unstressed. The same explanation can be given for why /ki/ is unstressed, because the following syllable /hai/ carries the same vowel and must be stressed.

These results help indicate what can be defined as a long or short vowel, but all sounds must be looked at in the context in which they occur.

It is expected that stressed vowels are longer in duration than unstressed vowels (Hayward 2000:274). It is important, however, to distinguish between unstressed vowels that have undergone lengthening as a result of their phrase final position, and short stressed vowels. Consequently other phonological factors and acoustic correlates should be considered when looking at stress. There does not appear to be a correlation between stress and vowel length occurring throughout the passage, however at the start of the passage vowel length appears to directly correspond to stress:

10. 'jama 'ekūja: jama 'ki: uta'hai ja'ma ki 'tainamu'

More accurately, vowel length appears to correlate to primary stress within this extract. The only stressed syllable that does not contain a vowel that is the longest in the word is the word initial vowel in /'ekūja/, however this syllable is comparatively longer than the adjacent unstressed syllable. Consequently, an acoustic correlate can be distinguished:

2 Although not marked for length, all stressed syllables carry the longest vowel in each word.

The vowels that are marked for length occur phrase finally.
Acoustic Correlate 1 - A stressed vowel is lengthened

It is important to note that this correlate does not apply exclusively throughout the passage. The acoustic correlates proposed in this paper can therefore be ordered rather like constraints in Optimality Theory (see section 4).

11. /eik’ja/
   e = 0.157 seconds
   i = 0.127 seconds
   a = 0.249 seconds

Figure 4

The final syllable in Figure 4 is lengthened because it occurs phrase finally, however it is likely that it is lengthened further because it is stressed, as predicted by acoustic correlate 1.

In Figure 4 the syllable predicted to be extraprosodic in isolation by Buller, Buller & Everett (1993) is stressed, and therefore can not be extraprosodic but is simply defined as "word initial". This word initial vowel is notably longer than other word
initial vowels that occur at the start of the passage, which range from 0.037 seconds to 0.09 seconds when stressed before a bilabial nasal and 0.065 when unstressed before a voiceless plosive.

It also appears that vowel length is related in some way to stress, because all CVV syllables that occur in multisyllabic words and contain a plosive in the onset, carry stress. This is expected from the Buller, Buller & Everett analysis (1993) because they define CVV syllables as containing two separate vowels and therefore 2 moras, consequently it is predicted that one of these vowels will always be stressed. This analysis does not seem to apply in connected speech because there are examples of CVV syllables not carrying stress. Using data from the passage it is not possible to tell whether the onset is relevant to stress, because there is only one example of a CVV syllable occurring in the passage without a plosive onset.

1 Throughout this paper, CVV will refer to syllables that contain 2 vowels of different qualities eg /tai/. CV will denote syllables which contain a pure vowel that is 2 moras in length. Despite Buller, Buller & Everett (1993) arguing against this distinction, it is considered necessary in this analysis because CVV syllables and CV syllables behave differently in connected speech in relation to stress.
12. *na*lahi’/"tree"

Figure 5

![Waveform with labels](image)

\[ \text{Duration} = 0.440789 \text{ seconds} \]

The stress on this syllable can be attributed to vowel length and therefore no definite correlation can be made between the syllable onset and stress. From this data it is possible to derive an acoustic observation:

*Acoustic Observation 2* – As predicted by Buller, Buller & Everett (1993) all CVV syllables that appear in a polysyllabic words carry stress.

This observation differs from *Acoustic Correlate 1* in that it can be successfully claimed that CVV syllables attract stress, therefore it is an observation rather than a correlate. This is because stress does not alter the syllable quality from CV to CVV as this would alter the meaning of the word as well. Consequently this observation can be adapted and used as a constraint in an analysis of the passage using Optimality Theory (see section 4).

*CVV Stress – All C/V syllables carry stress.*
The same generalisation does not apply to pure vowels that span two moras:

13. /taˈtunaːteːneː/ "that foot bone"

In the example above it is the final syllable /neː/ that has the longest vowel length at 0.197 seconds, however this syllable is not stressed. One possible reason for this is that the preceding syllable /teː/ could also be considered to consist of two moras due to it lasting 0.184 seconds. This syllable does carry stress and has been perceived as the carrier of primary stress within the word. Therefore it would be possible to assume that if two syllables, that both contain vowels of two moras, appear adjacent to each other, then only the first one will carry stress.

It is important to note that this word precedes a pause and therefore the increased length of the final syllable could be as a result of its phrase final position. This is particularly probable given that later in the passage the /teːneː/ morpheme appears again, this time not before a pause. In this position /teː/ is significantly longer than /neː/ and carries stress. Therefore it is probable that /teː/ is lengthened because it carries stress and /neː/ is lengthened in the first example because of its phrase final
position. However there is an example of a word containing two CV syllables occurring phrase medially in the passage. Here the first syllable is again stressed despite the second syllable being longer. This morpheme directly precedes an extraprosodic syllable, as does /ma'kau/ in Figure 8 in which the vowel of the second syllable is over three times longer than that of the first syllable, this substantial lengthening is unlikely to occur as a direct result of stress. These are the only two examples of extraprosodic vowels occurring phrase medially in the passage and both occurrences correspond with the final vowel of the preceding word being lengthened. This does not account for the lengthening of /ku/ which can only be attributed to stress.

14. /nu:ma u'd'us/u 'hurt'

Figure 7

![Graph showing sound wave with labels: k u m a: u d a d u s i]

Duration = 0.589116 seconds
consisting of two moras always occur word finally or word initially and are consequently stressed as a result of their position in the word rather than their length. Nevertheless it is still possible to exemplify the following acoustic correlate:

*Acoustic Correlate 3:* All CV: syllables are stressed unless they follow another CV: syllable.

This correlate can be predicted because generally only phrase final syllables are lengthened. When 2 CV: syllables occur adjacent to each other the first syllable is lengthened as a result of the stress it carries and the second is lengthened because of its phrase final position. It is important to also note that this pattern only occurs when V'=V whenever limited data available it is not possible to draw a definitive conclusion on this.

There are no examples in the passage of CV: and CVV syllables occurring adjacently. This could be because these patterns do not occur in Banawa however, with limited data available, I cannot conclusively state this. Therefore further research needs to be carried out on this to establish whether these patterns exist and, if so, how stress is assigned to them.

This section has presented conclusive evidence to illustrate a correlation between stress and vowel length, however it is important to determine whether stress leads to an increase in vowel length or whether vowel length attracts stress. If vowel length attracts stress then it could be successfully argued that that Ladefoged, Ladefoged & Everett’s (1997) analysis of the phonetic structure of Banawa is incorrect because it claims there are no long vowels (CVV syllables consist of 2 short vowels). If long vowels are a feature of the language then they would be expected to appear throughout words, however this is not the case (as explained above). If CV: syllables
attract stress then it would be expected that in a CV:CV sequence both syllables would carry stress, however as Figures 6 & 7 demonstrate this does not happen. Therefore it seems likely that within Banawa, vowels are not stressed because of their length but rather the vowel length is caused by a combination of the syllable’s position in the word and the placement of stress. It appears from the passage that the position of the syllable in the word is more of a factor than the placement of stress in determining vowel length, because otherwise it would be expected that in a sequence of CV:CV syllables the stressed syllable would be longer which, as noted above, is not the case.

3.1.2 Syllable Duration

Syllable duration measures the length of the syllable onset as well as the vowel and, as with vowel duration, it is expected that stressed syllables will be longer in duration than unstressed syllables (Hayward 2000:274). However syllable duration does not appear to directly correlate to stress patterns. Rather it appears to be used as an indication of word boundaries, with all of the longest syllables in each word of the passage being either word final or word initial, for example /tuwa'wisa/
16. /tuwa'wisa/

Figure 9

There appears to be one exception to this rule in which a word medial CVV syllable is the longest syllable, however since it follows an extraprosodic vowel it can be successfully claimed that this syllable is word initial according to Butler, Butler & Everett’s analysis (1993).

17. /n'dainu'ku/

Figure 10

Duration = 0.901256 seconds
The longest syllable in each word is usually word final. This is unsurprising because word final vowels are often lengthened as a result of their position in the word and this will have a major impact on the length of the syllable. Consequently this length is caused by the syllable’s position in the word and not by stress. This distinction does not have implications for the hearer but is important for the speaker because it discriminates between the cause of syllable length and the effect.

Word initial syllables that contain the maximum duration for the word in which they appear, are always stressed, for example:

18a. ‘sabotage (in which the first syllable is longest)

However stressed word initial syllables are not always the longest in the word, for example:

18b. ‘table (in which the final syllable is the longest)

It can therefore be argued that maximum syllable length in word initial position will attract stress. If it were stress that created this length then one would expect many more stressed, word initial syllables to carry maximum length. From this conclusion it is possible to generate another acoustic correlate:

**Acoustic Correlate 4** - If the word initial syllable is the longest in the word then it is stressed.

3.1.3 *Voice Onset Time (VOT) Duration*

Ladefoged, Ladefoged & Everett (1997) note that “the voiceless stops /l/ and /h/ are virtually unaspirated. The mean VOT for velars is 44ms, whereas that for dentals is 22ms” (1997:101). They also note that the VOT for /h/ can be affected by the

*It should be noted that these values were recorded using words in isolated speech rather than connected speech.*
following vowel, it being longer for /i/ than /a/; for the velar plosive there was no clear
difference (1997:101). VOT is generally greater in stressed syllables than in
unstressed syllables (Linker & Abramson 1987; cited in Hayward 2000:115). Within
the passage there are only two examples of each voiceless plosive (/p/ and /k/) being
unstressed as can be seen in Figures 11-14

19a. /nu/ = /wa/ = /sa/

VOT = 0.018 seconds

Figure 11

Duration = 0.860113 seconds
"Tap on"
0.029 seconds

Duration = 0.442222 seconds

"Tekija"

VOT = 0.056 seconds
da 13

Duration = 0.786553 seconds
19d. /jama /'ki/ "the jungle has"

VOT ~ 0.045 seconds

Figure 14

5000Hz

j a m a k i:

0Hz

Duration = 0.865669 seconds

None of the values in the above examples are substantially below the values given by Ladefoged, Ladefoged & Everett (1997). It is only the value in the first example that differs from the predictions. From this evidence it can be conclusively stated that the VOT values given by Ladefoged, Ladefoged & Everett (1997) can also be applied to connected speech. In comparison to Figure 14, /ki/ also appears slightly earlier in the passage as a stressed syllable in which the VOT is 0.056 seconds.
20. /ki/ "look"

VOT = 0.056 seconds

Figure 15

Duration = 0.373445 seconds

This value is slightly higher than the value recorded for the unstressed equivalent but it is unlikely that this small increase alone would be used to signify stress. There are also examples of VOT being considerably lower than one would expect for a stressed syllable:
21. /mə'ka:/ "after"
   VOT = 0.032 seconds

Figure 16

There are two examples of this word appearing in the text for which the VOT is 0.032 seconds for both, however the stressed syllable is clearly marked by greater amplitude and significant vowel lengthening, therefore VOT plays less of a role.

Although not always the case, there is a significant trend for the VOT of voiceless plosives to decrease as vowel length increases.
22. /təˈtunətəːne:/ "that foot bone"

\begin{itemize}
  \item ta VOT 0.023 seconds vowel length 0.119 seconds
  \item tu VOT 0.030 seconds vowel length 0.032 seconds
  \item te: VOT 0.021 seconds vowel length 0.184 seconds
\end{itemize}

Figure 17

In Figure 17 /te:/ carries primary stress. Therefore it can be claimed again that the longest vowel in a word will be stressed. However it can also be argued that the length of VOT plays a role in determining or illustrating stress and that the longer the VOT the more likely a syllable is to be stressed.

The apparent correlation between VOT and vowel length would account for why VOT is lower than expected in /maˈkə:/ because /kə:/ contains a long vowel and therefore there is less of a need for the VOT to be significantly long. Consequently, it can be suggested that the length of some part of the syllable will determine or illustrate stress, however only one part of the syllable needs to be significantly long for stress to be present. Therefore if the vowel is long it is unnecessary for the VOT to also be long to illustrate stress. It is not possible to make such a distinction regarding CVV syllables because there are no words containing a CVV syllable and another syllable.
with a voiceless plosive onset. However, because many CVV syllables occur phrase initially the VOT for these syllables is often longer than would be expected from Ladefoged, Ladefoged & Everett's analysis (1997).

23. /taimuru/ "stepped on (distant past)"

Figure 18

As with vowel length it is possible to conclude that there are definite links between the phonetic evidence, in this instance VOT, and stress. However once again it is crucial to identify the cause and the effect of these acoustic patterns. It seems likely that, as with vowel length, VOT length is an effect of stress rather than a cause. This is likely because the differences in VOT do not seem significant enough to attract stress. If VOT is a correlate of stress then it is also logical to predict that all stressed syllables have a longer VOT than unstressed syllables, however this regularity can not be found, particularly amongst velar plosives in which a stressed syllable can have a VOT of 0.032 seconds and an unstressed syllable has a VOT value of 0.05 seconds. As a result of these irregularities it is not possible to exemplify any acoustic correlates between stress and VOT.
3.2 Pitch

The use of pitch to illustrate stress is, like duration, language specific and dependent on the language's intonational system (Hayes 1995:7). It is not possible to claim, for example, that high pitch automatically correlates to stress because different languages will use pitch in different ways and to different extents (Hayes 1995:7). It should be noted that changes in pitch do not lead to changes in meaning because Banawá is not a tone language. However, pitch, conditional by stress, can play a vital role for the hearer in parsing words, even though it is not underlying and does not play a crucial role for the speaker.

Some syllables carry significant falls or rises in pitch, however throughout the data the changes in pitch are predominantly falls. Stress patterns in relation to variations in pitch have not been investigated before in Banawá, this is possibly because changes in pitch are predominantly found in connected speech (Hayward 2000:27). Within the passage it appears that significant changes in pitch can correlate to stress.

In collecting data and researching this paper, pitch was measured by establishing the maximum and minimum pitch level of a syllable and subtracting the highest value from the lowest value to determine the fall or rise in the pitch value (measured in Hertz, Hz). The duration of the pitch change (in seconds) was also recorded and the level of fall was then divided by the duration of change to establish the speed of pitch (measured in Hertz per second).

Within the passage, pitch levels appear to be partly dependent on vowel quality. For example /i/ generally contains the highest pitch levels. There appears to be no direct correlation between stress and the speed of the fall in pitch. However stressed syllables generally carry a greater maximum pitch level than unstressed syllables. For example:
24. \( r\)sebru\( '\)sib\( a\)ri \( '\)tuw\( i\)ne/

Figure 19

5000Hz

<table>
<thead>
<tr>
<th>sa bu ru s i b a ri t u wi ne</th>
</tr>
</thead>
</table>

Duration = 1.294649 seconds

This example is particularly interesting because the three unstressed syllables all carry the same maximum pitch level of 524.63Hz. Not all sections in the passage show such direct correlations between pitch and stress and it would appear that pitch does not play as an important role as vowel length and amplitude. In Figure 19 there are no vowels containing significantly longer duration than others, with all syllables being CV. There are also no dramatic differences in amplitude, in each word the most intense syllable is that which contains a plosive. In these conditions pitch then plays a role. Therefore it is possible to predict the following acoustic correlate:

*Acoustic Correlate 5 – Stressed syllables maintain the highest pitch level in a word in relation to vowel quality.*

This correlate will only apply if there are no significantly high levels of amplitude or vowel length elsewhere in the phrase. Consequently it can be argued that, if the

\[5\] It is important to study pitch levels in relation to vowel quality and in comparison to surrounding vowels as opposed to the passage as a whole.
acoustic correlates were ordered like constraints in Optimality Theory, correlates relating to duration and amplitude would outrank correlates relating to pitch such as the one above.

Throughout the passage it seems that only the maximum pitch value correlates to stress. There is no evidence suggesting that the change in pitch or the speed of this change can signify stress. The minimum pitch levels vary throughout the passage but do not appear to determine or depend on stress or vowel quality.

Once again it is important to establish what is a cause of stress and what is an effect. If pitch is a cause of stress then this would suggest that Banawá is a tone language. Since this is not the case it seems that changes in pitch occur as a result of stress placement. Ladefoged argues that "all languages use pitch to mark the boundaries of syntactic units" (1996:234) and consequently stress could be used in conjunction with pitch to help the listener parse the passage more effectively. Therefore the following sections will examine the effects of stress rather than the causes.

3.2.1 Word Initial Vowels

All word initial vowels carry falls in pitch, like most syllables in the passage. Most of these word initial vowels contain either the greatest or fastest fall in pitch in comparison to the other syllables in the same word. Of the 15 word initial vowels in the passage, 13 of them have produced data relating to pitch. All but one of them falls in pitch to a level between 370-500Hz, this is in comparison to the rest of the syllables analysed, in which the lowest pitch levels range from 102-678Hz. Therefore it can be argued that if stress on word initial vowels is related to pitch, it is related to maximum pitch levels, which range from 541-1209Hz, and the speed of the fall, rather than the lower levels of pitch. When looking at maximum pitch levels for word
initial vowels they are often higher than vowels of the same quality in the same phrase when unstressed and significantly lower when stressed.

25a. /ˈhɪbɪsə/ "dirty tooth"
   /ɪ/ = 932.93Hz
   /ɪ/ = 490.37Hz
   /sə/ = 541.76Hz

Figure 20

\[ \text{Duration} = 0.980383 \text{ seconds} \]
25b. /u/k/d/ub"/i/

/l = 610.27Hz

/kul/ = 832.53Hz

/ldul/ = 1055.6Hz

Figure 21

However, this generalisation can be made for stressed and unstressed syllables and therefore there doesn’t appear to be a direct correlation with stress.

3.2.2 Word Final Syllables

It is expected that word final syllables and in particular phrase final syllables, will carry a greater fall in pitch in comparison to other syllables in the passage (Hayward 2000:27). This assumption applies to most word final unstressed syllables in the passage, however there is an overwhelming trend for stressed word final syllables not to carry the greatest fall in pitch because stress generally involves a rise in pitch.
26a. /dana/m*ilu'du'ne:/
/dana/ Fall of 205.54Hz
/m*ilu/ Fall of 119.9Hz
/ilu/ Rise of 308.3Hz
/ilu/ Fall of 171.28Hz
/ne:/ Fall of 34.25 Hz

Figure 22

Duration = 1.403262 seconds
26a. '/tæ'biːsə/ "dirty cur"

/taɪ/ Fall of 239.68 Hz

/ˈbiː/ Fall of 102.77 Hz

/ˈsa/ Fall of 428.2 Hz

Figure 23

This could be because the stress system of Banawâ is trochaic and from this it would be expected that word final syllables are unstressed and carry the greatest fall in pitch. Therefore, as a way of marking them as exceptions to the trochaic stress patterns, the fall in pitch is less significant than would be expected for word final stressed syllables.

It should be noted that there are several exceptions to the analysis above in the passage. In most of these exceptions the unstressed syllables do not carry the fastest fall in pitch whereas the stressed word final syllables do.

It could be argued that this phenomenon occurs to help the listener parse the passage more effectively. If a word final syllable is not stressed then the fall in pitch signifies the word boundary instead.
3.3 Amplitude of the Sound

Amplitude refers to "how far a sine wave departs from its baseline value" (Hayward 2000:43) and is measured in decibels (dB). It can be correlated with intensity and it is claimed that stressed syllables will have a greater intensity in relation to the unstressed syllables around them (Hayward 2000:274). Stetson (1928) claimed that each syllable in an utterance is accompanied by a breath pulse in which the muscles of the chest wall contract to give the syllable increased sonority over a syllable boundary. Furthermore he believed that stressed syllables had a particularly strong breath pulse giving them greater intensity (Hayes:1995:6). Stetson's findings are controversial and it has since been argued (Lieberman et al 1957; Lieberman 1968; van Katwijk 1974; J Ohala 1977) that breath pulses can only define a subset of stressed syllables but that other criteria can distinguish stressed syllables as well. Fry (1955) discovered that "loudness had the least effect on stress perception, despite its intuitive status as the most natural correlate of stress," more recently Bolinger (1958); Morton & Jassem (1965); and Nakatani & Aston (1978) have agreed with these findings (Hayes 1995:5). Nevertheless intensity is still considered a useful diagnostic tool when establishing stressed syllables (Hayes 1995:6). According to the sonority sequencing generalisation vowels will always carry the greatest amplitude in a syllable and therefore \( \alpha \) is the amplitude of the vowel that is measured in each syllable.

3.3.1 Word Initial Vowels

Word initial vowels rarely contain the highest amplitude of the syllables within each of the words in which they appear, and generally the amplitude of word initial vowels is below average for the passage. This could be as a result of most word initial vowels in the passage being /a/ or /ə/, both of these high vowels are generally found to be lower in amplitude than other vowels found in the passage such as /æ/. Only two word initial vowels with the greatest amplitude in the word can be found in the
passage. Firstly there is word initial /i/ occurring with the greatest amplitude and secondly extraprosodic /a/.

27a. /ma/ "flesh"

/i/ 65.17dB

/m/ 60.3dB

Figure 24

Duration = 0.344717 second
27b. /siwisa/ “salt”
/a/ 79.7 dB
iw/ 66.11 dB
/sai/ 61.37 dB

Figure 25

The amplitude in Figure 24 cannot be as a direct result of context or vowel quality because /inal/ can also be found with the word final syllable /matal/ carrying the greatest amplitude, as seen below.
28. /l/ma/ “flesh”
\n/l/ 62.86dB
\nl/ma/ 63.34dB

Figure 26

The amplitude does not appear to relate to stress as perceived by the listener because /l/ma/ in both occurrences has a stressed word initial vowel, as would be expected, and /a/wisa/ contains an unstressed extraprosodic syllable. In relation to other vowels in the passage 70.7dB is not vastly greater than other vowels of the same quality. However 66.11dB as an amplitude value for /l/ is high in relation to other vowels of the same quality in the passage and therefore it is not surprising that /w/ is the stressed syllable within the word /a/wisa/.

Overall it seems that amplitude does not play a direct role in illustrating stress in extraprosodic and word initial vowels because if it does then it would be expected that both examples of /l/ma/ would have the word initial vowel carrying the greatest amplitude and /a/wisa/ would not carry the greatest amplitude on the word initial vowel (taking vowel quality into account the amplitude of the word initial syllable in this word is still significantly higher than would be expected, which can be seen when
comparing it with the final syllable in the word /səl/ which has an amplitude which is over 9dB lower). Therefore it seems that other acoustic features such as pitch and duration contribute to the determination of stress in word initial vowels.

3.3.2 CVV Syllables

CVV syllables containing a voiced or voiceless plosive in the onset will always carry the greatest amplitude in a word (see Figure 27). This can be defined as an acoustic correlate:

*Acoustic Correlate 6 – CVV syllables carry the greatest amplitude in the word when C is a plosive.*

Recall from section 3.1.1 that CVV syllables containing a plosive in the onset can only occur word initially or after an extraprosodic vowel. *Acoustic Correlate 5* applies unless the final syllable of the word consists of two moras as well, in which case that syllable will carry the greatest amplitude (see Figure 28).

*Acoustic Correlate 7 – Word final CV syllables carry the greatest amplitude in a word.*

If these correlates were ranked like constraints in Optimality Theory then it would be said that:

*Acoustic Correlate 7 >> Acoustic Correlate 6*

It should be noted that the difference between the first and final syllables in Figure 28 is so discrete that it is unlikely to be perceived by the listener, therefore other factors will play a role in signifying primary stress such as vowel duration.
29a  *naimaru* "stepped on (distant past)"

<table>
<thead>
<tr>
<th>Word</th>
<th>SPL</th>
<th>Vowel Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>nai</td>
<td>63.27 dB</td>
<td>0.198 seconds</td>
</tr>
<tr>
<td>mar</td>
<td>65.1 dB</td>
<td>0.083 seconds</td>
</tr>
<tr>
<td>rul</td>
<td>60.85 dB</td>
<td>0.103 seconds</td>
</tr>
</tbody>
</table>

Figure 27

Duration = 0.618163 seconds
The observation that diphthongs are always stressed in some way, whether primary or secondary, suggests a correlation between vowel length, amplitude and stress within Banawá however it is important to recall that Buller, Buller & Everett's (1993) analysis predicts that CVV syllables will be stressed due to them being considered as containing two separate vowels and consequently 2 moras. The data above suggests that the link between amplitude and stress isn’t direct because if it was /ma/ would have a greater amplitude than /ma/ (see Figure 27). This clearly suggests that although amplitude plays an important role in stress, other factors also contribute to the phenomenon. In Figures 27 and 28 this is most notably vowel length. This suggests that acoustic correlates relating to vowel length will outrank those relating to amplitude. Therefore it can be claimed that syllables of 2 moras will always carry the greatest amplitude in a word and be stressed, however it is not correct to claim that all syllables that carry the greatest amplitude levels are stressed.
3.4 Formant structure

Ladefoged, Ladefoged & Everett (1997:99) give the $F_1$ and $F_2$ values for Barawá vowels in stressed syllables as follows:

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>e</th>
<th>a</th>
<th>u</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_1$</td>
<td>200-450Hz</td>
<td>600-700Hz</td>
<td>700-900Hz</td>
<td>300-500Hz</td>
</tr>
<tr>
<td>$F_2$</td>
<td>2000-2500Hz</td>
<td>1600-2000Hz</td>
<td>1300-1500Hz</td>
<td>600-1000Hz</td>
</tr>
</tbody>
</table>

The findings proposed by Hayward suggest that stressed syllables in Barawá should contain vowels consisting of formants that correspond to the boundaries above. Ladefoged, Ladefoged & Everett note that vowels following bilabials generally have slightly lower formant frequencies than those that follow coronals (1997:99).

The $F_1$ and $F_2$ values for $i$ are predominantly consistent with Ladefoged, Ladefoged & Everett’s (1997) findings throughout the passage. The only $F_1$ formant to differ from the findings follows a bilabial /b/ and has a value of 192.07 Hz, slightly lower than the boundaries exemplified in Table 1, however this is less surprising given that the vowel follows a bilabial and occurs in an unstressed syllable and will therefore have slightly lower formant frequency values.
This relative conformity to the predictions of Ladefoged, Ladefoged & Everett (1997:99) suggests that formant structure is not the most important factor when establishing stress patterns in syllables containing /a/, had it been more important one would expect to see a greater variety in formant frequencies. The variety found within the data does not have any correlation to perceived stress patterns, rather it is likely that it occurs as a result of the preceding and following sounds.

Formant values for /a/ rarely coincide with Ladefoged, Ladefoged & Everett's (1997:99) figures. F1 and F2 values often fall within the boundaries when the vowel occurs in a word final position and is considerably longer than other syllables in the word. These syllables can be stressed or unstressed and therefore there does not appear to be any direct correlation between the formant structure and stress.
31a. /niib/sa:/ "dirty tooth"

/ssa:/ - F1 713.04Hz
F2 1398.2Hz
0.29 seconds

Figure 30

31b. /ekij/a:

/ija:/ - F1 867.19Hz
F2 1363.9Hz
0.249 seconds

Figure 31
By looking at /ei/ and /u:/ similar patterns occur. /ei/ is only found to correlate with Ladefoged, Ladefoged & Everett’s (1997:99) findings in word final and word initial syllables when the vowels are of a significant length or the syllables occur before a pause.

32. /’tuna’te:ne:/ “that foot, bone”

/ei/ F1 = 695.9, F2 = 1894.9

/u:/ F1 = 678.75, F2 = 1860.6

Figure 32

There appears to be no regular correspondence between /u:/ and the F2 values given by Ladefoged, Ladefoged & Everett (1997:99), which are substantially lower than those found in connected speech. The F1 values for /u:/ correspond with those given by Ladefoged, Ladefoged & Everett (1997:99) but have a much narrower range. Therefore it can be argued that formant values differ between isolated and connected speech and that new formant values for stressed syllables in connected speech need to be proposed in relation to connected speech. The graphs below illustrate formant values for each vowel in Banawa. Firstly for all the vowels of each quality and secondly for those that are stressed.
Graph 7

Formant Values for /i/ in stressed syllables

Graph 8

Formant Values for /i/ in stressed syllables

From the analysis and data above it is possible to propose the following values for F1 and F2 in stressed syllables occurring in connected speech:
Table 2

<table>
<thead>
<tr>
<th></th>
<th>/a/</th>
<th>/e/</th>
<th>/i/</th>
<th>/u/</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>500-750Hz</td>
<td>600-700Hz</td>
<td>300-400Hz</td>
<td>350-450Hz</td>
</tr>
<tr>
<td>F2</td>
<td>1100-1650Hz</td>
<td>1600-2000Hz</td>
<td>2000-2500Hz</td>
<td>1000-1300Hz</td>
</tr>
</tbody>
</table>

Using these values it is now possible to analyse the data further to establish any correlations between the structure of vowel formants and stress assignment in connected speech.

The F1 boundaries for sounds in connected speech are considerably narrower than the boundaries for sounds found in isolated speech. Throughout the passage occurrences of /i/ with an F1 value below 300Hz are always unstressed unless they are word initial, and those with values above 400Hz are always stressed however there is not a clear distinction between the formant values of stressed and unstressed syllables however, for example /ki:/ (Figure 33) is stressed with an F1 value of 301.96Hz and /hasi/ (Figure 34) is unstressed with an F1 value of 370.48Hz.

33a. /jama ki: utahai/ "the jungle has trees"

Figure 33

![Waveform of /jama ki: utahai/](image)

Duration = 1.358084 seconds
F2 values for /i/ are not affected by stress but rather the place of articulation of the syllable onset. Those with a value above 2500Hz have an onset of /i/ or no onset. Values below 2000Hz occur either after /b/ or /w/ which is expected because formant frequencies are generally slightly lower when vowels follow bilabials.

Formant values for /a/ do not seem to correlate to stress patterns with both stressed and unstressed syllables having F1 values above and below those expressed in Table 2. Instead the formant frequencies appear to be affected by their position in the word. All F1 values below 500Hz occur word initially apart from one unstressed syllable /sa/ which occurs word and indeed phrase finally, and /ral/ which occurs word medially (see below). All F1 values above 750Hz occur either word finally or word initially. 2 stressed syllables have F1 values above 750Hz /tal/ and /kαl/. It is surprising that /tal/ has a higher F1 value for /αl/ because the following vowel /i/ will have a comparatively low F1 value.
34. /tai'bisa/ "dirty cut"

Figure 35

Duration = 1.147053 seconds

/ka/ probably has a higher F1 value to distinguish it from the surrounding syllables /ma'ka ma'ka/. As Lieberman notes "Due to the greater acoustic reliability of stressed syllables, stress can affect recognition: stressed syllables are more readily identified than unstressed syllables when cut out of their original context" (1963).

35. /ma'ka ma'ka/ "after...after"

Figure 36

Duration = 1.981438 seconds
F2 values appear to be affected by quality of onset and position in the word. F2 values below 1100Hz are mostly found in syllables that are word final or word initial. Four of the five of these syllables are /ma/ - unsurprising because of the bilabial quality of the onset. There is also a word medial syllable with an F2 value below 1100Hz. The likely reason for this is to distinguish the syllable from neighbouring /da/ in /da'rame/ because the F1 value is also below what would be expected for a stressed syllable.

36. /da'rame/ "a bit overgrown"

Figure 37

![Waveform](image)

Duration = 0.326587 seconds

The formant frequencies of /æ/ appear to be more closely related to stress than those for /il/ and /al/. Only one example of an F1 being above 700Hz is found in the passage. This is a stressed syllable, which is phrase final. A similar phenomenon can be found when looking at F1 values below 600Hz in which the only stressed syllable found is also phrase final. Another syllable with a low F1 value also has a high F2 value, probably to distinguish it from the neighbouring consonant /t/. This distinction is not always necessary, however, as the same morpheme can be found in which both vowels have F1 and F2 frequencies that fall within the parameters
shown in Table 2. There are no F2 frequencies below 1100Hz. It should be noted that all examples of /e/ containing formant frequencies outside the values in Table 2 are word final.

All F1 values for /u/ that occur below 350Hz or above 450Hz are either word initial or word medial. Syllables with F1 values above 450Hz are either word medial (one stressed, one unstressed) or extrametrical. There is also an example of an extrametrical syllable with an F1 frequency below 350Hz. The F2 values that are above 1300Hz are predominantly word medial apart from one which is phrase final /taimaru/. F2 values below 1000Hz are found in word medial or word initial position. There appears to be no correlation between syllable onset and these values but it is important to note that all syllables are unstressed. Of the four syllables found in Banawâ it seems that /u/ has the closest correlation between formant structure and stress.

By comparing these values with the values proposed by Ladefoged, Ladefoged & Everett (1997) one can establish that the formant values for /e/ and /i/ are not dramatically affected in connected speech. However the F1 value for /a/ is notably lower in connected speech and the F2 value is much broader. F1 values for /u/ are similar to those in isolated speech however the F2 values are substantially higher. These results, whilst not giving us any greater understanding of stress in Banawâ, underscore the importance of looking at phonetic and prosodic features in isolation and context.
4. The ordering of stress rules in Banawa using Optimality Theory

4.1 Overview of the theory

Optimality Theory was introduced by Prince & Smolensky in 1991 in oral presentation and became widely accepted by 1993 (Prince & Smolensky 1993, McCarthy & Prince 1993). The theory is an outgrowth of work in generative phonology and computer science and postulates that Universal Grammar contains a set of violable constraints which constrain the sound systems of natural language.

Optimality Theory proposes a non derivational system in which an input maps directly to an output. FAITHFULNESS constraints require that input and output forms are identical. Violations of the faithfulness constraints by MARKEDNESS constraints lead to differences between the output and input. All constraints are violable however they can only be violated in order to satisfy a higher ranked constraint.

There are two operations that are performed in Optimality Theory. Firstly GEN (generator) creates all possible outputs. Then EVAL (evaluator) uses the constraint hierarchy of the language to select the output that best fits with the input from the options given by GEN. The EVAL process will always generate different outputs for different languages because each language ranks constraints in a different order thus making each language unique.

Everett argues that in relation to Banawa "an OT analysis provides a clearer picture of the relationship between stress, syllable size, word shape, and sonority" (1996:9).
4.2 Analysis of the passage using Optimality Theory

Buller, Buller & Everett claim that "the basic stress placement is: stress every other vowel from left to right" (1993:287). This analysis works for isolated words and also accounts for a lot of stress placement in connected speech.

37a. ḥasįhabu’tu a’wisa
37b. ’wid’sa tu’wawi’sa

Therefore this will become the first constraint.

SWSW: stress every other vowel from left to right, ignoring word and morpheme boundaries.

Despite this Faithfulness constraint, other constraints are required to explain exceptions and irregularities from the trochaic stress assignment pattern within the passage. Buller, Buller & Everett (1993:286) note that extrametricity occurs word initially:

ExMtr (Extrametricality): V → EP/[

This means that word initial vowels will not be stressed in isolated speech. However in connected speech word initial vowels can be stressed when they occur phrase medially:
<table>
<thead>
<tr>
<th>jama ekjja:</th>
<th>SWSW</th>
<th>ExMet</th>
</tr>
</thead>
<tbody>
<tr>
<td>→'jama ekjja:</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>'jana ekjiya:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the above tableau it can be argued that, word medially:

**SWSW -> ExMet.**

However in phrase initial position word initial vowels are not stressed. This is because they are not counted as part of the phonological phrase as a result of there not having an onset.

**ALIGN S-L:** Phonological word aligns with the leftmost syllable.

<table>
<thead>
<tr>
<th>u'dainuku “trees”</th>
<th>ALIGN S-L</th>
<th>SWSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>udainuku</td>
<td></td>
<td></td>
</tr>
<tr>
<td>→ u'dainuku</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>u'dainuku</td>
<td></td>
<td>&quot;I&quot;</td>
</tr>
</tbody>
</table>

There is an exception to **ALIGN S-L** however that needs to be accounted for:

38. "uku'dub"l:

This can be explained by noting that when two neighbouring syllables include vowels of the same quality then SWSW outranks **ALIGN S-L**.
Tableau 3

<table>
<thead>
<tr>
<th></th>
<th>SWSW</th>
<th>ALIGN S-L</th>
</tr>
</thead>
<tbody>
<tr>
<td>ukudub*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>→'uku'dub*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u'kudub*</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

This can be illustrated in more detail by the following phrase:

39a. uta'hai ja'ma "the jungle has trees"

In the above example it can be said that /hai/ has the same vowel quality as the neighbouring syllables because it includes /a/. However if this were to be simply explained using the SWSW constraint then one would expect a different output:

39b. utahai ja'ma "the jungle has trees"

Consequently we need another constraint that can explain why the FAITHFULNESS constraint does not account for the stress patterns found here. There are two possible explanations for this stress placement, both of which are constraints that are needed to explain stress placement.

*+2STRESS: no more than 2 adjacent syllables can carry the same stress.
CVVSTRESS: stress CVV syllables

*+2STRESS does not account for why utahai ja'ma does not occur because this example has alternating stress and therefore complies with this constraint, however it could tell us why /hai/ is stressed following two unstressed vowels. This phenomenon is already accounted for, however, using the CVVSTRESS constraint. Therefore it would appear that CVVSTRESS accounts for the placement of stress within this phrase:
Tableau 4

<table>
<thead>
<tr>
<th></th>
<th>CVVSTRESS</th>
<th>ALIGN S-L</th>
<th>*+2STRESS</th>
<th>SWSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>utahai jama</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>utahai jama</strong></td>
<td><em>1</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>→utahai jama⁶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'utahai jama</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from the above tableau, there is no use for *+2STRESS and therefore to account for the stress placement in the following phrase we can simply argue that:

CVVSTRESS >> SWSW

ALIGN S-L >> SWSW

Once again these constraints do not exclusively account for stress placement within the passage, there is one clear exception to these constraints:

40. ɪma 'ki: da'nane

This example is unusual because from Buller, Buller & Everett's analysis and the CVVSTRESS constraint it would be expected that ɪa' would carry stress. Buller, Buller & Everett's analysis also predicts that the stress assignment in ɪma' is ɪma'. Finally if the SWSW constraint was to apply it would be expected that ḏa'nane/ would be stressed ḏa'nane. In this example there are several constraints working to create the stress patterns.

First it should be noted that all words carry stress.

⁶ The unstressed word initial vowel occurs as a result of a pause before the syllable. This is addressed later in the analysis.
WORDSTRESS: all words must carry stress

However if this constraint applied without exception /taɪ/ would also be stressed because in this phrase it is a separate word, but it isn’t stressed. Therefore another constraint is required to explain this. The phenomenon can be explained by *+2STRESS which states that no more than 2 weak syllables or two stressed syllables can appear together.

Tableau 5

<table>
<thead>
<tr>
<th>&quot;ima ‘ki: tai ‘dara’me</th>
<th>*+2STRESS</th>
<th>WORDSTRESS</th>
<th>CVVSTRESS</th>
<th>SWSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>ima ki: tai darame</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;ima ‘ki: tai da’rame</td>
<td>*</td>
<td>*</td>
<td>***i</td>
<td></td>
</tr>
<tr>
<td>ima ‘ki: ‘tai ‘dara’m ‘e</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>→ima ‘ki: tai ‘dara’me</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As can be seen above these constraints alone do not account for the stress placement in the above phrase. Therefore it is important to introduce a new constraint:

CV=CV – syllables with the same place of articulation in the onset, and the same vowel carry the same stress. Syllables with the same onset also carry the same stress.
Tableau 6

<table>
<thead>
<tr>
<th>#</th>
<th>*2STRESS</th>
<th>CV=CV</th>
<th>WORD- STRESS</th>
<th>CVV-, STRESS</th>
<th>SWSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ima ki: tai darame</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>→'ima ki: tai da'rame</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>'ima ki: 'tai darame me</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>'ima ki: 'tai darame me</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From this tableau it is possible to establish that:

*2STRESS >> CV=CV

The CV=CV constraint also accounts the irregular stress patterns found in:

41. u'da'dusi

This constraint works for all consonant sequences apart from /w/, for which I currently have no explanations. This requires further analysis.

42. *tuwa'wisa – the stress assignment for which complies with SWSW as predicted by Buller, Buller & Everett (1993).

There are some other irregularities within the passage that do not comply with the SWSW constraint and cannot be explained by the constraints illustrated above.

43a. ma'ka ma'ka "again...again"

43b. u'dainu'ku 'hama "angry trees"

These exceptions can be explained by the following constraint:

*NASAL: Syllables that have a nasal in the onset are not stressed.
Tableau 7

<table>
<thead>
<tr>
<th>udainulu hama</th>
<th>*NASAL</th>
<th>Swsw</th>
</tr>
</thead>
<tbody>
<tr>
<td>→udainulu' hama</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>udainulu' hama</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

There are some exceptions to this constraint, which can be explained by looking at other constraints already illustrated above.

Tableau 8

dana'm"'tudü'ne:

<table>
<thead>
<tr>
<th>Janam'm&quot;tudune</th>
<th>*2STRESS</th>
<th>CV=CV</th>
<th>*NASAL</th>
<th>Swsw</th>
</tr>
</thead>
<tbody>
<tr>
<td>'dana'm&quot;'tudune</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>da'ham&quot;tudune'ne</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>→'dana'm&quot;'tudun'ne</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tableau 9

uta'hai ja'ma "the jungle has trees"

<table>
<thead>
<tr>
<th>ALIGN S-L</th>
<th>CVVSTRESS</th>
<th>*NASAL</th>
<th>Swsw</th>
</tr>
</thead>
<tbody>
<tr>
<td>utahai jama</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>→uta'hai ja'ma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'uta'hai ja'ma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>utahai jama</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>


5. Conclusion

This paper has exemplified several acoustic correlates relating to stress in connected speech in Banawá that will help those carrying out further phonological and phonetic studies on the language. The overall implications of this paper are significant in that they illustrate the importance of looking at stress in relation to connected speech as well as isolated speech.

The analysis demonstrates the close relationship between the length of the vowel or syllable and the stress patterns, but also notes the effect of stress on amplitude and pitch levels. By looking at vowel quality it is also possible to distinguish some relationship with stress, but more significantly this data has illustrated the importance of looking at stress in connected speech, independently of isolated speech. The F1 and F2 values for Banawá vowels in connected speech proposed in this paper could be significant for future work, but it is important to note that they are currently based on one speaker's voice. Therefore it is important that they are tested further, with a variety of speakers, before they can be conclusively stated.

The previous work carried out on Banawá, most notably by Buller, Buller & Everett (1993) and Ladefoged, Ladefoged & Everett (1997) focused exclusively on isolated speech. Arguably the most important contribution of this paper is to establish that, whilst working for isolated speech, the stress patterns proposed by Buller, Buller & Everett such as the trochaic assignment and extraprosody, do not occur with such regularity in connected speech. Therefore it can be conclusively argued that other factors play a role in the assignment of stress in connected speech.

It is possible to claim, using the data, that the acoustic correlates proposed actually attract stress rather than occur as a result of stress placement. I argue against this
because there is no obvious reason for syllables to be lengthened, to be greater in amplitude or to show changes in pitch without stress being present. One strong argument against this is that if changes in pitch were to occur independently of stress this would suggest that the language is tonal. The phonetic and acoustic analyses carried out on Banawâ to date have all concluded that it is not a tonal language. There are also examples of long vowels and syllables occurring without being stressed, for example at the end of a phrase. If length attracted stress then one would expect these syllables to also carry stress. The same can be said for amplitude and vowel quality.

Using the Optimality Theory analysis it is possible to predict stress placement by looking at phonological features as opposed to the acoustic features exemplified in section 3. From the data it seems that it is phonological features that lead to the assignment of stress as opposed to acoustic features. Having used the phonological features to predict stress placement it is possible to establish the effects of this stress placement by looking at the acoustic correlates. From this Optimality Theory analysis, it is possible to predict some functions of stress in Banawâ. For example the **+2STRESS and CV=CV constraints can be used to distinguish syllables and hence enable the listener to parse the passage more successfully.

Further work is necessary to gain a more comprehensive understanding of stress in connected speech. The analysis illustrates many acoustic correlates, and using Optimality Theory a brief attempt has been made to predict stress placement in Banawâ. However it would be interesting to establish if any of the acoustic correlates exemplified could be used to predict the placement of stress. Currently the acoustic correlates predominantly occur as a result of stress placement, is it possible to find acoustic correlates that attract stress? Finally it is important to note that this paper has been written using limited data. Further work on this area of Banawâ should
strive to use more comprehensive data, from a variety of speakers and discourses in order to draw more solid conclusions.
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