

Acoustic Correlates of Stress in Tone Language: A Comparison between Indian and Chinese Languages

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Abstract

As tonal languages use pitch and stress to signal a difference in meaning between words (Avery 1977), the acoustic factors which contribute to this stress patterns in Indian tonal languages may differ from the stress patterns in Chinese tonal language. Hence the present study aimed at identifying the acoustic correlates of stress in the Mizo language and Mandarin language. 10 native Mizo speakers and 10 native Mandarin speakers participated in the study. Ten phrases were selected in each language. All the speakers were asked to say those phrases in stressed and unstressed conditions. Recorded phrases of both the languages were subjected to acoustical analysis and Tone Duration, Tone Height and Peak Amplitude was measured and S-ratios for the same parameters were calculated. The results indicated that tone duration was the major cue for stress in Mizo language and both tone duration and peak amplitude were the cues of stress in Mandarin language. The obtained data will foster our understanding of the behavior of stress in Indian tonal languages as well as Chinese tonal languages.

Keywords: Stress pattern, Tonal Language, Chinese, Mandarin, Mizo.

Introduction

A tone language is one having a lexically significant, contrastive but relative pitch on each syllable (Beach, 1924). Tone language has four basic characteristics:lexically significant pitch (pitch distinguishes the meanings of words), contrastive pitch (pitch that can be differing within a functional system), relative pitch (relative height of the toneme), significant pitch unit (most frequently there is one to one correlation between the number of syllables and the number of tonemes in any specific however a syllable may have more than one toneme).

The languages of South Eastern Asia, (China, and Indo-China) and West and South Africa (Sudanic, Bantu, Bushman and the Hottentot group) are largely tonal (Tuker, 1940). In North America, various tone languages are found in South Western (Mexico, Mazateco, Otomi, Tlapaneco, Trique and Zapoteco) regions. There are very few studies on tone languages spoken in

North-Eastern part of India (Manipuri, Mizo and Naga languages), which belong to Tibeto-Burman group of the Tibeto Chinese family.

Efforts have been made to investigate the production and perception of tone in past. Researchers have tried to investigate the type of tones, its perception and cues used by the native and non native speakers for the perception, identification and discrimination of tones. Most of these studies are on Cantonese, Thai and Mandarian-Chinese languages. There are very few studies on tone languages of India. A few researchers (Radhakrishnan, 2005; Rohini, 2007) have studied the types of tone in Mizo and Manipuri languages and perception of these tones by native and non-native speakers.

Tone languages use pitch to signal a difference in meaning between words (Avery 1977), these pitch variations are an important part of the language. In these languages, word meanings or grammatical categories such as tense are dependent on stress. Stress is assigned to that syllable of a word which stands out more conspicuously. The acoustic correlate of stress varies depending on the language under the study. Stress is cued by acoustic parameters such as increased F0, increased A0, prolonged duration or change in the vowel quality. The importance of these parameters indicating stress is language dependant. Stress is the relative force with which a given sound, syllable or word is pronounced. Stress is assigned to that syllable of a word which stands out more conspicuously. It is conveyed by variation of frequency, intonation, duration and pause (Hargrove and McGarr, 1994). While in languages such as English (Bolinger, 1958; Morton & Jassem, 1965), Polish (Jassem, Morten & Steffen-Botog, 1968) and French (Rigault, 1962), Fo is the primary acoustic correlate of stress whereas duration is found to be major correlate in Swedish (Westin, Buddenhagen & Obrecht, 1966), Estonian (Lehiste, 1968a), Italian (Bertinetto, 1980), Tamil (Balasubramanyam, 1981), and Kannada (Savithri, 1987; Raju Pratap, 1991; Savithri 1999). There may be various acoustic factors which contribute to this stress patterns in tonal languages. Duration was the major cue for stress in Serbo-Croatian which is a tone language.

There are a few studies done on stress patterns in western languages. Some of them are summarized in the table 1.

Language	Author	Year	Cue for stress
French	Rigault	1952	Fo,Do
English	Fry	1955	Do, Ao
Swedish	Fant	1958	Do
English	Bollinger	1958	Fo, Do
English	Marten and Jassen	1965	Fo

Swedish	Westin et.al.	1966	Fo
Estonian	Lehiste	1968a	Do
Polish	Jassen	1968	Fo
Serbo-Croatian	Rehder	1968	Fo
Italian	Bertinetto	1986	D0

Table 1: Cues for stress in different languages (Western studies)

Very few studies on stress have been done in Indian languages. Some of the works done in Indian languages are summarized in the table 2.

Language	Author	Year	Cue for stress
Kannada	Rathna et al,	1981	Do, Ao
Kannada	Savithri	1987	Do
Kannada	Raju Prathap	1991	Do
Kannada	Savithri	1999	Do
Hindi	Ruchi et. al.	2007	Do, Fo

Table 2: Cues for stress in different languages (Indian studies)

Need for the Study

Efforts have been made to investigate the stress patterns of tone languages in the past. Most of these studies are on Cantonese, Thai and Mandarin-Chinese languages. Some studies have also concentrated on the stress patterns in tone languages of India namely Mizo and Manipuri. However, no studies have focused on the comparison of stress correlates of Indian and foreign tone language which would help in understanding universal factors related to the stress patterns in the tone languages. Thus the present study was planned.

Aim of the Study

Analyse and compare the acoustic correlates of stress in the Mizo (Indian tone language) and Mandarin language (Chinese tone language).

Method

Subjects

Two groups of subjects were considered for the present study. Group 1 consisted of 20 native Mizo speakers and group 2 consisted of 20 native Mandarin speakers in the age range of

20-23years. All the subjects were screened for speech, language and hearing and the subjects who passed the screening were chosen for the study.

Procedure

10 Mizo phrases and 10 Mandarin phrases (which had noun + adjective combination) served as the stimuli. The group 1 subjects were asked to say Mizo phrases and group 2 subjects were asked to say Mandarin phrases in two conditions; first, with no stress, i.e., speaking as naturally as possible and secondly, stressing the adjective. The stimuli were recorded using praat software with a sampling frequency of 22 KHz. Two Mizo and two mandarian native speakers listened to the recorded samples of the subjects and were asked whether the two conditions (stressed and unstressed) were produced correctly or not in their respective languages. Out of 20 subjects, no speakers' data was eliminated from the study as the stress patterns produced by all the speakers were judged appropriate by the listeners.

Analysis

All the phrases recorded were subjected to acoustic analyses using PRAAT software and the following parameters were extracted:

- a) Tone Height (TH) was measured as the difference between the starting (A) and ending point (B) of Fo contour. $TH = A - B$ (in Hz).
- b) Tone duration (TD) was measured as the time difference between the starting and ending point of the Fo contour (in ms).
- c) Peak Intensity/ Amplitude (PA) was measured as the maximum intensity in the utterance (in dB).
- d) S-Ratio i.e., difference between stressed and unstressed words for subjects of both groups were calculated and tabulated.

Further, the tabulated data was statistically analysed. Paired sample t-Test at 0.05 level of significance was done to compare the acoustical correlates of stress (Tone Height, Tone Duration and Peak Amplitude) in both Mizo and Mandarin speakers. Paired sample t test was also done to compare the S-ratio between both the languages. SPSS software (17th version) was used for analysis.

Results and Discussions

Parameters	Conditions	Mandarin		Mizo	
		Mean	SD	Mean	SD
TH	Stressed	31.9	32.3	19.15	22.3

	Unstressed	29.4	30.9	14.13	17.9
TD	Stressed	282	91.8	499.8	99.6
	Unstressed	269.9	90.0	393.7	65.6
PA	Stressed	91.3	1.6	90.1	2.6
	Unstressed	90.8	2.3	90.9	2.4

Table 3: Mean and Standard Deviation of TH, TD and PA for Stressed and Unstressed words in Mandarin and Mizo language.

Results of the paired sample t-test suggested that among group 1 subjects, there was a statistically significant difference found between stressed and unstressed conditions for TD ($t=11.7$, $p<0.05$) but not in TH and PA. Even though, TH and PA were seen to be higher in a stressed condition compared to the unstressed condition, there was no statistically significant difference noted. Thus the results suggested that the TD was a sole acoustic correlate of stress in Mizo language. Among group 2 subjects, there was a significant difference noted between stressed and unstressed condition in terms of both TD ($t=1.98$, $p<0.05$) and PA ($t=1.99$, $p<0.05$). However, TH was not statistically significant between stressed and unstressed conditions. These results suggested that the TD and PA both correlated stress in Mandarin language.

The results of acoustic analysis indicated that tone duration (TD) was the major cue for stress in Mizo language and both tone duration and peak amplitude were the cues of stress in Mandarin language. This is further evidenced by the higher S- ratio obtained for TD across both the languages. Paired sample t-test was also done between the S-ratio of Mizo and Mandarin language across all the three acoustic correlates. The results showed that there was a significant difference between the S-ratio obtained for TD ($t=5.54$, $p<0.05$) and PA ($t=4.24$, $p<0.05$) between both the languages.

Thus the results indicated that tone language speakers give stress by increasing the duration of the word or the syllable and they also perceive the stress with increased duration of the word or the syllable. The results are in consonance with the studies done on Estonian (Lehiste, 1968) Serbo-Croatian (Rehder, 1968) and Mizo and Manipuri (Litha et al, 2008) where the results suggested that the TD was major acoustic correlate of stress in tone languages. The results also indicated that unlike Indian tone language speakers, the speakers of Mandarin language use the amplitude changes with the change duration of word to cue stress patterns in their language. Thus, this data in the present supports the notion that acoustic cues of stress could differ between tone languages itself. However the common feature could be that the relative pitch (i.e.TH) is lexically significant in a tone language, i.e., change in TH changes the meaning of the word and thus cannot correlate stress in tone languages. Thus TD alone or with PA can cue stress in tone languages.

Summary and Conclusion

In this study, we analyzed the acoustic correlates of stress in Indian tone language i.e. Mizo and Chinese tone language, Mandarin. It was found that the tone duration was the major cue for stress in Mizo language while in Mandarin tone duration and peak amplitude was the major cue for stress which is in consonance with other studies in tone languages. The obtained data will foster our understanding of the behaviour of stress. It will provide a thrust to the long felt need for research in the field of stress pattern in Indian and Chinese tone languages. Further, stress analysis should be done on speech and language disorders (like Hearing impairment & dysprosody) in tone languages of world to better understand prosodic deficits in them. It will also be a useful input in text to speech synthesis and can also be used in forensic sciences in the speech identification.

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