© 2014 IJSRSET | Volume 1 | Issue 1 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

A Proposal for the Acoustic Modelling for Word Stress

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ABSTRACT

The present study proposes a method for acoustic correlates of stress at word level or words in sentence level, to explain the pattern of distribution of each acoustic correlate, from the observation that it is possible to generate a common pattern of distribution of correlates at least within a group of words belong to same structure within a language. The most reliable or robust acoustic cue to primary stress which is always linked with primary stress. The study has named it as Maximal Acoustic Correlate for Primary stress (MaxACPS). The most reliable or robust acoustic cue to stressed or prominent Syllables (Primary, secondary and tertiary etc): named as, Maximal Acoustic correlate of stressed syllables ((MaxACS). More Potential Acoustic correlates which play lesser role than other correlates named Medium Acoustic correlate of stressed syllable (MidACS). Means in a language some acoustic correlate will occur prominently in stressed syllable in one case and at the same time in another case it occurs less prominently in stressed syllables. Minimal Potential Acoustic correlate (MinACS), plays lesser role than other correlates for stressed syllable. It has used high quality speech corpus in Malayalam for the analysis and conclusion.

Keywords: Acoustic Modelling, Pitch, Intensity, Duration.

I. INTRODUCTION

The present study in Malayalam proposes an acoustic modeling of word stress. This kind of modeling is useful for the development of pronunciation lexicon. For the analysis, the speech corpus developed by the author in Malayalam is used in the study. The acoustic analysis on lexical words is considered for the analysis. It is based on the previous evidences depicted by following seminal works. Mainly English (Fry 1955, 1958; Beckman 1986), Polish (Jassem, Morton & Steffen-Bat´og 1968), Mari (Baitschura 1976), Indonesian (Adisasmito-Smith & Cohn 1996), Tagalog (Gonzalez 1970), Dutch (Sluijter & van Heuven 1996), Pirah˜a (Everett 1998), Chickasaw (Gordon 2004), Turkish (Levi 2005) etc.,. Details of these works have taken manly from these works (Okobi (2006), Gordon (2004),Gordon and Applebaum(2010), Sluijter and Van Heuven (1996), Liebaria Marta (2006) Marion G. Caldecott (2006),Beckman (1997)).

1.1 Acoustic correlates of stressed syllables considered in this study

a. Fundamental Frequency
b. Intensity
c. Duration

1.2 Nature of word Stress in Malayalam

According to Mohanan (1983), Malayalam does not exhibit any difference in amplitude between stressed and stressless syllables. If the first syllable of a word has a short vowel and the second syllable has long one, the primary stress falls on the second syllable; otherwise primary stress falls on the first syllable 2. Secondary stress falls on all remaining long vowels.

II. Proposal for a Hypothetical Model to explain the Distributional pattern of Acoustic correlates

The present study proposes a method for acoustic correlates of stress at word level or words in sentence level, to explain the pattern of distribution of each acoustic correlate, from the observation that it is possible to generate a common pattern of distribution of correlates at least within a group of words belong to same structure within a language.

The pattern has labelled each acoustic correlate in the following way,

1. The most reliable or robust acoustic cue to primary stress which is always linked with primary stress. This correlate might be always prominent in primary stressed syllable than its prominence in unstressed syllables in all contexts (means all syllable types). The study has named it as **Maximal Acoustic Correlate for Primary stress (short form=MaxACPS):**

2. The most reliable or robust acoustic cue to stressed or prominent Syllables (Primary, secondary and tertiary etc): named as, **Maximal Acoustic correlate of stressed syllables. (short form= (MaxACS)**

3. More Potential Acoustic correlates which play lesser role than other correlates named **Medium Acoustic correlate of stressed syllable (MidACS).** Means in a language some acoustic correlate will occur prominently in stressed syllable in one case and at the same time in another case it occurs less prominently in stressed syllables.

4. **Minimal Potential Acoustic correlate (MinACS):** plays lesser role than other correlates for stressed syllable**.**

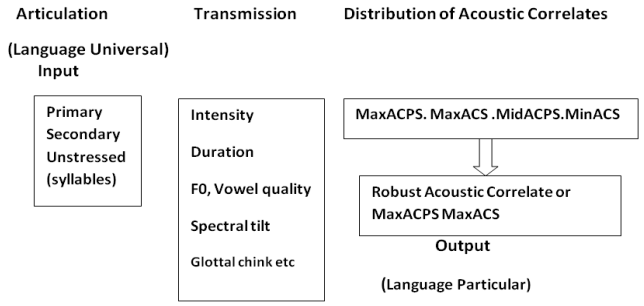

Figure 1: Hypothetical Model explains the distribution acoustic correlates of word stress.

The present study explains the evidence of word stress based on this pattern.

III. Methodology

Words with different syllable structures are used for the analysis. **L** means light syllable and **H** means Heavy syllables.

For example (1) : /de:vada/ "Godess" in which /de:/ is a heavy syllable (H) . /va/ and /da/ are light syllable (L).

a. Simple Words Syllabic Structure

i. Disyllabic: A1. LL A2. LH A3. HH and A4. HL
ii. Try syllabic words: B1. LLL B2.LHL B3.LHL B4.HLL B5.HLH B6.HHL B7.HHH
iii. Tetra Syllable: C1.LLLL C2.LLLH C3. HLLL C4.HHLL C5. HHLH C6.HLHL C7.LHHL C8. LHLL C9.LLHL

IV. Data and Experiment

4.3 Pre-recording face

Two corpuses

1. Duration, Intensity and F0 (250 words) 2. Formant Frequency (50 words).

4.4 4.2 Research Participants

Professional experienced and educated Malayalam speakers from JNU, (3 female and 2 male) for the maximum uniformity of the data.

4.5 Recording phase

Participates were asked to speak each word in natural and clear manner .Recording has been conducted in Professional Sound Proof Recording studio using a portable solid state Professional digital voice recorder (Edirol- R09, with sampling frequency of 44 kHz and 16bit).

4.4 Post recording phase

Labeled the data, selected 50 words with maximum syllable structure for present analysis due to time frame. For getting an impression, 250 words were used for marking stress..

V. Method of Acoustic analysis

Acoustic analysis was conducted using the Praat software designed by Paul Boersma and David Weenink (www.praat.org)

The developed speech corpus has been used for following three measurements in syllable nucleus of primary stressed, secondary stressed and unstressed syllables: intensity, F0 (pitch), duration. Mean Intensity and F0 were averaged over the entire duration of each vowel using the query function of praat. "Duration of each vowel in a syllable nucleus was measured from the wave form in conjunction with a wideband spectrogram. The onset and offset of second formant served as the beginning and end points, respectively, of each duration measurement", following Gordon (2004).

Second corpus is presenting a preliminary evidence of vowel quality as an acoustic correlate of stress. Here average values of First, second and third formant values of stressed and unstressed vowels were measured in stressed and unstressed syllables and presenting the evidence of reduction of vowel /a/ to /ə/ in unstressed syllable and how energy level is reducing using following methods in praat. 1. **Extracting the vowe**l of each syllable. 2. Analysis of this vowel into **formant &LPS** and to **formant burg** using Praat method menu. 3. **Draw the scatter plot F2 vs F1** which exactly gives the evidence for change in position and reduction of energy level which assumes the need of detailed study in spectral cues also.

VI. Analysis and Results

The analysis has done in each syllable structure in following way based on the proposed distributional pattern.

6.1 LLL Syllable structure

6.1.1 Intensity

In try syllabic words with all short syllable (for example: /avasaram/ "Opportunity"). shows 13 out 20 cases **Mean Intensity of syllable nucleus (**MISN) , MISN2 > =MISN1, 4 cases MISN1>=MISN2 and in very few cases MISN3 is getting almost equal intensity with MISN1 or MISN2 (Figure 4) . Average MISN1, MISN2 and M1SN3 of each speaker in all cases are given in the table: 2

IN LLL words Intensity is MaxACPS and MaxACS
Reason: 13 out of 20 cases MISN2>=MISN1
4 cases MISN1>= MISN2

The reason is in Maximum cases primary stress is getting greater means intensity than unstressed syllable.

Speakers	SN1	SN2	SN3
SIF AVGLLL	72	74	71
S2F AVGLLL	68	68	62
S3F AVGLLL	65	67	63
B1W4TSS1M	79	83	77
S1M AVGLLL	80	81	75
S2M AVGLLL	71	71	706.

Table 1: Mean Intensity of syllable nucleus in different syllable positions.

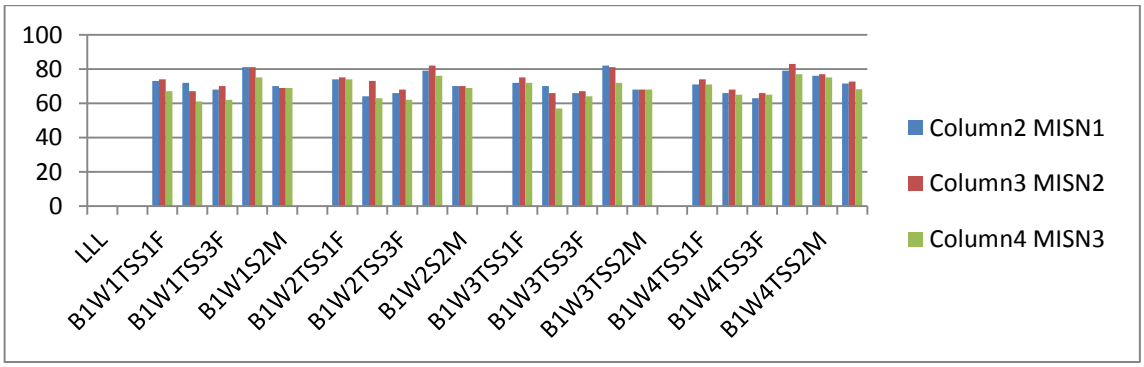

Figure 2: Graphs shows the mean intensity of syllable nucleus in trisyllabic words in each speaker.

6.1.2 Fundamental Frequency

In LLL syllable structure, **F**0 is MaxACS and MidACS. Table 5 shows the Average of syllable nucleus in different speakers.

Reason F0 of SN varies (Figure 5, Table 2)

Speakers	SN1	SN2	SN3
SIFAVGF0LLL	244.2	253.5	212
S2FAVGF0LLL	190.5	193.7	169
S3FAVGF0LLL	204	204.7	200
S1MAVGF0LLL	153.2	157.2	126.7
S2MAVGF0LLL	129.7	135.5	131.5

Table 2: Mean F0 of syllable nucleus in different syllable positions.

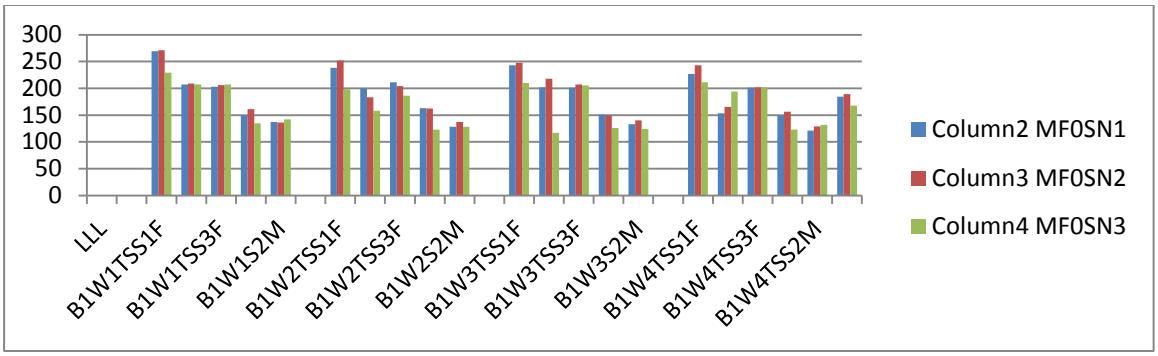

Figure 3: Graphs shows the mean F0 of syllable nucleus in trisyllabic words in each speaker.

6.1.3 Duration

LLL Words : In the case of LLL words there is only a very little variation between, Duration of Syllable Nucleus(DSN), DSN1 and DSN2 in the average duration of each speaker (Table 6, Figure 6).

Therefore, in LLL D MaxACPS and MaxACS

Reason: Here in 12 out of 20 cases DSN1>DSN2 and 3 cases DSN1>DSN2.
Here in maximum cases primary stressed vowels show slightly more duration

	ADSN1	**ADSN2**	**ADSN3**
S1F AVD DLLL	**0.07**	**0.07**	**0.0525**
S2FAVGDLLL	**0.09**	**0.075**	**0.0625**
S3FAVGDLLL	**0.0925**	**0.085**	**0.0725**
S1M AVGDLLL	**0.1**	**0.09**	**0.0575**
S1MAVGD LLL	**0.0875**	**0.0825**	**0.0675**

Table 3: Mean Intensity of syllable nucleus in different syllable positions.

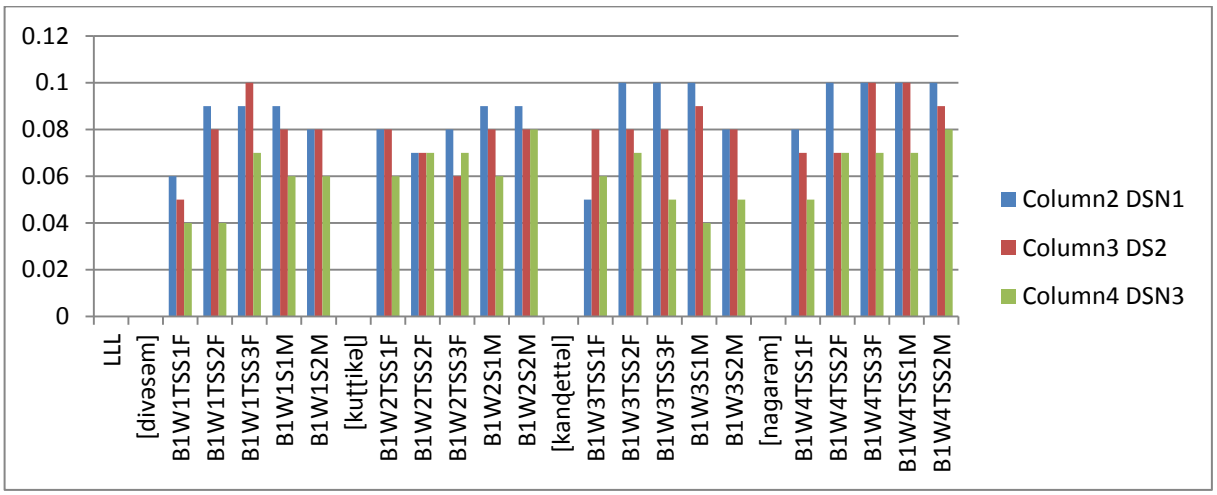

Figure 4: Graphs show the mean duration of syllable nucleus in trisyllabic words in each speaker.

LLLH

6.1.4 Intensity

In LLLH word gives the result for MISN1, MISN2 and MISN3 having higher intensity than MISN4
In LLLH I is PACPS and PACS
Reason: stressed syllables carries greater intensity than unstressed syllables and greater intensity between primary stress and secondary stress have slight variation only.

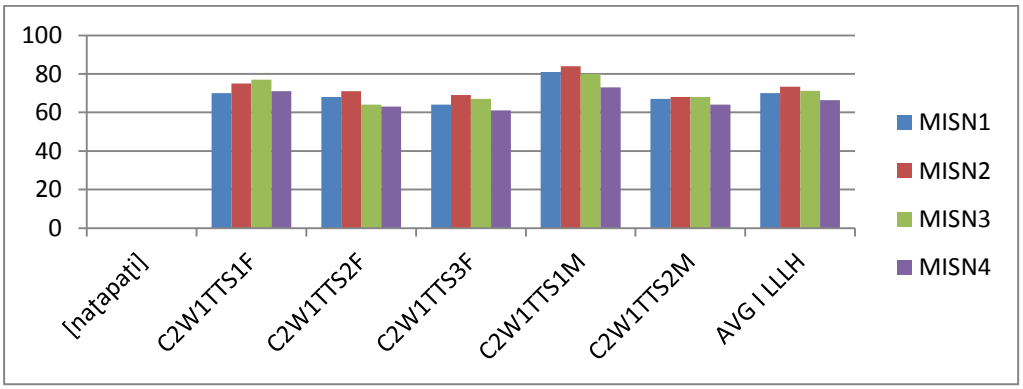

Figure 5: Graphs shows the mean intensity of syllable nucleus in trisyllabic words with LLLH in each speaker.

6.1.5 Fundamental Frequency

LLLH words with final vowel lengthening also shows the same result of greater F0 of SN in the initial syllable.

Therefore, in LLLH F0 is MaxACS and MidACS

Reason MF0SN is greater in stressed syllables in most cases and sometimes it is prominent in unstressed syllable also

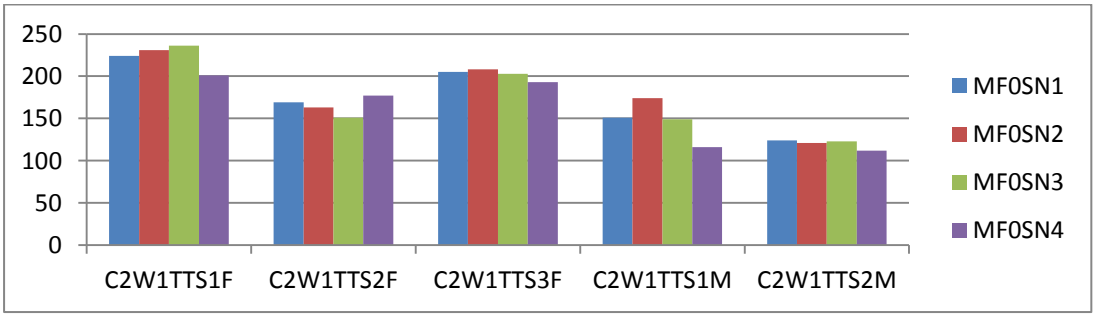

Figure 6: Graphs shows the Mean F0 of the syllable nucleus in LLLH syllables.

LLLH

6.16 Duration

Here in LLLH the larger duration of SN4 is due to final vowel lengthening in final syllable. Higher duration is not playing an important role in stress in here. Otherwise in most of the cases DSN1 is slightly greater than other syllables (Figure: 55)

LLLH word D MinACS

Reason Greater duration has no effect in stress LLLH syllable structure

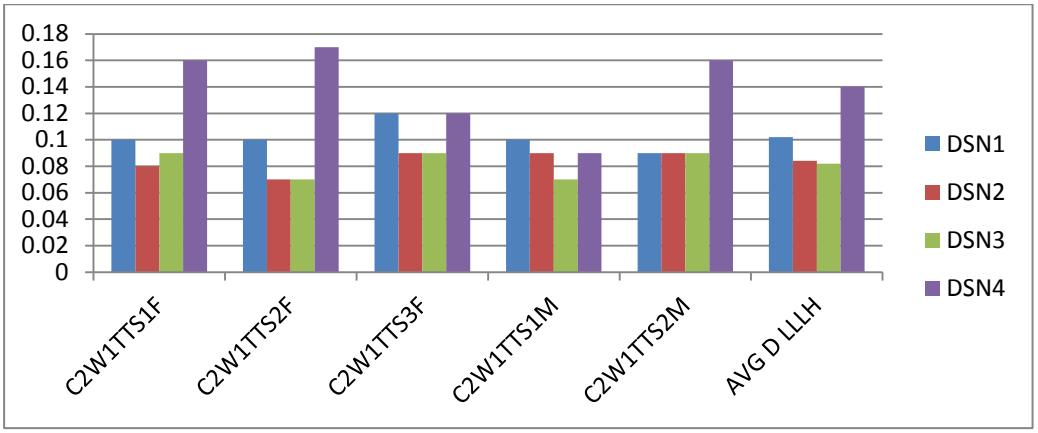

Figure 7: Graphs shows the duration of the syllable nucleus in LLLH syllables.

Syllable Structure	Mean Intensity of Syllable Nucleous	Mean F0 of Syllable Nucleous	Duration of Syllable Nucleus
LL	MaxACPS or MaxACS	MidAS	MaxACPS
LH	MaxACPS and MaxACS	MidACS	MinACS
In HH	MaxACPS & MaxACS	MaxACPS	MaxACPS
HL	MaxACPS &MaxACS	MidACS	MaxACPS
LLL	I MaxACPS and MaxACS	MidACS	MaxACPS
LHH	MaxACPS and MaxACS	MidACS	MaxACS
LHL	MaxACPS and MaxACS	MaxACS	MaxACPS
HLL	MaxACPS &MaxACS	MidACS	MaxACPS
HLH	MaxACPS and MaxACS	MidACS	MaxACPS and MinACS
HHL	MaxACPS and MaxACS	MaxACS	MaxACPS and MaxACS
HHH	MaxACPS and MaxACS	MaxACS	MaxACPS and MaxACS, MinACS
LLLL	MaxACPS ans MaxACS	MidACS and MaxACS	MaxACPS and MaxACS
LLLH	MaxACPS ans MaxACS	MaxACS and MinACS	MinACS
HLLL	MaxACPS ans MaxACS	MaxACS	MaxACPS and MaxACS

HHLL	MaxACPS ans MaxACS	MaxACS	MaxACPS and MaxACS
HHLH	MaxACPS ans MaxACS	MaxACS and MidACS	MaxACPS and MidACS
HLHL	MaxACPS and MaxACS	MaxACS and MidACS	MaxACPS and MaxACS
LHHL	MaxACPS and MaxACS	MaxACS and MidACS	MaxACPS and MaxACS
LHLL	MaxACPS ans MaxACS	MaxACS and MaxACPS	MaxACPS
LLHL	MaxACS	MaxACS	MaxACPS

Total			
MaxACPS	20	2	18
MaxACS	19	19	18
Mid ACS		6	2
MinACS			2

Table 5: Pattern in each syllable structure: Table shows the suitable output of acoustic correlates for word stress in different syllable structure.

VII. CONCLUSION

From this model, the intensity is always linked with stressed syllable, since there is very less variation between primary stressed syllable and secondary stress stressed syllable, data assumes Intensity is the Most Potential Acoustic correlate of Primary Stress (MACPS) and In fact F0 is also playing a major role, but it not always linked with stressed syllable. It must due to various phonological and phonetic reasons. Duration is also a very much reliable cue, but in very few cases it is not a cue to stress, in that context only we call it MinACS. More research is needed to reach in final conclusion. This kind model can be useful in developing the application of pronunciation lexicon through speech synthesis.

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