

ACOUSTIC CORRELATES OF EMPHASIS IN TAMIL

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ABSTRACT

Stress, one of the prosodic features, refers to the degree of prominence of individual syllables of single words. The acoustic correlates of stress include fundamental frequency, duration and intensity, and their relative importance in each language is language specific. Though many authors have studied stress correlates in Tamil (Andronov, 1973; Asher, 1985; Balasubramanian, 1981; Christdas, 1988; Nagarajan, 1994), they are still highly debated because of contradictory results. Hence, the present study investigated acoustic correlates of emphatic stress by comparing acoustic parameters- frequency, intensity and duration- in stressed and unstressed words in seventeen native Tamil speakers in each gender within the age range of 18- 30 years. Ten two- word noun phrases, were read and recorded under the two conditions. The waveforms, pitch curve and intensity curve of the first word was displayed using Praat software and duration, peak frequency, and peak intensity of the first word were extracted. Results indicated duration to be a major correlate of emphasis in Tamil.

Keywords: Emphasis, stress, Tamil, frequency, duration, intensity.

INTRODUCTION

Stress indicates the most prominent syllable/word in an utterance. There are many types of stress. One of them, the *emphatic stress*, serves to highlight, focus, contrast, comment, or indicates new information and it contributes to identification of intonation pattern of a phrase/sentence (Hirst, 1977). The major acoustic cues of emphasis are fundamental frequency, duration and intensity (Lehiste, 1968a). It is generally recognized that different languages, different speakers of the same language, and even the same speaker in different contexts can make use of different complex combinations of these correlates to mark stress (Vinton, 1994), with the relative importance of these cues varying from language to language (Gandour & Weinberg, 1982). Phonetic correlates of stress must therefore be sought on a language-specific basis, and may involve several different dimensions of variation. For example, fundamental frequency is said to be major acoustic correlate of stress in French (Rigault, 1962), English (Bolinger, 1958; Morton & Jassem, 1965), and Polish (Jassem, Morten & Steffen-Botog, 1968), and duration is the main correlate in Swedish (Westin, Buddenhagen & Obrecht, 1966), Italian (Bertinetto, 1980) and Estonian (Lehiste, 1968a). Among Indian languages, duration and fundamental frequency are reported to be the major correlates of stress in Hindi (Agarwal, Ghosh, & Savithri, 2007). Among Dravidian languages, duration and intensity are reported to cue stress in Kannada (Rathna, Nataraja, & Subrahmanyaiah, 1981), duration alone is indicated to be the major cue in Kannada (Savithri, 1987; Rajupratap, 1991; Savithri, 1999a, b), Konkani (Kumar & Bhat, 2009) and Tamil (Balasubramanian, 1981). In Telugu, Sitapati (1936) and Srinivas (1992) established that intensity alone is the cue signalling stress.

In Tamil, word- level refers to sharp pitch rises occurring in stressed syllables when the context requires a particular word or syllable to be stressed (Balasubramanian, 1972). Ravisankar (1994) observed increases in pitch level associated with emphasis and contrast, as well as in loudness and duration. It is clear, however, that any word-level prominence that exists in Tamil is marked primarily through differences of F_0 and that duration and loudness, which mark stress in many other languages, are not robust correlates in Tamil, but are involved in marking contrastive focus or emphasis on initial syllables.

The phonetic correlates of phrasal stress in Tamil are contradictory. Christdas (1988), comments that pitch, intensity and duration, prime exponents of stress cross-linguistically, are all unaffected. On the contrary, extra low pitch (Nagarajan, 1994), and increase in intensity (Andronov, 1973; Asher, 1985) have been reported to be a correlate of prominence in Tamil. Duration has also been implicated by Andronov (1973), who comments that the length of vowels may be in some way dependent on accent in the colloquial language, but gives no supporting evidence. Balasubramanian (1981) claims that

vowel duration varies according to the prosodic weight of the syllable in which it occurs. Both pitch and loudness are significant correlates of emphasis in Tamil according to Vinton (1997), however, he also concluded that neither peak frequency nor peak amplitude will, by itself, always mark an emphasized item in a sentence.

As the review indicates above, there has been no conclusive/satisfactory evidence provided about the acoustic correlates of emphasis/ stress patterns in Tamil language. This study will address the issue of acoustic correlates of emphatic stress at the phrase level in Tamil language by comparing stressed words versus unstressed words.

METHOD

Participants: The subject group was constituted by 17 participants from each gender. All of them were native speakers of Tamil¹, belonging to the age group of 18- 30 years. All of them had normal oral structure and function, and no speech, language, sensory and neurological deficits.

Material: The material consisted of a list of ten two-word noun phrases, each of which had an adjective as the first word and noun as the second. They were selected by short listing from a list of 14 phrases by two native Tamil speakers on the basis of familiarity.

Procedure: Subjects were tested individually. They were seated in a quiet environment and were instructed to read the list provided to them. Initially, trial was given and they were allowed to practice speaking out the test stimuli. Following this, they were instructed to read out the 10 phrases in neutral condition (Condition 1), and in stressed condition (Condition 2) in which the first word of each phrase was stressed. All samples were recorded using an omni-directional microphone held at a constant distance of 10 cm from the mouth. The data was transferred onto the laptop memory. The audio samples were perceptually evaluated by the experimenter for correctness of stress. There were a total of $34 * 10 * 2 = 680$ tokens. Of these, only 511 tokens were analyzed further and 169 tokens were excluded as they were not perceived as emphasized.

Analysis: Using Praat software (Boersma & Weenink, 2009), Wide Band Spectrograms and waveforms, pitch contour and intensity contour of target words were displayed. Duration, peak frequency, peak intensity of the initial word in each noun phrase was measured in each condition. Figure 1 depicts the measurement of the three parameters.

Statistical analysis: Independent t- test and Repeated measure ANOVA was done using SPSS17.0 (Statistical Package for Social Sciences 17.0) to find out significant difference between conditions and gender considered as individual groups.

¹Tamil is a Dravidian language spoken by people in India, Sri Lanka, Singapore, where it has official status; with significant minorities in Canada, Malaysia, Mauritius and Burma and emigrant communities around the world by 66 million native speakers. It is one of the 22 scheduled languages of India and the first Indian language to be declared as a classical language by the Government of India (http://en.wikipedia.org/wiki/Tamil_language).

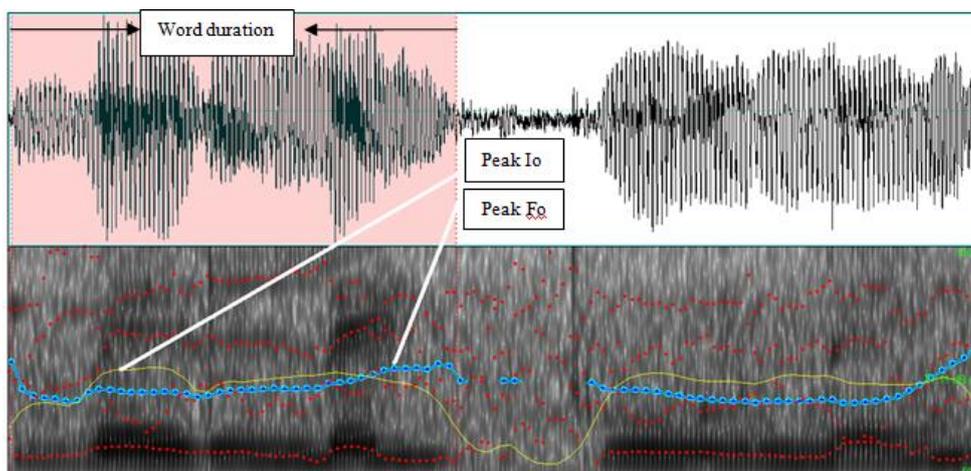


Figure 1: Shows spectrogram and the duration of the word (highlighted), peak intensity (I_0), and peak frequency (F_0) of phrase /vellai pu:nai/.

RESULTS

Results of independent t- test indicated significant difference between gender [$t = 3.472, p < 0.05$], [$t = -6.284, p < 0.05$] for F_o and I_o , respectively. In both conditions, F_o was significantly higher and I_o was significantly lower in females compared to males. Table 1 shows the duration, F_o and I_o in both genders in two conditions.

	Males – Mean (SD)		Females- Mean (SD)	
	Condition 1	Condition 2	Condition 1	Condition 2
Do (ms)	335 (40.56)	427 (62.19)	334 (32.37)	448 (55.07)
Fo (Hz)	163 (38.20)	186 (42.47)	250 (41.57)	292 (31.78)
Io (dB)	78 (5.51)	81 (5.99)	72 (3.73)	76 (3.52)

Table 1: Mean duration (ms), peak intensity (dB) and peak frequency (Hz) in 2 conditions in males and females.

Results of paired t- test showed significant difference between conditions on all parameters. D_o , F_o , and I_o were significantly longer/ higher in condition 2 compared to condition 1 in both genders [$t = 13.202, p < 0.01$], [$t = -8.426, p < 0.01$] & [$t = -8.188, p < 0.01$].

Results of 3- Way repeated measures ANOVA revealed significant difference between conditions { $F[(1, 16) = 20.15, p < 0.01]$ }, Parameters { $F[(2, 32) = 548.58, p < 0.01]$ }, and gender { $F[(1, 16) = 176.61, p < 0.01]$ }. Also, significant interaction effect of stress * parameters { $F[(2, 32) = 28.28, p < 0.01]$ }, stress * gender { $F[(1, 16) = 6.814, p = 0.01]$ }, and stress* parameters * gender { $F[(1, 16) = 27.92, p < 0.01]$ } was observed.

The data was normalised and Principle component analysis was done to find the hierarchy of cues which correlated with stress. Duration accounted for 54.4% of the variance, intensity for 25%, and frequency for 20.4% of variance. Cluster analysis was done to find the primary acoustic correlate of stress in Tamil. The results indicated duration to be the prominent cue followed by F_o and I_o . The dendrogram generated is in figure 2.

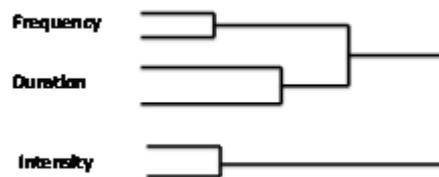


Figure 2: Shows dendrogram generated after cluster analysis.

DISCUSSION

The results yielded several points of interest. Firstly, F_o was significantly higher and I_o was significantly lower in females compared to males. The higher F_o in females can be attributed to longer vocal folds. Reduced I_o in females can be attributed to the size of the vocal tract and the radiation area. Second, all three parameters were significantly higher/ longer in condition 2 compared to condition 1. This is in consonance with the reports of earlier researchers (Balasubramanian, 1981; Bolinger, 1958; Gandour & Weinberg, 1982; Morton & Jassem, 1965; Savithri, 1987; Vinton, 1994). Third, the major cue for emphasis in Tamil was lengthening of duration. This is in agreement with other studies done in Kannada (Savithri, 1987; Raju Pratap, 1991; Savithri, 1999a, b), Konkani (Kumar & Bhat, 2009) and Tamil (Balasubramanian, 1981). In the previous study in Tamil, the experiment had included stressed and unstressed tokens in the word level and the author reported duration as the major cue for stress. He had also reported that increase in F_o occurs when the context requires a particular word or syllable to be stressed (Balasubramanian, 1972). But in other studies in Tamil, F_o has been reported to be primarily associated with emphasis and contrast, with secondary importance to loudness and duration (Ravisankar, 1994). In Tamil, the ratio of duration between short and long vowels is 1: 2 and in English it is 1: 1.6. Hence, though there is no physiologic reason for lengthening of duration during emphasis, it is apparent that in English a little lengthening of vowels results in perception of long vowels whereas in Tamil it does not. According to Lehiste (1970), intensity increase cannot be solely a cue for stress perception though stress is accompanied by

increase in loudness. This is because some phonemes are inherently high in intensity, and the intensity of phoneme may increase when F_0 coincides with the first formants. Also, intensity of a phoneme may increase owing to coarticulation. Also, the increase in subglottal pressure which is the physiological factor that accompanies stress production controls both rate of vocal fold vibration and intensity. Thus stress production is intimately connected with frequency also. Unless an adjustment is provided in the tension of the vocal folds, increased subglottic air pressure results automatically in an increased rate of vocal fold vibration. Therefore, in many languages, higher F_0 provides a strong cue for the presence of stress. But unlike French, English and Polish, which do not have vowel differences signalled by fine ratio in duration, in Tamil, phonological differences of phonemes are indicated by durational differences. Therefore, it is possible that the native speakers are very tuned to subtle differences in duration and hence perceive stress with increase in duration.

Fant (1960) comments that an increase of 3 dB intensity results in doubling of loudness and stress is perceived. In the present study the difference in I_0 between conditions was ≥ 3 dB. However, the present study did not include perceptual analysis and hence no comments can be offered on this subject. The results of the present study have contributed to literature on emphasis in Tamil. Future research on emphatic stress at sentence level is warranted.

REFERENCES

- Agarwal, R., Ghosh, K., & Savithri, S. R. (2007). Acoustic correlates of stress in Hindi. *Proceedings of the International Symposium of Frontiers of Research on Speech and Music*, 281- 283.
- Andronov, M. (1973). Observations on accent in Tamil. In H. Schiffman & C. Eastman (Eds.), *Dravidian Phonological Systems* (pp. 3- 10). Seattle: South Asian Studies Program.
- Asher, R. E. (1985). *Tamil*. London: Croom Helm.
- Balasubramanian, T. (1972). *The phonetics of colloquial Tamil*. Ph.D. dissertation, University of Edinburgh.
- Balasubramanian, T. (1981). Emphasis in Tamil. *Journal of Phonetics*, 9, 139-150.
- Bertinno, P. M. (1980). Perception of stress by Italians. *Journal of Phonetics*, 8, 385-395.
- Bolinger, D. L. (1958). Theory of Pitch Accent in English. *Word*, 14,109-149.
- Boersma, P., & Weenink, D. (2009). Praat: doing phonetics by computer (Version 5.1.05) [Computer program]. Retrieved Oct 2, 2009, from <http://www.Praat.Org/>
- Christdas, P. (1988). *The Phonology and Morphology of Tamil*. Unpublished Ph.D. dissertation, Cornell University.
- Fant, G. (1960). *Acoustic theory of speech production*. The Hague: Mouton.
- Gandour, J., & Weinberg, B. (1982). Perception of contrastive stress in alaryngeal speech. *Journal of Phonetics*, 10, 347- 359.
- Hirst, D. J. (1977). *Intonative features: A syntactic approach to English intonation*. The Hague: Mouton.
- Jassem, W.J., Morton, J., & Steffen-Batog, M. (1968). The perception of stress in synthetic speech like stimuli by polish listeners, *Speech Analysis and Synthesis*, 1, 289-308.
- Kumar, R. B., & Bhat, J. S. (2009). Acoustic correlates of stress in Konkani language. *Language in India*, 9, 329-335
- Lehiste, I. (1968a). Vowel quality in word and utterances in Estonian. *Congresses secundus internationalis finno-ugristarum*, 293-303.
- Lehiste, I. (1970). *Suprasegmentals*. Cambridge: M.I.T Press.
- Morton, J., & Jassem, W. (1965). Acoustic correlates of stress. *Language and Speech*, 8, 159-187.
- Nagarajan, H. (1994). *A Theory of Post-syntactic Phonology*. Madras: T. R. Publications.
- Rajupratap, S. (1991). Production of word stress in children-3-4 years. In M. Jayaram & S. R. Savithri (Eds.), *Research at AIISH. Dissertation Abstracts, Vol III*, (pp11- 12).
- Rathna, N., Nataraja, N. P., & Subrahmanyaiah, M. G. (1981). A Study on Prosodic Aspects of Kannada Language. *Journal of All India Institute of Speech and Hearing*, 12, 1-6.
- Ravisankar, G. (1994). *Intonation patterns in Tamil*. Pondicherry Inst. of Linguistics and culture, xvii, 431.
- Rigault, A. (1962). *Proceedings of the 4th International Congress of Phonetic Sciences, Helsinki*, pp.735-748.The Hague: Mouton & Co.

- Savithri, S. R. (1987). Some acoustic and perceptual correlates of stress in Kannada. *Proceedings of the National Symposium on Acoustics, Special edition*, pp. 209.
- Savithri, S. R. (1999a). Perception of word stress. *Proceedings of the Madras India Regional Conference of the Acoustical Society of America (2)*, 110-113.
- Savithri, S. R. (1999b). Perceptual cues of word stress in Kannada. *The Journal of the Acoustical Society of India*, 25, 1- 4.
- Sitapati, G.V. (1936). Accent in Telugu speech and verse, *Indian Linguistics*, (6), 201- 245.
- Srinivas, C. (1992). *Word Stress in Telugu and English*. Unpublished Dissertation submitted to C.I.E.F.L.
- Vinton, J. E. (1994). Phonetic Emphasis in Tamil. In S. C. Herring & J. C. Paolillo (Eds.), *UTA Working Papers in Linguistics*, 1,(pp 95- 107). Texas.
- Westin, K., Buddenhagen, R. G., & Obrecht, D. H. (1966). An experimental analysis of relative importance of pitch quantity and intensity as cues to phonemic distinctions in southern Swedish. *Language and Speech*, 9, 114-126.