# PERCEPTION OF MIZO AND MANIPURI TONES BY NATIVE AND NON NATIVE SPEAKERS

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A Dissertation submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology)
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APRIL 2007

*Dedicated to*

*"Mummy-Papa & my guide who mean lots to me"*

# CERTIFICATE

This is to certify that this dissertation entitled *"Perception of Mizo and Manipuri tones by native and non-native speakers"* is the bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student (Register No. 05SLP013). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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April, 2007

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# CERTIFICATE

This is to certify that this dissertation entitled ***"Perception of Mizo and Manipuri tones by native and non-native speakers"*** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier in any other University for the award of any Diploma or Degree.

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# DECLARATION

This is to certify that this dissertation entitled *"Perception of Mizo and Manipuri tones by native and non-native speakers"* is the result of my own study under the guidance of Prof. S. R. Savithri, Professor & Head of the Department, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any diploma or degree.

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# Chapter 1

# Introduction

Speech perception is one of the few human abilities that is almost universal in scope at birth and then improves by the selective inattention to sounds not used in the surrounding language. Historically, research in speech perception deals with how adults identify and discriminate phonetic information in the acoustic input. This focus on adults is not surprising because what investigators sought to explain was the end state-that is, how the mature listener perceived linguistic information. A challenge for these theories was to explain how listeners handle the lack of invariance in the speech stream: no one-to-one mapping between information in the acoustic waveform and the listener's percept. Many theorists proposed innate, speech-specific mechanisms to account for this fact (Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967; Repp 1982; Liberman and Mattingly, 1985). In recent times, cross-language perception has gained impetus for theoretically based research in the field of speech perception. Cross language perception in simpler terms refers to the perception of non-native contrasts by native listeners.

One of the most enduring and exciting challenges in speech perception concerns identifying the kinds of abilities the young infant brings to the speech perception process, and how these abilities are modified as a function of experience with a particular language. Developmental studies of cross-language speech perception provide an ideal way to address these questions, because one can assess the ways in which infants, children and adults perceive speech both before and after relevant listening experience. Thus cross-language perception also allows a unique perspective by identifying the perception abilities of the young infants prior to experience with any specific language and by charting age related changes in performance as a function of experience with a particular language.

The pattern of results in cross-language research has lead investigators to propose that exposure to specific phonetic contrasts during an early critical period is needed to maintain the neural elements that are innately tuned to the phonetic feature involved and, conversely, that lack of exposure to particular contrasts results in attrition of the associated neural elements (Eimas, 1975, Aslin & Pisoni, 1980).

Languages across the world vary in the type of speech sounds they use. A particular phone may be present in one language, which may be absent or may occur as allophonic variation in another language. This has captured attention of various investigator and several questions have been asked about the potential role of linguistic experience in the perception of phonological categories. The questions posed in cross-language research include (a) listener's perception abilities when he/she acquires a native language, (b) listener's ability to identify and discriminate speech contrasts that are not present in the language learning environment, (c) loss of listener's perception abilities because the neural mechanisms have atrophied due to lack of stimulation during development or are simply realigned and only temporarily modified due to changes in selective attention, and (d) the developmental changes occurring in cross-language perception.

Existing empirical research has indicated that young infants can discriminate native and non-native phonetic contrasts (Lasky, Syrdal, Lasky & Klein, 1975; Streeter & Landaner, 1976; Trehab, 1976; Aslin, Pisoni, Hennessy & Percy, 1981) but that adults and children often have difficulty discriminating non native contrast (Singh & Black, 1966; Lisker & Abramson, 1970; Goto, 1971; Miyawaki, Strange Verbrugge, Liberman, Jenkins & Fujimura, 1975; Trehab, 1976; Snow & Hoejnagel-Hohle, 1978; Mac Kain, Best & Strange, 1981; Sheldon & Strange, 1982). If such findings are true for phonetic contrasts, then it should also hold good for tones. Subjects who speak language that does not have tone should find it difficult to identify and discriminate tone, as they are not tuned to tones. Best (1995) reported that infants and adults are able to distinguish some non-native contrasts; therefore non-native speakers should also be able to distinguish tones to some extent.

Beach (1924) & Pike (1948) defined a tone language as a having lexically significant, contrastive, but relative pitch on each syllable. A tone language uses pitch to signal a difference in meaning between words (Avery, 1997).

The languages of Southeastern Asia (China, Indo-china, Siam) and West and South Africa (Sudanic, Bantu, Bushman & the Hottentot groups) are largely tonal (Tuker, 1940). In North America various tone languages are found in South-Western (Mexico, Mazateco, Otomi, Tlapaneco, Trique and Zapoteco) region.

Roughly 60-70% of the world's languages are tonal insofar as they utilize pitch to contrast individual lexical items or words. The relationship between tone and its tone-bearing unit can be described as symbiotic. While tonal contrasts are realized primarily by differences in fundamental frequency (FO) height or contour, they may also involve systematic differences in duration. The perception of duration, on the other hand, may. be influenced by the FO pattern. These types of interplay between tonal contrasts and duration are commonly reflected in the world's languages (humanities.uchicago.edu/phonlab/projects.html).

Tone languages have four basic characteristics. Firstly, *lexically significant pitch,* i.e. pitch distinguishes the meanings of words. Secondly, a *contrastive pitch* is present in tone languages. Contrastive pitch is a pitch that can be differing within a functional system. Thirdly, tone languages have a *relative pitch* that is a major characteristic in common. It is the relative height of their toneme, not their actual pitches, which is pertinent to their linguistic analysis. Finally, each syllable of a tone language carries at least one *significant pitch unit.* Most frequently there is one to one correlation between the number of syllables and the number of tonemes in any specific utterance. Tone languages may have monosyllabic or disyllabic (or trisyllabic and so on) words and morphemes (James and Bargery, 1923, 1925).

Efforts have been made to investigate the production and perception of tone in past. Researchers (Abramson, 1962; Hashimoto, 1972; Hombert, 1976; Garding and Lindell, 1977; Gandour, 1978; Gandour and Harsman, 1978; Gandour, 1983; Ching, 1990; Burnham, Francis, Webster, Luksaneeyanawin, Lacerda, & Attapaiboon, 1996; Bauer and Benedict, 1997; Qian-Jie Fu, 1998; Ye and Connine, 1999; Lui, 2000; Lee, Chiu and Van Hasselt, 2002; Liu & Samuel, 2004; Radhakrishnan, 2005; Schwanhaeusser, 2005; Lee, Tao & Bond, 2006) 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 Mandarin- Chinese languages. The results of these studies revealed the different tone patterns available in these tone languages and the tone envelope cues used by the native speakers to differentiate the tones.

The questions that arise on 'Tone' are multifold and are as follows:

- What are the tones in a given tonal language?
- Do native and nonnative speakers perceive the tone in a similar way?
- What age do children (native speaker of a tone language) acquire the tones?
- Is the auditory processing for tone perception special?

There are very few studies on tone languages spoken in north- eastern part of India (Manipuri, Mizo and Naga languages), which belong to Kuki-Chin group of the Tibeto-Chinese subfamily. Radhakrishnan (2005) analyzed production of Manipuri tones and perception of these tones by native and non native speakers, Non-native speakers comprised of 20 adult normal subjects in each group, speaking Hindi, Kannada, Malayalam, Telugu and Tamil. Results indicated (a) three simple tones (rising, falling and level) two complex tone (rising-falling, falling-rising) and one compound tone (rising-falling- rising) in Manipuri language (b) native speakers tone discrimination was significantly better than non native speakers, and (c) some tone contrasts were best discriminated and some were not discriminated by non native speakers.

As there is no information on the tonal languages of India except one study on Manipuri tones, the present study was planned. The objectives of the present study were multifold and are as follows:

1) Production of Tones

    a) Acoustic analyses of Mizo tones.
    b) Comparison of tone patterns of Mizo and Manipuri language (material will be taken from study by Radhakrishnan, 2005).

2) Tone Perception

    c) Perception of Mizo and Manipuri tones by native and non-native speakers in original and truncated (for equal word, vowel and consonant duration) condition.

A discrimination task was used to study perception of tones. It was hypothesized that (a) there will be no significant difference between native and non-native speakers on tone discrimination, and (b) there will be no significant difference between conditions (truncated and original).

The information obtained from this study will have several implications. The additional feature tone in a language poses challenge to a speech language pathologist. S/he should have the knowledge of tone; know whether a speaker properly produces the tone, and how tonal patterns differ from one tonal language to other. Further in a child with hearing impairment, or an adult with dysprosody, the task of teaching tones would be very important in a tool of a speech language pathologist. Under these conditions the knowledge of tone and its perception becomes significant. FO contour will also serve as visual cues for teaching tones in such patients. The material of this study can be used to develop a "test of tone in Mizo" and the data obtained can be used as a normative. Also, speech language pathologist can be trained to identify and discriminate tones that would help in assessing and treating patients speaking tonal languages.

# Chapter II

## Review of Literature

As the present study is on tone perception, the review will be dealt under the following headings:

(a) Tone and tone language,

(b) Tones in various tonal languages, and

(c) Studies on perception of tones.

### Tone and Tone language

Pitch in itself is not a phonological feature but a phonetic feature; it is a phonetic feature with variety of prosodic functions, and it can only be interpreted phonologically in the light of these different functions. These functions are usually assigned to one of the three broad types: *tone, accent* and *intonation. Intonation* can be distinguished from the other two, first because its domain of application is the phrase or sentence, rather than the word, and second because its function is discourse oriented rather than grammatical or lexical. *Pitch accent* involves the use of pitch in an accentual function, i.e. to give prominence to one particular element. *Tone* has lexical or grammatical significance, as an intrinsic property of morpheme, word, or grammatical construction.

The basis of tone is pitch of the voice, and pitch itself is the auditory impression produced by rate of vibration of the vocal cords, the fundamental frequency, measured by the number of cycles per second, Hertz. The physiological mechanism responsible for production of voice and for control of rate of vibration is complex but reasonably well understood. The significant point for study of tone is that speakers are able to produce, and perceive, a continuously variable vocal feature which can be exploited linguistically.

The significance of the phonetic basis of tone reveals itself in several ways, for example in determining the appropriate distinctive feature of the tone and explaining the origin and evolution of tone system. The establishment of the typology of languages based on their use of tone and related features can also not be achieved on functional grounds alone, but must take account of the phonetic nature of the parameter involved.

A tone language is a language having a lexically significant, contrastive, relative pitch on each syllable (Beach, 1924, Pike, 1948). A tone language uses pitch to signal a difference in meaning between words (Avery, 1997). The languages of Southeastern Asia (China, Indo-china, Siam) and West and South Africa (Sudanic, Bantu, Bushman & the Hottentot groups) are largely tonal (Tuker, 1940). In North America various tone languages are found in South-Western (Mexico, Mazateco, Otomi, Tlapaneco, Trique and Zapoteco) region.

Tone languages have four basic characteristics. Firstly, *lexically significant pitch*, i.e. pitch distinguishes the meanings of words. These pitch variations are important part of the language, just as stress and proper word order are in any language. In tonal languages, word meanings or grammatical categories such tense are dependent on pitch level (Crystal, 1982). For example in Mixteco (a tone language of southern Maxico) ***zuku*** means ***'mountain',*** and ***'brush'*** and the only difference between them is that first word ends in medium-pitched syllable and the second words ends in a low tone.

Secondly, a *contrastive* ***pitch*** is present in tone languages. Contrastive pitch is a pitch that can be differing within a functional system. Thus within a system of English sound [p] is different from or contrasts with [b], as seen in ***pan*** vs ***ban,*** similarly *No!* from a contrast with *No?* and so on. The contrastive, lexical units of sound are phonemes, or in tonal analysis, Tonemes. In tone language the pitch contrasts or significant pitch differences entail one pitch being kept different or separate from another pitch in the immediate context. Two pitches may contrast by one of them being relatively higher than the other. On the other hand, rising pitch may contrast with a falling pitch, or one rising pitch with a second pitch which, relatively rises higher.

Thirdly, tone languages have a ***relative pitch*** that is a major characteristic in common. It is the relative height of their toneme, not their actual pitches, which is pertinent to their linguistic analysis. It is immaterial to know the number of vibrations per second of a certain syllable. The important feature is the relative height of a syllable in relation to preceding and following syllables. A man and a woman may both use the same tonemes, even though they speak on different general levels of pitch. Either of them may retain the same tonemes while lowering or raising the voice in general, since it is the relative pitch of syllables within the immediate context they constitutes the essence of tonemic contrast.

Finally, each syllable of a tone language carries at least one ***significant pitch unit.*** Most frequently there is one to one correlation between the number of syllables and the number of tonemes in any specific utterance (eg: Mixteco). In some languages, however a syllable may have more than one toneme (e.g. Mazateco), as said by Pike & Pike (1974). Tone languages may have monosyllabic or disyllabic (or trisyllabic and so on) words and morphemes (James and Bargery, 1923-1925). It is however convenient to consider that the tonemes are basic to or inherent in the lexical form of the words and their syllables. Each syllable in a tone language has pitch as fully basic to the words in which it occurs. However, some of the tonemes may be replaced by others in the grammar of tone languages.

In tone languages (e.g., those of Asia, Central America and West Africa - e.g., Thai, Mixtec, and Yoruba), over and above vowel and consonant variations, words are distinguished by lexical tone. Tone consists primarily of variations in the level and/or contour of the fundamental frequency (FO) of syllables (Gandour & Harshman, 1978) perceived by the listener as pitch. Other acoustic features also figure in tone distinctions - physical duration, the second formant, F2 (perceived vowel backness, e.g., *IV* to /u/), voice quality (perceived as vowel quality), and amplitude (perceived as loudness) (Abramson, 1978; Henderson, 1981; Tseng, Massaro, & Cohen, 1985). Tone is unique because it can be considered to be both a segmental and suprasegmental feature of speech. From a functional perspective, tones can be considered to be segments, for a change in tone within a word results in a change of meaning, just as a change of a consonant or vowel does. However, from a structural perspective tones can be considered to be suprasegmental because they are carried upon vowels, and tones extend across at least one syllable in tone languages.

Given the widespread use of tone in the world's languages (Fromkin, 1978; Yip, 2002) the study of tone is important. More than 70% of the world's languages are tone languages (Yip, 2002) and over half the world's population speak a tone language (Fromkin, 1978) yet speech perception research has typically focused on consonants and vowels and not on tones.

Maddieson (1979) assembled reliable data on tone systems through a survey of a large sample of tone languages. Simple two-tone systems are the most frequent; added tones reduce the frequency of occurrence. While two- and three-tone systems generally have only level tones, both level and contour tones are commonly included in four-tone systems. Five-tone systems generally include level, rising and falling tones, while contours that move in the same direction but differ in the amount of pitch change are typically found only in large tone inventories. Thus, the commonest inventories exploit only contrasts of pitch level, larger inventories add contrasts on a dimension of direction of movement, and only the most elaborate and least common inventories are likely to use contrasts of amount of change. These dimensions correspond in ranking with the cognate perceptual dimensions of *average pitch*, *direction*, and *slope* found by Gandour and Harshman (1978). Here the ranking implies, roughly, that subjects relied most on the average pitch dimension to discriminate between tones, and then next they relied on the direction dimension, and so on. The correspondence between the two rankings suggests that tone inventories are elaborated by recruiting progressively less salient perceptual dimensions.

Tones in various tonal languages

*Tones* of several languages have been identified. *Cantonese* (Hong Kong) has six contrastive lexical tones (Chao, 1947; Kao, 1971). Tone 1 has been described as *high falling* or *high level,* tone 2 as *high rising,* tone 3 as *high-mid level,* tone 4 as *low falling* or *low level,* tone 5 as *low rising* and tone 6 as *low-mid level. Mandarin* (Taiwan) has four contrastive lexical tones (Chao, 1948; Chuang, 1972; Cheng, 1973). Tone 1 has generally been described as *high level,* tone 2 as *high rising,* tone 3 as *low falling rising* or *low level,* and tone 4 as *high falling. Porto-Maxtecan* has 14 tones, 8 of these patterns reconstruct with considerable regularity and appear to have been in basic forms and other six are tone patterns are reconstructed from the sporadic appearance of high tones in other languages which occur only during sandhi (Longacre, 1957). *Thai* (Bangkok) also has five contrastive lexical tones on long unchecked syllables (Gandour, 1975), traditionally labeled *mid, low, falling, high, rising. Yoruba* has four tones labeled *high level, high, low falling rising, and high rising* (Hombert, 1976). Northern Kammu has three different kinds of fundamental frequency patterns *falling, level, and level-falling* (Garding & Lindell, 1977). *Taiwanese* has five contrastive lexical tones on long unchecked syllables (Zee, 1978). These five tones have been impressionistically labeled *high level, high falling, low falling, mid level, low rising* or *high rising. Manipuri* (North-eastern part of India) has three simple tones (rising, falling and level) two complex tone (rising-falling, falling-rising) and one compound tone (rising-falling- rising) (Radhakrisnan, 2005)

Thus in terms of tonal inventory, Porto-Maxtecan has fourteen, Manipuri and Cantonese has six lexical tones, Mandarin and Yoruba have four, and Taiwanese and Thai both have five, Kammu has three and Manipuri has 6 tones.

**Studies on perception of tone**

Cross-linguistic influences on lexical tone perception have been frequently reported both in behavioral and brain-imaging studies. Several studies have been conducted on *tone identification.* Liang (1963) found that 94.6% correct tone recognition can be achieved with the speech high-pass filtered at 300 Hz. He argued that this high level of tone recognition in the high pass filtered speech is due to the residue pitch, extracted from the harmonic information and termed as the "phenomenon of the missing fundamental". Liang also found that 64% tone recognition can be achieved in whispered speech in which neither fundamental frequency nor the harmonic fine structure was present. The whispered speech results indicated that the temporal envelope could also encode information for tone recognition. However, other studies found that tonal contrasts were not well preserved in whispered speech (Abramson, 1972). Although the F0 pattern is the dominant cue for tone recognition, other acoustic cues can contribute to tone recognition. For example, Ching (1984) investigate the identification of Cantonese tones and reported 32 % identification. Lui (2000) reported 66 % identification of Cantonese tones.

Fok's (1974) listening tests on the perception of Cantonese tones found that tones were sometimes misidentified, but that not all six tones (Tone 1 has been described as ***high falling*** or ***high level,*** tone 2 as ***high rising,*** tone 3 as ***high-mid*** differences were observed for minimal pairs, whereas consistently different fundamental frequency of the pair was found to carry a fundamental frequency contour 20-25 Hz higher than the "low-tone" member.

Abramson (1977) studied noncategorical perception of tone categories in Thai. 34 native speakers of Thai, a language with five phonemic tones, discriminated sixteen flat Fo variants synthesized on a syllable of the type [kha:] sorted into the three "static" high, mid and low tones with considerable overlap. Discrimination tests yielded a high level of discrimination across the continuum with no effects of boundaries between categories, thus implying noncategorical perception of tone categories.

Using an individual differences multidimensional scaling model of perception, Gandour (1977) determined what dimensions underlie the perception of linguistic tone, and to what extent an individual's language background (Thai, Yoruba, or American English) influences his perception. Dissimilarities data were obtained from subjects paired—comparison judgments of thirteen different pitch patterns superimposed on a synthetic speech like syllable. A multidimensional scaling analysis of the data for the total group revealed that five dimensions—interpretively labeled, average pitch, direction, length, extreme endpoint and slope—best summarizes the perceptual structure underlying the dissimilarities data. Language subgroup variation in relative importance of these dimensions appeared to be primarily related to subgroup differences in the way pitch is used to convey linguistic information. Discriminant analysis showed that most individual speakers of a tone language (Thai or Yoruba) could be easily distinguished from speakers of a nontone language

(English) on the basis of their distinctive patterns of perceptual saliency for these five dimensions. Using an individual differences multidimensional scaling model of perception, Gandour (1977) determined what dimensions underlie the perception of linguistic tone, and to what extent an individual's language background (Thai, Yoruba, or American English) influences his perception. Dissimilarities data were obtained from subjects paired—comparison judgments of thirteen different pitch patterns superimposed on a synthetic speech like syllable. A multidimensional scaling analysis of the data for the total group revealed that five dimensions—interpretively labeled, average pitch, direction, length, extreme endpoint and slope—best summarizes the perceptual structure underlying the dissimilarities data. Language subgroup variation in relative importance of these dimensions appeared to be primarily related to subgroup differences in the way pitch is used to convey linguistic information. Discriminant analysis showed that most individual speakers of a tone language (Thai or Yoruba) could be easily distinguished from speakers of a nontone language (English) on the basis of their distinctive patterns of perceptual saliency for these five dimensions.

Gandour (1978) studied the extent of FO differences that could provide sufficient cues for the identification of the tonal categories. Representative tokens of /klang / 'stone' and /klang/ 'kite', as spoken in phrase final position, were chosen for subsequent analysis. The stimuli were presented on a tape recorder at a comfortable listening level. The subject (an adult male native speaker of Northern Kammu) was instructed to identify the stimulus as either /klang/ 'stone' or /klang/ 'kite', by checking one of two columns on the answer sheet - one column headed by a picture of a stone, the other headed by a picture of a stone, the other headed by a picture of a kite. Results revealed that the identification response reached a peak of 100% for at least six stimuli along the fundamental frequency continuum.

Listeners gave consistent /klang/ 'stone' responses for the ***low falling*** stimuli, but sometimes gave /klang/ 'kite' responses for the ***low level-falling*** stimuli. For the high falling and high-level falling stimuli, the situation was reversed. The listeners gave consistent /klang/ 'kite' responses for the ***high level falling*** stimuli, but sometimes gave /klang/ 'stone' responses for the ***high falling*** stimuli. These results lead to hypothesize that Northern Kammu speakers rely on ***integrated pitch*** *values* rather than the configuration of the fall in distinguishing high-tone and low-tone words. This hypothesis is consistent with level-falling fundamental frequency patterns which are observed to favor a high-tone labeling response, and a low-tone labeling response. The results indicated that fundamental frequency contours provided sufficient cues for the identification of the two tonal categories in Northern Kammu. Three different kinds of fundamental frequency patterns -***falling, level, and level-falling*** - may serve to differentiate the tonal categories. Listener's identifications strongly suggest that the tonal contrast in Northern Kammu is one of high versus low rather than high falling versus low-falling.

In another study, Gandour (1978) investigated the fundamental dimensions - average pitch, endpoint, extreme endpoint and length - underlying English listeners' perceptual judgements of tones and assessed the degree and kinds of individual differences in their tonal perception. He used 13 different tonal patterns. There were three level tones, ten contour tones, five falling and five rising. Twenty- four native speakers of American English participated in the experiment. Most subjects were recruited from undergraduate classes in linguistics. None of the subjects had any known speech or hearing defects. Subjects were told that they were going to hear words from a foreign language, and that these words all had the same sequence of consonant and vowel but different pitch patterns. The stimulus set was played twice to acquaint the subjects with the nature and range of pitch variations between the 13 tones. They were then told that their task was to report their impression of how different the pitch patterns were between those words, by circling an appropriate number on an 11- point dissimilarity scale (0 = no difference; 5 = medium difference; 11 = extreme difference). They were also told to ignore any other differences between the words that they might hear. Four blocks of trials were presented, each block consisting of 19 trials, yielding a total of 364 paired- comparison judgements, four judgements for each stimulus pair. Stimuli were presented on an Uher Model IC-4000 tape recorder over a loudspeaker in a conventional classroom setting.

Results revealed that of the four dimensions that emerged from the analysis, none appear to be related to the direction of pitch movement or slope of pitch contour. The first dimension indicates that subjects emphasized the *average pitch height* in making their dissimilarity ratings. The fact that this dimension was the most important for the majority of subject's clearly reinforces the psychological reality of pitch height as a fundamental dimension of tone perception. The second and third dimensions, in particular, indicate that subjects placed considerable emphasis on the *ending point* rather than the beginning point of the stimulus tones. Since the group of English subjects cannot be conveniently partitioned into meaningful subgroups, it is not possible to attribute individual differences in dimension weights to any special characteristic of subgroups of individuals. These English data, however, constitute a part of a multidimensional scaling study of tone perception across typologically and genetically unrelated languages.

Gandour (1983) investigated the perceptual dimensions of tone and the effect of linguistic experience on a listener's perception of tone, specifically, the number and nature of perceptual dimensions of tone and to what extent individual differences in tone perception are influenced by a listener's language background. Major questions addressed in this study included (a) do speakers of tone languages employ the same number and type of perceptual dimensions?, (b) is it the case that speakers of typologically and genetically unrelated tone languages employ the same underlying dimensions?, and (c) is it possible to relate differences in perceptual saliency of dimensions across languages to abstract structural properties of phonological systems (number and type of lexical tones and tone sandhi rules)? Five languages were selected for this study of tone perception: four tone languages of the Far East (Cantonese, Mandarin, Taiwanese, Thai) and one nontone language (English).

Fifty listeners from each of four oriental tone languages (Cantonese, Mandarin, Taiwanese, Thai) and fifty listeners from a nontone language (English) were asked to make direct paired- comparison judgements of tone dissimilarity. The stimulus set consisted of 19 tones. This particular set reflected pitch distinctions commonly found in tone languages of the world, including the four languages of their sample. The stimulus set was played twice in order to acquaint subjects with the nature and range of pitch variation between the 19 tones. They were instructed to report their impression of how different the pitch patterns were between pairs of these words, by circling an appropriate number on an 11-point dissimilarity scale (0 = no difference, 11 = extreme difference), and to ignore any other differences between the words they might hear. Four blocks of trials were presented, each block consisting of 190 trials, yielding a total of 760 paired- comparison judgements, 4 judgements for each pair of stimulus tones. For each subject, a 19 x 19 symmetric dissimilarities matrix was constructed by averaging the four scaling judgements for each pair of stimulus tones.

Results revealed that on an average, listeners from a nontone language attached more importance to the *height* dimension than did listeners from three (Cantonese, Mandarin, Taiwanese) of the four tone languages. Listeners from the three Chinese tone languages placed more emphasis on this dimension in comparison to Thai listeners. The nontone language group of listeners gave less weight to the *direction* dimension than did listeners from all four languages. Thai listeners attached greater importance to the 'direction' dimension in comparison to listeners from all three Chinese tone languages. Regardless of language group, however, listeners generally placed relatively more emphasis on the 'height' dimension. Since English has no lexical tones, English listeners directed their attention almost exclusively to the level fundamental frequency characteristics of these monosyllabic stimuli. In Cantonese, four of the six tones were relatively homogeneous in direction of movement of fundamental frequency. Thus, Cantonese listeners attached relatively more importance to the 'height' dimension than either Mandarin or Taiwanese listeners.

For speakers of a tone language, a close functional association exists between segmental structure and $F_O$ contour (i.e., tone) in speech because both dimensions are needed to identify words. Using the speeded classification paradigm, which does not require lexical access, the hypothesis that segmental and tonal dimensions are perceptually more strongly integrated for speakers of a tone language (Mandarin Chinese) than for speakers of a nontone language (English) was examined by Repp & Lean (1990). In four classification tasks, requiring attention to one dimension (either segmental or tonal) of CV syllables while ignoring the other, *both* subject groups showed strong interference from orthogonal variation in the unattended dimension. The Chinese subjects showed significantly more interference than the English subjects in only one of the four tasks (vowel classification with irrelevant tonal variation). These findings thus provide only weak evidence of differences between Chinese and English speakers in the perceptual integrality of segments and tones.

Burnham, Francis, Webster, Luksaneeyanawin, Lacerda, & Attapaiboon (1996) conducted study in order to determine whether English speakers perception of pitch variations in lexical tones is improved when they are able to process these as non-speech. Subjects were 144 adults (48 native English speakers, 48 native Thai speakers, and 48 native Cantonese speakers). Three stimulus sets were created; speech, filtered speech and music, each comprising 3 exemplars of each of the 5 Thai tones. Results revealed that English speakers perceived pitch variation in filtered speech and music better than the same pitch variations presented as lexical variations in speech. Thus that the perception of a basic psychodynamic dimension, pitch is compromised in linguistic contexts in which it is irrelevant. Presumably such attenuation is attentional and allows the listener to concentrate on the important features in their linguistic environment. Tonal language speakers performed equally well in all three contexts showing that tone perception development does not involve augmentation of underlying psychoacoustic abilities, which presumably have biological limits. However, the Reaction time results for Thai speakers show that within these limits, linguistic experience with a particular dimension, lexical tone, results in subtle change in the manner in which phonologically relevant variations are perceived. This appears to be specific to the actual variations in the ambient language as the differential reaction time results for Thai and Cantonese speakers demonstrate. These results point to English speakers' difficulty in discriminating linguistic but not non-linguistic tone distinctions, an effect that has been shown by Gandour, Wong, and Hutchins (1998) to reflect differences in neural activation. Gandour and colleagues found that Thai speakers' discrimination of lexical tone activated left hemisphere language regions because lexical tone is phonologically significant in the Thai language. However, such activation was *not* observed for Thai listeners presented with non-linguistic pitch variations nor was it for English listeners' discrimination of either non-linguistic pitch or lexical tone.

Moorea and Jongmanb (1997) investigated speaker normalization in perception of Mandarin tone 2 (midrising) and tone 3 (low-falling-rising) by examining listeners' use of FO range as a cue to speaker identity. Two speakers were selected such that tone 2 of the low-pitched speaker and tone 3 of the high-pitched speaker occurred at equivalent FO heights. Production and perception experiments determined that turning point (or inflection point of the tone), and AFO (the difference in FO between onset and turning point) distinguished the two tones. Three tone continua varying in either turning point, AFO, or both acoustic dimensions, were then appended to a natural precursor phrase from each of the two speakers. Results showed identification shifts such that identical stimuli were identified as low tones for the high precursor condition, but as high tones for the low precursor condition. Stimuli varying in turning point showed no significant shift, suggesting that listeners normalize only when the precursor varies in the same dimension as the stimuli. The magnitude of the shift was greater for stimuli varying only in AFO, as compared to stimuli varying in both turning point and AFO, indicating that normalization effects are reduced for stimuli more closely matching natural speech.

Liu & Samuel (2004) used a combination of acoustic analysis, signal-processing techniques, and perceptual tests to examine how lexical tone perception depends on different mixtures of cues in different situations. The primary cue to lexical tone identity is the fundamental frequency (F0) contour, with each tone associated with a particular F0 pattern. Twelve native mandarin speakers participated. Two served as speakers and 10 served as listeners. Eighty Mandarin monosyllables comprising 20 stimulus sets were selected from a Chinese dictionary. Within each set, the same syllable (e.g. 'Feng') was used four times, once with each of the four tones. A list of the stimuli, with Mandarin phonetic symbols (Pinyin) and with IPA transcriptions was made. One male and one female, read the 80 mono syllables into a microphone that was interfaced to a Pentium III 450 computer. The signal was amplified, low-pass filtered at 5.5 k Hz, and digitized (12 bit A/D) at 11 k Hz. Listeners used three response buttons: one was for stimuli perceived as Tone 2 and another was for stimuli perceived as Tone 3, and the third button was for Tone 1 or Tone 4 (or for any other percept; we included the "other" option in case the signal processing had disrupted tone perception, although in practice this did not seem to occur). The participants were told to push the corresponding button for whatever tone they perceived. For both tone 2 and tone 3 stimuli, tone recognition was 75-80 % accurate. This level of performance is consistent with a number of studies that support a role for additional cues such as tone duration (Blicher, Diehl, Cohen, 1990) and amplitude contour (Fu & Zeng, 2000), and for the correlation of several cues (Nearey, 1997; Kluender & Lotto, 1999; Fu & Zeng, 2000).

Radhakrishnan (2005) analyzed production of Manipuri tones and perception of these tones by native and non-native speakers. Four groups with 20 subjects (10 males and 10 females) in each group in the age range of 18-25 years participated in the study. Non-native group comprised of Hindi, Kannada, Malayalam, Telugu and Tamil speakers. Forty-five Manipuri word pairs differing in tone were iterated thrice and randomized to form 135 word pairs as material of the study. Subjects were individually tested and the material was audio presented through headphones at comfortable listening levels. Subjects were instructed to record ***'same'*** **or** ***'different*** on a given binary-forced choice format Results indicated (a) three simple tones (rising, falling, and level) two complex tone (rising-falling, falling-rising) and one compound tone (rising-falling- rising) in Manipuri language, (b) native speakers tone discrimination was significantly better than non native speakers, and (c) some tone contrasts were best discriminated and some were not discriminated by non native speakers. He commented that there were also other acoustic cues, which coexisted with the tone contrast which might have helped the non-native speakers for tone perception. These were aspiration, consonant duration, stress on word initial consonant, lengthened vowel and word duration, and distorted vowel.

Schwanhaeusser (2005) studied lexical tone and pitch perception in tone and non-tone language speakers. In Experiment 1 tonal (Mandarin, Vietnamese) and non-tonal (Australian) adults were tested for identification and discrimination on speech and non-speech (sine-wave) tone continua. Tonal language speakers' category boundaries and discrimination peaks were near the middle of the asymmetric continuum, whereas non-tonal speakers used an acoustically flat stimulus as a reference, indicating that tone space is linguistically oriented in tonal, and acoustically oriented in non-tonal language speakers. In Experiment 2, three tonal language (Thai) groups (musicians, perfect pitch musicians, and non-musicians) were tested on two new continua represented as speech or sine-wave tones. Identification boundaries were in the middle of the continuum for most participants. In discrimination, the flat stimulus was used as a perceptual anchor, and this was independent of musical background, indicating that the musical Thai participants use the same mid-continuum strategy as the Mandarin and Vietnamese speakers in identification, but the flat no-contour strategy in discrimination. Hence, perception depends on the type of task in Thai speakers: it is linguistic in identification, but acoustic in discrimination.

Lee, Tao & Bond (2006) conducted four experiments to examine how well Mandarin tones can be identified with partial acoustic information and whether native and non-native listeners show differences in the use of the limited acoustic information. Twelve minimal tone pairs including all six tonal contrasts in Mandarin were digitally processed to generate four types of stimuli: silent-center, center-only, onset-only, and intact syllables. The stimuli were presented in the original carrier phrase, excised from the carrier phrase, or excised and pasted onto another carrier phrase. Participants included 40 non-native speakers with 1-3 years of Mandarin instruction at Ohio University and 40 native speakers. Both learners and native speakers could identify the tones under all modification conditions at better than chance levels. For both groups, the onset-only syllables were the most difficult. Tone

2 received the fewest correct identifications and longest response times, being confused with tone 3.

The review indicated that the perception of tones by non-native speakers is also better than chance and the reasons may be that the identification/discrimination of tones depends on the height, duration as well as amplitude. However, there is no information on the tonal languages of India except one study on Manipuri tones. Thus, the present study investigated the perception of Mizo tones by native and non-native speakers. The study also compared the perception of Mizo and Manipuri tones.

# Chapter III

# Method

Two experiments were conducted in this study. Experiment I involved acoustic analysis and experiment II involved perceptual analysis.

**Experiment I: Tones in Mize**

**Experiment I (A): Acoustic Analyses of Mizo Tones**

**Subject:** A 20-year-old native Mizo speaking adult female volunteered as subject for the study.

**Material:** Twenty-four monosyllabic Mizo words differing in tone and having 2 or 3 lexically significant meanings were collected. Out of 24 words, 17 words had two meanings and 7 words had three meanings. These words as spoken 5 times by the subject were audio-recorded using a unidirectional microphone at sampling frequency of 16 kHz, digitized using a 12-bit A/D converter and were stored onto the computer memory. A total of 55 words were audio-recorded five times. Table 1 shows the material.

| Mizo words | No. of lexically significant meaning | Different meanings of the Words |
|---|---|---|
| ban | 3 | Pillar, reach, sticky |
| bang | 2 | Resign, wall |
| bel | 3 | Vessel, stick, rely |
| beng | 3 | Slap, ear, stuff |
| chang | 3 | Bread, answer, next in size |
| chum | 2 | Cloud, boil |
| kal | 2 | Go, kidney |
| kawng | 3 | Road, waist, bald |
| khur | 2 | Shake, pit |
| klai | 2 | Late, satisfied |
| lai | 2 | Digging, middle |
| lang | 2 | Appear, float |
| lei | 3 | Buy, bridge, tongue |
| mit | 2 | Eye, extinct |
| ngun | 2 | Bangle, frequent |
| nou | 2 | Cup, soft |
| shrwak | 2 | Throat, scold |
| thang | 3 | Popular, oily, trap |
| thing | 2 | Shake, free |
| thuk | 2 | Deep, stove |
| tlan | 2 | Run, save |
| zai | 2 | Sing, cut |

Table 1: Original material.

**Procedure:** Two Mizo speakers identified the tones in all the 55 words. Out of the five iterations, 51 words identified to have correct tones were subjected to acoustic analyses using SFS (Speech Filling System) software and the following parameters were extracted from the FO contour:

a) *FO contour* of the syllable was defined as rising, falling or level depending on the change in FO. Figure 1 illustrates the FO contour.

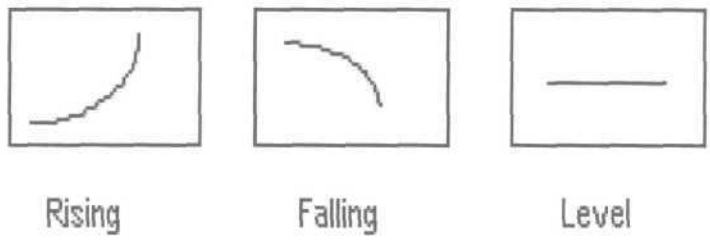


Figure 1: Illustration of FO contours.

b) *Tone Height* (TH) was measured as the difference between the starting (A) and ending point (B) of FO contour. TH = A - B (in Hz). Figure 1 illustrates the measurement of tone height and duration.

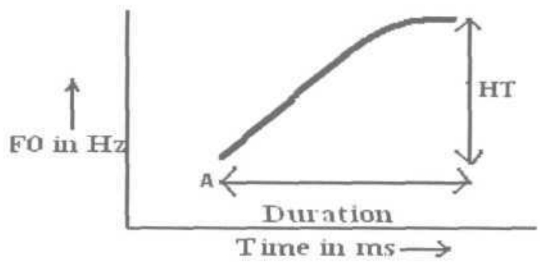


Figure 2: Illustration of tone height and duration.

c) *Tone duration* (TD) was measured as the time difference between the starting and ending point of the FO contour (in ms). TD = B-A (figure 2).

d) *Speed of tone transition* (STT) was measured as the shift in FO per unit time using the formula, STT = TH/T (Hz/ms).

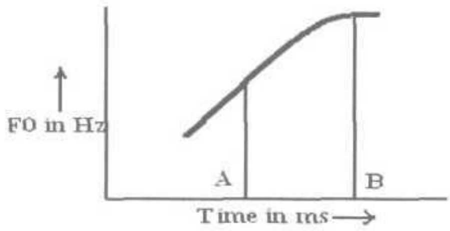


Figure 3: Illustration of tone transitions (point A to B in figure)

**Experiment I (B): Comparison of Manipuri and Mizo tones**

Tone patterns of Mizo words obtained in experiment I (A) were compared with the Manipuri tone patterns (Radhakrishnan, 2005).

**Experiment II: Perception of Mizo and Manipuri tones by native and non-native speakers.**

**Subjects:** Four groups of subjects - two speaking tonal and two non-tonal languages - participated in the study. In each group, there were 10 males and 10 females in the age range of 18-25 years. Group I and II had Mizo and Manipuri native speakers, respectively and group III and IV had Kannada and Hindi native speakers, respectively. Subjects were matched for age, gender and educational qualification. They were pursuing graduate or postgraduate degree from different colleges in Mysore. None of the subjects had any hearing, otorhinolaryngological or neurological problems as screened by the experimenter.

**Material**

**Condition (1) - Mizo original tones:** Fifty-one words were selected from experiment I (A). Each word was paired with the same but contrasting tone. Thirty-six minimal word pairs contrasting in tones were formed. Also, 51 words with same tones were paired. These pairs were used as check. Pairing of words was done using PRAAT software. Thus, a total of 87 word pairs formed the material for the study.

**Condition (2) - Mizo truncated stimuli:** The same 87 word pairs were used. However vowel, consonant and word duration in the two words in a pair was kept constant by truncating the durations using PRAAT software. Truncation was dependent upon just noticeable difference (JND) for duration. JNDs were obtained for vowel /a/ and consonant /*ml* from 10 subjects. Subjects discriminated pairs of/a/ and /*ml* differing in duration. The mean JND was 40 ms. Thus, durations longer than 40 ms were truncated.

**Condition (3) - Manipuri truncated stimuli:** Radhakrishnan (2005) analyzed production of Manipuri tones and perception of these tones by native and non-native speakers. Native speakers tone discrimination was significantly better than non-native speakers and some tone contrasts were best discriminated and some were not discriminated by non-native speakers. He commented that there were also other acoustic cues, which coexisted with the tone contrast. These were aspiration, consonant duration, stress on word-initial consonant, lengthened vowel and word duration, and distorted vowel. Material from his study i.e. 15 minimal tone pairs were given to a native Manipuri speaker for identification of tones. Of these 15 tone pairs, 10 were identified to have correct tone. These 10 word pairs differing in tones were truncated for duration using PRAAT software such that the vowel, consonant and word duration was constant in the two words in a pair. Following truncation, 10 minimal word pairs differing in tone and 20 word pairs with same tones were formed. Truncation of duration was based upon JND. Thus, a total of 30 word pairs formed the material.

Stimuli for perception study included 3 conditions of tone pairs. Conditions (a) consisted of 87 Mizo original tone pairs (36 different and 51 same tones pairs), Conditions (b) had 87 Mizo truncated tone pairs (36 different and 51 same tones pairs), and Conditions (c) included 30 truncated Manipuri tone pairs (10 different and 20 same pairs). Inter-stimulus duration of 3000 ms and intra-stimulus duration of 500 ms was maintained between and within the stimulus pairs, respectively. Tone pairs in each condition were iterated 3 times and randomized. Thus, a total of 612 word pairs formed the material (table 2).

| *Mizo words* | *Different tone pairs* | *Same tone pairs* |
|---|---|---|
| ban | GF-SF, SF-L, GF-L | GF-GF, SF-SF, L-L |
| bang | FRF-FR | FRF-FRF, FR-FR |
| bel | L-SF, SF-GF, L-GF | L-L, SF-SF, GF-GF |
| beng | RF-FLF, FLF-SF, RF-SF | RF-RF, FLF-FLF, SF-SF |
| chang | SF-GR, GR-L, SF-L | SF-SF, GR-GR, L-L |
| chum | RF-GF | RF-RF, GF-GF |
| kal | RF-FRF | RF-RF, FRF-FRF |
| kawng | GR-SF, SF-L, GR-L | GR-GR, SF-SF, L-L |
| khur | FR-L | FR-FR, L-L |
| klai | FR-GR | FR-FR, GR-GR |
| lai | SF-RF | SF-SF, RF-RF |
| lang | GF-SR | GF-GF, SR-SR |
| lei | SR-GF, GF-GR, SR-GR | SR-SR, GF-GF, GR-GR |
| mit | FLF-GF | FLF-FLF, GF-GF |
| ngun | GR-GF | GR-GR, GF-GF |
| nou | GR-FRF | GR-GR, FRF-FRF |
| shrwak | GF-SF | GF-DF, SF-SF |
| thang | SF-FRF, FRF-FR, SF-FR | SF-SF, FRF-FRF, FR-FR |
| thing | FRF-LF | FRF-FRF, LF-LF |
| thuk | SF-GF | SF-SF, GF-GF |
| tlan | FRF-SF | FRF-FRF, SF-SF |
| zai | LF-L | LF-LF, L-L |

Table 2: Material for the study (R- Rising, GR- Gradual rising, SR- Steep rising, F-Falling, GF- Gradual Falling, SF- Steep Falling, L - Level, RF- Rising Falling, FR - Falling Rising, LF - Level falling, FLF - Falling level falling, FRF- Falling rising falling,).

**Procedure:** Each subject was individually tested and the material was audio presented through headphones at comfortable listening levels. They were instructed to listen carefully to the two words in **a** pair and record same or different on a given binary forced choice format (Appendix I). Five trials were given prior to the experiment for familiarization with the task. Subjects were given reinforcement after the test. The data was tabulated and percent correct response (for different stimulus) was calculated for each subject each type of tone contrast.

**Statistical analyses:** Repeated measure ANOVA using a commercially available SPSS (version 10) package was performed to calculate the significant difference between languages, conditions and gender. Mixed ANOVA was done compare conditions within each language and one-way ANOVA was performed to compare languages within each group.

## Chapter IV

## Results and discussion

### Experiment I: Tones in Mize

### Experiment I (A): Acoustic Analyses of Mizo Tones

Eight tone patterns - rising (steep/gradual), falling (steep/gradual), level, falling-rising, rising-falling, level-falling, falling-rising-falling, and falling-level-falling were identified in Mizo languages which are shown in figure 4.

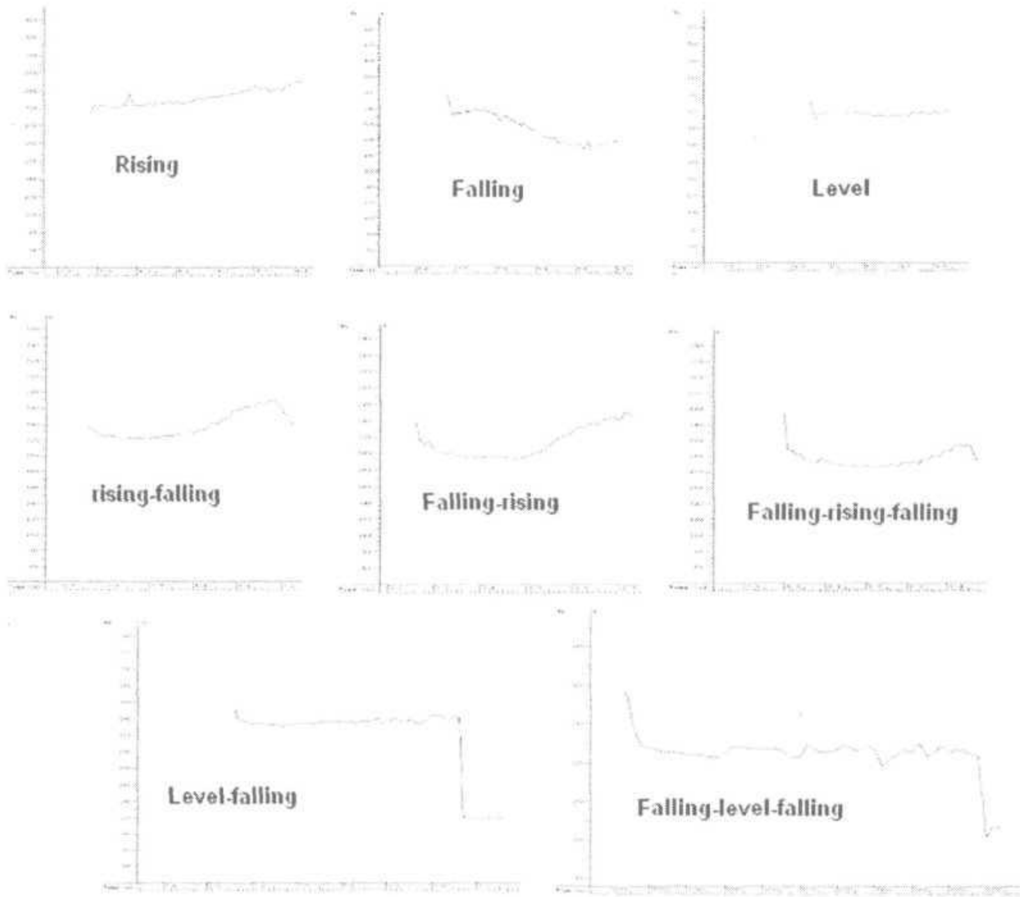


Figure 4: Mizo tonal patterns.

Mizo tonal patterns can be classified into three simple (rising, falling, level), three complex (rising-falling, falling-rising, level-falling), and two compound (falling-rising-falling, falling-level-falling) tones. Among the three simple tones, falling pattern has maximum tone height followed by rising and level; level pattern has longest duration followed by falling and rising; and rising pattern has maximum speed followed by falling and level. Between the three complex tones, rising-falling pattern had maximum tone height and longest duration followed by level-falling and falling-rising; level-falling pattern has maximum speed followed by falling-rising and rising-falling. In the compound tones, falling-level-falling pattern had maximum tone height and speed, and longest duration. Tone height (TH), tone duration (TD), and tone speed (TS) of all the eight tone patterns of Mizo language are shown in table 4.

| Sl. No. | Types | No. | Tone height | Tone duration | Tone speed |
|---|---|---|---|---|---|
| 1. | Rising (R) | 8 | 24 | 363 | 0.31 |
| 2. | Falling (F) | 19 | 44 | 394 | 0.18 |
| 3. | Level(L) | 8 | 7 | 430 | 0.02 |
| 4. | Rising-falling (RF) | 3 | 26; 63 | 441; 73 | 0.06;0.8 |
| 5. | Falling-rising (FR) | 3 | 40; 38 | 188;263 | 0.27;0.1 |
| 6. | Level-falling (LF) | 2 | 12; 74 | 436; 58 | 1.1; 0.55 |
| 7. | Falling-rising-falling (FRF) | 6 | 41; 34;22 | 102;272;75 | 0.66;0.37;0.5 |
| 8. | Falling-level-falling (FLF) | 2 | 37;13; 119 | 67;317;355 | 1.2; 0.3; 0.5 |

Table 3: Tone height, duration, and speed of tones in Mizo language (in complex tones the height, duration and speed are provided in the order).

**Experiment 1 (B): Comparison of Manipuri and Mizo tones**

**In** contrast to six tones in Manipuri language (Radhakrishana, 2005) i.e., rising, falling, level, rising-falling, falling-rising, and rising-falling-rising, Mizo language had eight tones that included level-falling, falling-rising-falling and falling-level-falling patterns in addition to the rising, falling, level, rising-falling, falling-rising, patterns present in Manipuri language. Among all the tonal patterns, falling tones were maximally found.

## Experiment II: Discrimination of Mizo and Manipuri tones by native and non-native speakers.

### Condition (1) - Discrimination of Mizo original tones

There were 4 languages (Mizo, Manipuri, Kannada and Hindi), 3 conditions (Mizo original, Mizo truncated and manipuri truncated) and 2 genders. Repeated measure ANOVA showed a significant difference between languages [F (3, 72) 34.072, $p < 0.05$] and conditions [F (2, 144) = 47.104; $p < 0.05$], and no significant difference between genders [F (1, 72) = 2.458; $p > 0.05$]. Duncan's post hoc test indicated significant difference between Hindi and other languages, Mizo and other languages, and no significant difference between Manipuri and Kannada at 0.05 level of significance. Results showed that Mizo and Manipuri speakers discriminated the tones better than the non-native speakers. Among the tone language speakers, Mizo speakers discriminated the tones better than Manipuri speakers and among the non-tonal speakers Kannada speaker's discrimination was better than Hindi speakers. Table 4 shows percent discrimination scores and SD in all languages. Figure 5 shows percent discrimination scores on Mizo original tones across languages.

| Language | Gender | Condition (1) | | Condition (2) | | Condition (3) | |
|---|---|---|---|---|---|---|---|
| | | **Mean** | SD | **Mean** | SD | **Mean** | SD |
| Mizo | Female | 97.00 | 1.41 | 91.10 | 2.96 | 84.30 | 10.49 |
| | Male | 95.40 | 2.11 | 77.70 | 17.01 | 84.40 | 9.14 |
| | Total | 96.20 | 1.93 | 84.40 | 13.73 | 84.35 | 9.58 |
| Manipuri | Female | 88.60 | 6.32 | 85.10 | 5.91 | 60.30 | 22.76 |
| | Male | 91.70 | 6.12 | 87.60 | 7.80 | 78.80 | 9.02 |
| | Total | 90.15 | 6.26 | 86.35 | 6.86 | 69.55 | 19.34 |
| Kannada | Female | 88.70 | 12.63 | 78.40 | 19.10 | 69.60 | 25.36 |
| | Male | 90.90 | 7.37 | 80.40 | 9.75 | 78.10 | 9.80 |
| | Total | 89.80 | 10.12 | 79.40 | 14.80 | 73.85 | 19.21 |
| Hindi | Female | 86.40 | 5.31 | 63.30 | 14.50 | 62.00 | 24.36 |
| | Male | 67.50 | 16.40 | 50.00 | 15.04 | 33.20 | 25.62 |
| | Total | 76.95 | 15.32 | 56.65 | 15.91 | 47.60 | 28.47 |

Table 4: Mean percent discrimination scores and SD in all languages.

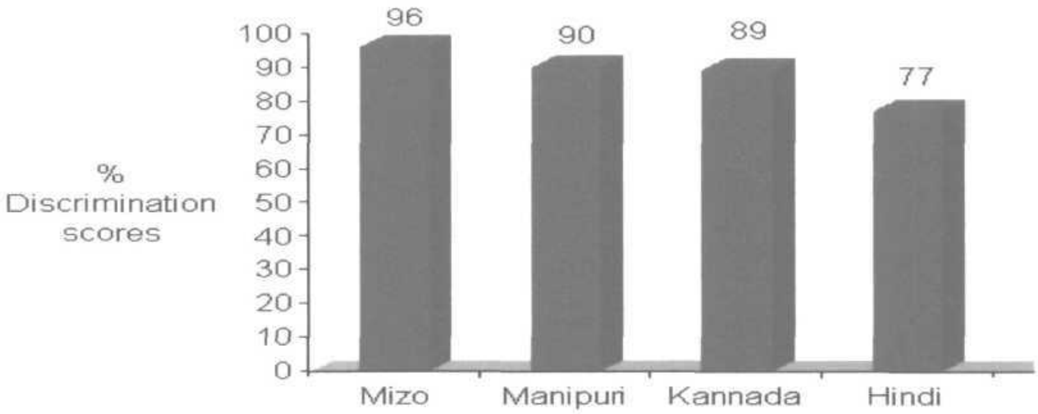


Figure 5: Mean percent discrimination scores on Mizo original tone pairs across Mizo, Manipuri, Kannada, and Hindi languages.

**Condition (2) - Discrimination of Mizo truncated tones**

Condition * language ($p < 0.05$) and language * gender ($p < 0.05$) interaction was significant; however condition * gender and condition * language * gender were not significant. Bonferroni's Multiple Comparison showed significant difference between condition 1 (Mizo original) and condition 2 (Mizo truncated) at 0.05 level of significance in all languages. Figure 6 shows percent discrimination scores in the two conditions across languages.

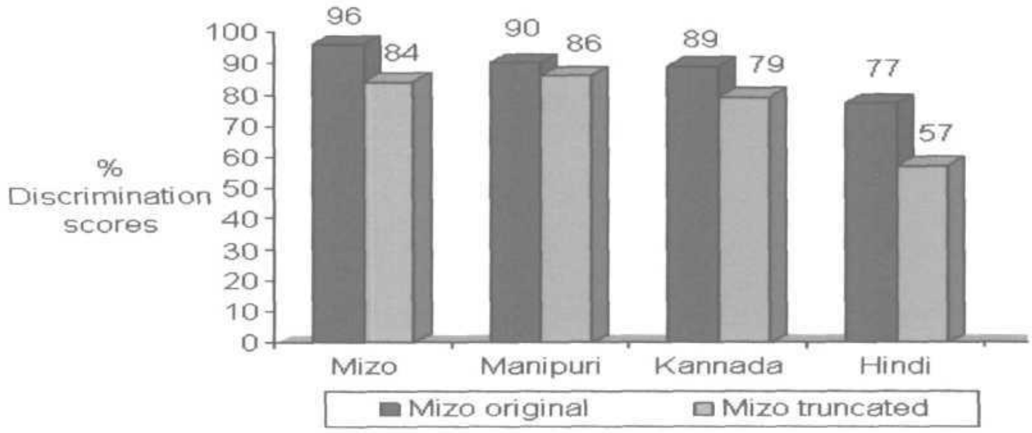


Figure 6: Mean percent discrimination scores in the two conditions (Mizo original and Mizo truncated) across languages.

**Condition (3) - Discrimination of Manipuri truncated tones**

Radhakrishnan (2005) said that there were other acoustic cues, which coexisted with the tone contrast which might have helped non-native speakers in tone discrimination. Therefore, percent correct scores of Manipuri original pairs (Radhakrishnan, 2005) were compared with Manipuri truncated pairs (condition 3 of present study). Manipuri sand Hindi speakers discriminated the original stimuli better than the truncated. However, Kannada speakers discriminated the truncated stimuli better than the original. Figure 7 shows percent discrimination scores in the two conditions (i.e. Manipuri original and Manipuri truncated pairs) across languages. Mizo language was not considered for comparison as Mizo subjects had not discriminate Manipuri original pairs in Radhakrishnan's study.

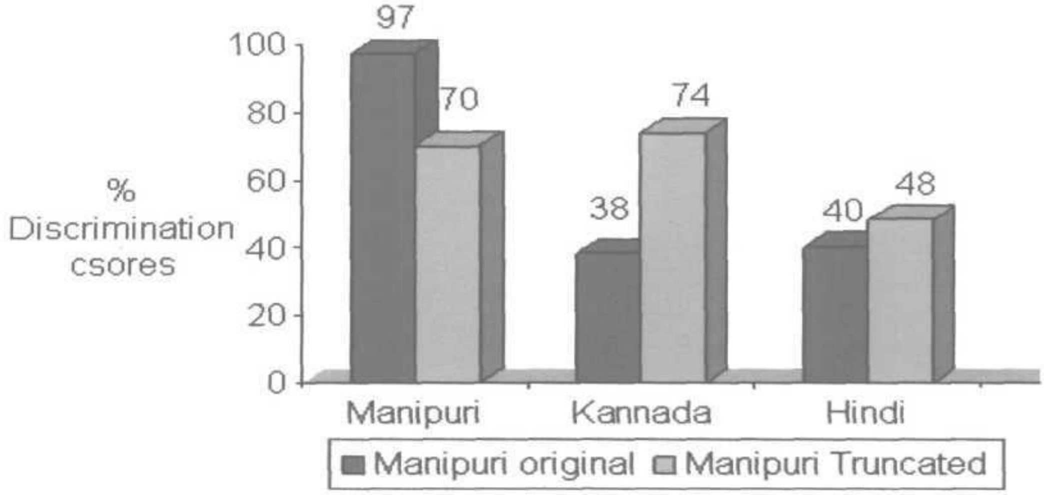


**Figure 7:** Mean prcent discrimination scores on Manipuri original tone pairs (Radhakrishnana, 2005) and Manipuri truncated tone pairs (condition 3 of present study) across languages.

**Comparison of conditions within languages**

One-way Repeated measure AVOVA with pair-wise Bonferroni's test was done to compare conditions within each language. There was significant difference between conditions in all the languages {Mizo - [$F(2, 38) = 9.907$; $p < 0.05$], Manipuri - [$F(2, 38) = 29.058$; $p < 0.05$], Kannada - [$F(2, 38) = 6.399$; $p < 0.05$], Hindi - [$F(2, 38 = 15.622$; $p < 0.05$]}. Condition 1 and 2 were significantly different ($p < 0.05$) in all the languages. Percent scores deteriorated for Mizo truncated stimuli (condition 2) compared to Mizo original stimuli (condition 1) across all languages.

**Comparison of languages within each condition**

One-way ANOVA with Duncan's post hoc test was done to compare languages within each condition. The results indicated a significant difference between languages for each condition {Condition 1 - [$F(3, 76) = 13.799$; $p < 0.05$; condition 2 - [$F(3, 76) = 21.152$; $p < 0.05$]; condition 3 - [$F(3, 76) = 11.621$; $p < 0.05$]}. Hindi was significantly different ($p<0.05$) from other 3 languages on all conditions in that the percent discrimination score was lowest in Hindi. Mizo was significantly different ($p<0.05$) from other 3 languages on conditions (1) and (2) in that percent discrimination score was highest in Mizo speakers. However, there was no significant difference between Manipuri and Kannada language, and Mizo and Kannada language.

**Comparision of each tone contrast within languages**

22 Mizo original, 22 Mizo truncated tone contrasts used in the study and 11 Manipuri tone contrasts (Radhakrishnan, 2005) are shown in table 5 and 6, respectively.

| *SLNo* | *Tone contrasts (Mizo original & truncated)* | *Mizo words pairs* |
|---|---|---|
| 1. | GF-SF | Ban 1-2, bel 2-3, shrawk 1-2, thuk 1-2 |
| 2. | GR-SR | Lei 1-3 |
| 3. | GF-GR | Lei 2-3, ngun 1-2 |
| 4. | SF-GR | Chang 1-2, kawng 1-2 |
| 5. | GF-SR | Lang 1-2, lei 1-2 |
| 6. | SF-L | Bang 2-3, bel 1-2, chang 1-3, kawang 2-3 |
| 7. | GF-L | Ban 1-3, bel 1-3 |
| 8. | GR-L | Chang 2-3, kawng 1-3 |
| 9. | LF-L | Zai 1-2 |
| 10. | FR-L | Khur 1-2 |
| 11. | FR-GR | Klai 1-2 |
| 12. | RF-GF | Chum 1-2 |
| 13. | RF-SF | Beng 1-3, lai 1-2 |
| 14. | FR-SF | Thang 1-3 |
| 15. | FRF-SF | Thang 1-2, tlan 1-2 |
| 16. | FRF-GR | Nou 1-2 |
| 17. | FRF-RF | Kal 1-2 |
| 18. | FRF-FR | Bang 1-2, thang 2-3 |
| 19. | FRF-LF | Thing 1-2 |
| 20. | FLF-RF | Beng 1-2 |
| 21. | FLF-SF | Beng 2-3 |
| 22. | FLF-GF | Mit 1-2 |

Table 5: Mizo tone contrasts (original and truncated) of the words used in the study.

| Sl no | Tone contrasts | Words |
|---|---|---|
| 1 | R,F | I,Tui, Phi |
| 2 | RF, F | Thong |
| 3 | FR, R | Sing |
| 4 | RF, F, RFR | Lei |
| 5 | GF, SF | Tuba, Cha |
| 6 | L, F | Chek |

Table 6: Manipuri tone contrasts of the words.

(a) *Mizo original tone contrasts:* All the Mizo original tone contrasts were well discriminated by tonal speakers except falling-level-faUing vs gradual falling contrast, which was worst perceived even by non-tonal speakers. Hindi speakers discriminated gradual rising vs level, level falling vs level, falling rising vs level, falling-rising-falling vs steep falling, and falling-level-falling vs rising-falling tone contrast better than others, and discriminated gradual-rising vs steep rising, steep-falling vs level, gradual-falling vs level, falling-level-falling vs gradual-falling and falling-level-falling vs steep falling tone contrast poorly. Also, Kannada speakers discriminated gradual-falling vs gradual-rising, steep-falling vs gradual-rising, falling rising vs level, falling-rising vs gradual rising, rising-falling vs gradual falling, rising-falling vs steep-falling, falling-rising-falling vs steep falling, and falling-level-falling vs rising-falling tone contrasts better, and discriminated gradual-falling vs steep-falling, gradual-rising vs steep rising, and Falling-level-falling vs gradual falling tone contrast poorly. Figures 8, 10, 12, and 14 shows percent discrimination scores for Mizo original tones by Mizo, Manipuri, Kannada, and Hindi speakers, respectively. And figures 9, 11, 13, and 15 shows percent discrimination scores for Mizo truncated tone contrasts by Mizo, Manipuri, Kannada, and Hindi speakers, respectively.

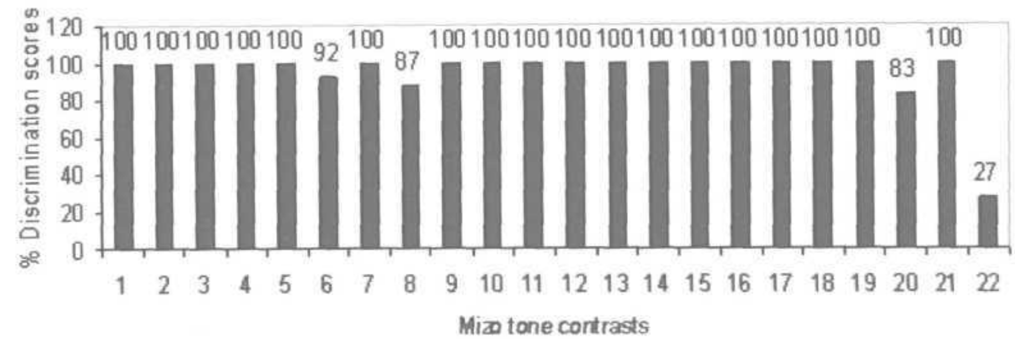


Figure 8: Percent discrimination scores for Mizo original tone contrasts in Mizo subjects.

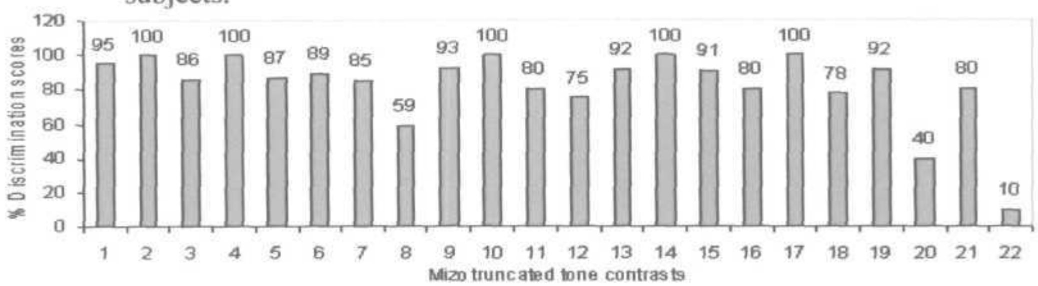


Figure 9: Percent discrimination scores for Mizo truncated tone contrasts in Mizo Subjects

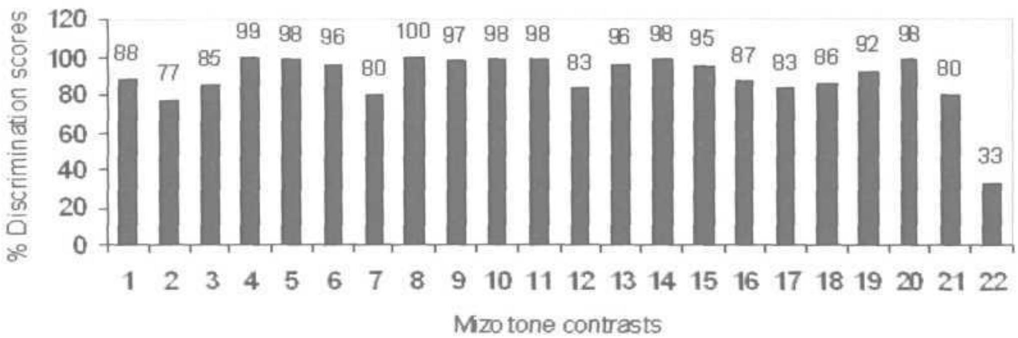


Figure 10: Percent discrimination scores for Mizo original tone contrasts in Manipuri subjects.

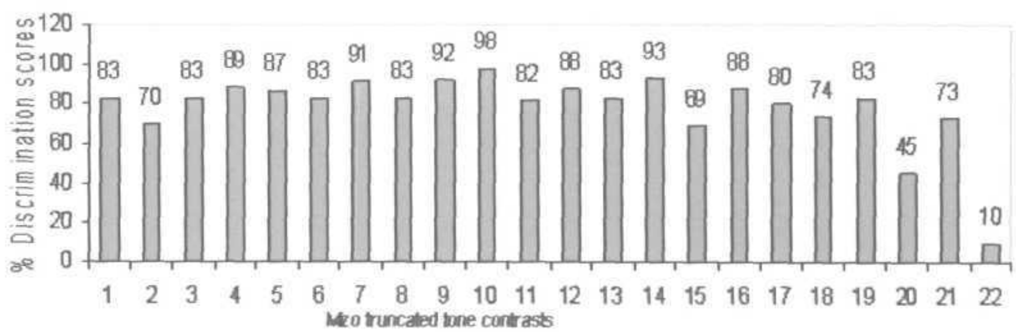


Figure 11 :Percent discrimination scores for Mizo truncated tone contrasts in Manipuri subjects.

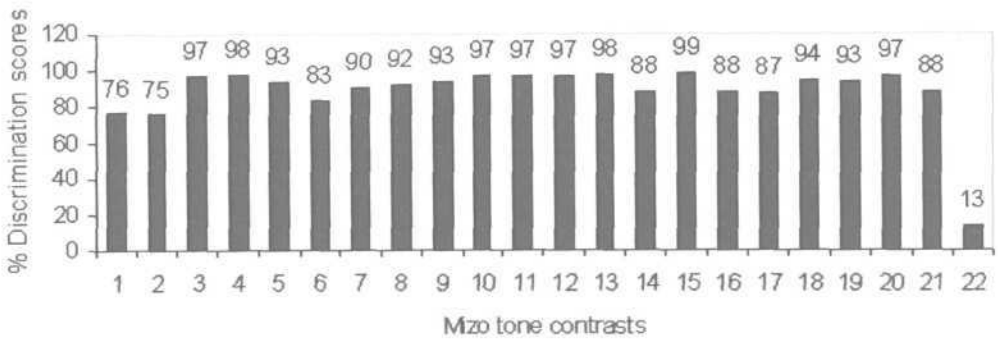


Figure 12: Percent discrimination scores for Mizo original tone contrasts in Kannada subjects.

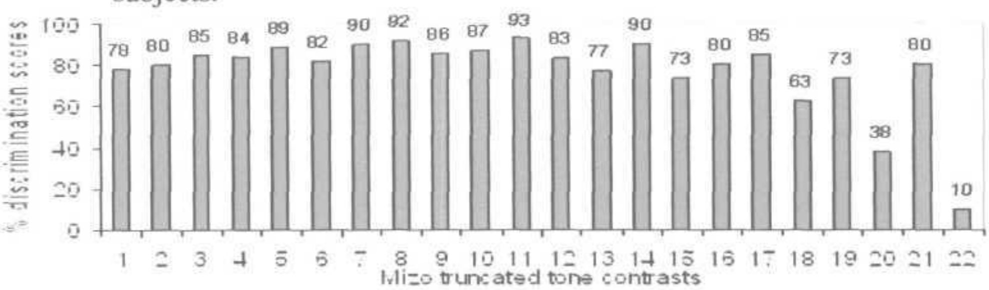


Figure 13: Percent discrimination scores for Mizo truncated tone contrasts in Kannada subjects

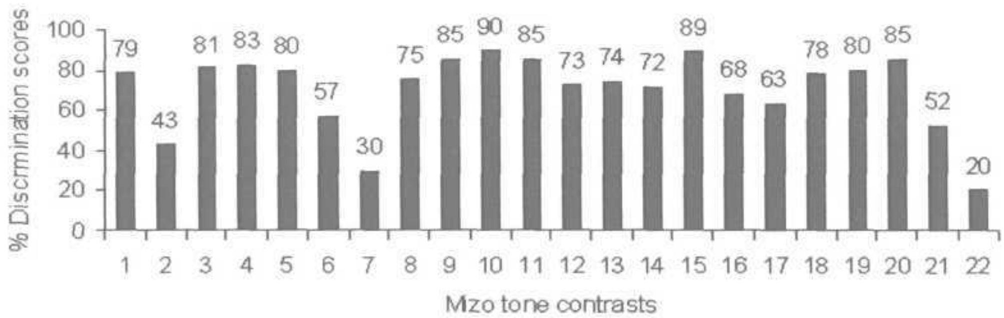


Figure 14: Percent discrimination scores for Mizo original tone contrasts in Hindi subjects.

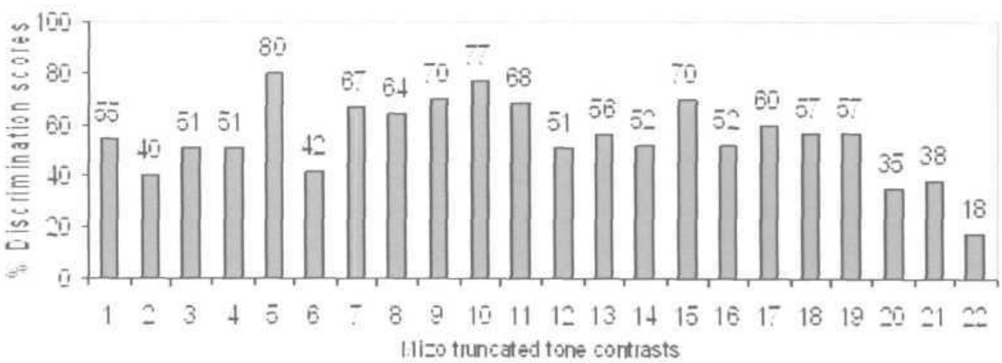


Figure 15: Percent discrimination scores for Mizo truncated tonecontrasts in Hindi subjects.

(b) *Mizo truncated tone contrasts:* When tone contrasts were compared within truncated and original conditions (figure 8-15), it was observed that there was deterioration in tone discrimination across all languages. This change was very evident for falling-level-falling vs rising-falling tone contrast for all languages. Deterioration was more for non-tonal languages as compared to tonal languages. Within tone language speakers, deterioration was more for Manipuri speakers and within non-tone language, for Hindi speakers. Hindi speaker's discrimination reduced markedly for gradual-falling vs steep-falling, gradual-falling vs gradual-rising, and steep-falling vs gradual-rising.

To summarize, native speakers discriminated the tones better than the non-native speakers. Among the tone language speakers, Mizo speakers discriminated the tones better than Manipuri speakers and among the non-tonal speakers Kannada speakers' discrimination was better than Hindi speakers. Also Manipuri and Kannada speakers' perception was similar. There was deterioration in the discrimination of tones in all language speakers when the duration of Mizo words were truncated. And this deterioration was more for non-tonal speakers compared to tonal speakers. Among the non-tone language speakers, Hindi speaker's discrimination was poor compared to Kannada. Kannada speaker's discrimination was better when the Manipuri words were truncated. Also, no significant gender difference was observed.

## Discussion

The results reveal several interesting points. First, 8 tone patterns were identified in Mizo language - rising (steep/gradual), falling (steep/gradual), level, falling-rising, Rising-falling, level-falling, falling-rising-falling, and falling-level-falling - in contrast to 6 tones in Manipuri language (Radhakrishana, 2005). Among all the tonal patterns, falling tones were maximally found in both Manipuri and Mizo language. While some languages have distinguished low fall, high fall, low rise and high rise, some do not. Also, compound tones are not mentioned in any languages except Manipuri. It is not known whether they consider it as combination of simple tones or such tones don't exist. Mizo tonal patterns were classified as 3 simple, 3 complex and 2 compound like tones because we know compound tones exists only on bisyllabic words and, in this study, Mizo words taken for acoustic analyses were monosyllabic. Table 7 summarizes the tone patterns of different tone languages.

| Sl. No. | Type of tone patterns | C | M | T | Th | NK | Y | Man | Mizo |
|---|---|---|---|---|---|---|---|---|---|
| 1 | High falling or high level/Steep Falling | + | + | + | + | + | | + | + |
| 2 | Low falling or low level/Gradual Falling | + | | + | | + | | + | + |
| 3 | High rising /SteepRising | + | + | + | + | | + | | + |
| 4 | Low rising/Gradual Rising | + | | + | | | | + | + |
| 5 | High mid level/ Level | + | + | + | | + | + | | |
| 6 | Low mid level/Level | + | | + | | | | + | + |
| 7 | Mid | | | | + | | | | |
| 8 | Low | | | | + | | | | |
| 9 | High | | | | + | | + | | |
| 10 | Low falling rising or low level | | + | | | | + | + | + |
| 11 | Rising falling | | | | | | | + | + |
| 12 | Rising falling rising | | | | | | | + | |
| 13 | Falling rising falling | | | | | | | | + |
| 14 | Falling level falling | | | | | | | | + |
| 15 | Falling level | | | | | | | | + |

Table 7: Tone patterns of different tone languages (C - Cantonese, M - Mandarian, T - Taiwanese, Th - Thai, NK - North-Kammu, Y - Yoruba, Man - Manipuri).

Second, *tone language speakers discriminated tone pairs better than non-tone language speakers.* Mizo and Manipuri speakers discriminated the tones better than the Kannada and Hindi speakers. This can be attributed to developmental absence of exposure to lexical tone result in a linguistic mode of processing which involves the attenuation of a basic psychodynamic phenomenon i.e. pitch discrimination (Burnham, 1996). Among the tone language speakers, Mizo speakers discriminated the tones better than Manipuri speakers which can be attributed to the fact that linguistic experience with a particular dimension, lexical tone, results in subtle change in the manner in which phonologically relevant variations are perceived which is specific to actual variation in the ambient language (Burnham, 1996). Among the non-tonal speakers Kannada speaker's tone discrimination was better than Hindi speaker's. Though statistically not significant, non-native speaker's (Kannada, Hindi) discrimination scores were good. This result is in consonance with a number of indigenous experiments conducted by (Werker, 1991) which shows that adults usually perceive non-native contrasts better when testing conditions favor phonetic or acoustic processing by reducing the inter-stimulus interval (ISI) between to be discriminated to be 500 or 250 ms than when the ISI is 1500 ms, forcing reliance on long-term memory and thus phonemic processing. And in the present study the ISI within a tone pair was 500 ms that would have favored acoustic processing. Also, Best (1995) reported that adults are able to distinguish some non-native contrasts; therefore non native speakers should also be able to distinguish tones to some extent, which can be attributed to above chance level discrimination of tones by non-native speakers (Kannada, Hindi) in the present study.

Third, *discrimination scores were poor in truncated conditions compared to original stimuli for all the languages (i.e. tonal and non-tonal).* This decrease was more for non-tonal than tonal speakers. This level of performance is consistent with a number of studies that support a role for additional cues such as physical duration, the second formant, F2 (perceived vowel backness, e.g., *l\l* to /u/), voice quality, amplitude (Abramson, 1978; Henderson, 1981; Tseng, Massaro, & Cohen, 1985), tone duration (Blicher, Diehl, Cohen, 1990) and amplitude contour (Fu & Zeng, 2000), aspiration, lengthening of word, vowel distortion and frication (Radhakrishnan, 2005). The result of the present study supports the notion that there are other cues which help non-native speakers to discriminate tonal contrasts. In addition to FO pattern which is the dominant cue for tone recognition, other acoustic cues can contribute to native speaker's perception tone recognition. This is evident by decline in native speaker's discrimination scores on truncated Mizo tones. Also Gandour (1983) investigated the perceptual dimensions of tone and the effect of linguistic experience on a listener's perception of tone Listeners from a non-tone language (English) attached more importance to the *height* dimension and they gave less weight to the *direction* dimension than did listeners tonal languages (Cantonese, Mandarin, Taiwanese, and Thai). Regardless of language group, however, listeners generally placed relatively more emphasis on the 'height' dimension. Since English has no lexical tones, English listeners directed their attention almost exclusively to the level fundamental frequency characteristics of these monosyllabic stimuli. Thus, the results indicate that perception of tones by native and non-native speaker's discrimination of tones depends on the height, and duration of the tone.

Fourth, ***Kannada speaker's discrimination scores improved on Manipuri truncated tones compared to the original tones.*** This might be because of the 2 different groups of subjects used in the present study and the study by Radhakrishnan (2005). However, an improvement by 36% mights not be a chance effect. One may speculate that Kannada speakers are exposed to tonal languages or the Kannada speaking subjects in the present study were good in discriminating tones. The question as to why these speakers discriminate tones better than Hindi speakers needs to be answered. It appears that Kannada speakers JND for duration may be lesser than measured in this study (40 ms). Future research needs to be carried out in this area.

Fifth, *All the original Mizo original tone contrasts were well discriminated by tonal speakers* except falling-level-faUing vs rising-falling which was worst perceived even by non-tonal speakers. Non-native speakers discriminated some tone pairs better than others. Such (better discriminated) tones contrasts including tones differing in extremities; for example, simple vs complex, simple vs compound like etc. However, steepness was not discriminated well by non-native speakers. This indicates that discriminating relative height of tone within a tone pattern is difficult for non-native speakers.

**Sixth, *there was deterioration in tone discrimination across all languages for Mizo truncated tone contrasts, when compared with original Mizo contrasts.*** This change was very evident for falling-level-faUing vs rising-falling tone contrast for all languages. Deterioration was more for non-tonal languages as compared to tonal languages. Within tone language speakers, deterioration was more for Manipuri speakers and within non-tone language, for Hindi speakers. Hindi speaker's discrimination reduced markedly for gradual-falling vs steep-falling, gradual-falling vs gradual-rising, and steep-falling vs gradual-rising.

Seventh, *no significant difference between gender* was noticed on percent discrimination scores, which in contrary to the previous findings by Radhakrishnan, 2005.

The information obtained from this study will have several implications. The additional feature tone in a language poses challenge to a speech-language pathologist. The presence of lexical tones in tone language has led to speculation that the lateralization of language functions in speakers of tone language differ from non-tone language speakers. S/he should have the knowledge of tone; know whether a speaker properly produces the tone, and how tonal patterns differ from one tonal language to other. Further, in a child with hearing impairment, specific language impairment or an adult with dysprosody, or aphasia, the task of teaching tones would be very important in a tool of a speech-language pathologist. Under these conditions the knowledge of tone and its perception becomes significant. F0 contour will also serve as visual cues for teaching tones in such patients. The material of this study can be used to develop a "test of tone in Mizo" and the data obtained can be used as a normative. Also, speech language pathologist can be trained to identify and discriminate tones that would help in assessing and treating patients speaking tonal languages.

# Chapter V

## Summary and Conclusions

A tone language uses pitch to signal a difference in meaning between words (Avery, 1997). 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 Mandarin- Chinese languages. The results of these studies revealed the different tone patterns available in these tone languages and the tone envelope cues used by the native speakers to differentiate the tones. In the past, the tones of Cantonese (6), Mandarin (4), Taiwanese (5), Thai (5), Northern Kammu (3), and Yoruba (4), Manipuri (6) have been investigated. However, there are very few studies on tone languages spoken in north- eastern part of India (Manipuri, Mizo and Naga languages) except one on Manipuri language by Radhakrishnan (2005). Thus, the present study investigated the perception of Mizo tones by native and non-native speakers. The study also compared the perception of Mizo and Manipuri tones.

Two experiments were conducted in this study. Experiment I involved acoustic analysis and experiment II involved perceptual analysis. A 20-year-old native Mizo speaking adult female volunteered as subject for experiment I. Twenty-four monosyllabic Mizo words differing in tone and having 2 or 3 lexically significant meanings were collected. Out of 24 words, 17 words had two meanings and 7 words had three meanings. These words as spoken 5 times by the subject were audio-recorded using a unidirectional microphone at sampling frequency of 16 kHz, digitized using a 12-bit A/D converter and were stored onto the computer memory. A total of 55 words were audio-recorded five times.Two Mizo speakers identified the tones in all the 55 words. Out of the five iterations, 51 words identified to have correct tones were subjected to acoustic analyses using SFS (Speech Filling System) software and the tone height, speed of tone transition was measured as the shift in FO per unit time using the formula, STT = TH/T (Hz/ms). Tone patterns of Mizo words obtained in experiment I was compared with the Manipuri tone patterns (Radhakrishnan, 2005).

Four groups of subjects - two speaking tonal and two non-tonal languages - participated in experiment II. In each group, there were 10 males and 10 females in the age range of 18-25 years. Group I and II had Mizo and Manipuri native speakers, respectively and group III and IV had Kannada and Hindi native speakers, respectively. Subjects were matched for age, gender and educational qualification. They were pursuing graduate or postgraduate degree from different colleges in Mysore. None of the subjects had any hearing, otorhinolaryngological or neurological problems as screened by the experimenter. Stimuli for perception study included 3 conditions of tone pairs. Conditions (a) consisted of 87 Mizo original tone pairs (36 different and 51 same tones pairs), Conditions (b) had 87 Mizo truncated tone pairs (36 different and 51 same tones pairs), and Conditions (c) included 30 truncated Manipuri tone pairs (10 different and 20 same pairs). Inter-stimulus duration of 3000 ms and intra-stimulus duration of 500 ms was maintained between and within the stimulus pairs, respectively. Tone pairs in each condition were iterated 3 times and randomized. Thus, a total of 612 word pairs formed the material.

Each subject was individually tested and the material was audio presented through headphones at comfortable listening levels. They were instructed to listen carefully to the two words in a pair and record same or different on a given binary forced choice format (Appendix I). Five trials were given prior to the experiment for familiarization with the task. Subjects were given reinforcement after the test. The data was tabulated and percent correct response (for different stimulus) was calculated for each subject each type of tone contrast.

The results reveal several interesting points. First, 8 tone patterns were identified in Mizo language - rising (steep/gradual), falling (steep/gradual), level, falling-rising, Rising-falling, level-falling, falling-rising-falling, and falling-level-falling - in contrast to 6 tones in Manipuri language (Radhakrishana, 2005). Among all the tonal patterns, falling tones were maximally found in both Manipuri and Mizo language. While some languages have distinguished low fall, high fall, low rise and high rise, some do not. Also, compound tones are not mentioned in any languages except Manipuri. It is not known whether they consider it as combination of simple tones or such tones don't exist. Mizo tonal patterns were classified as 3 simple, 3 complex and 2 compound like tones because we know compound tones exists only on bisyllabic words and, in this study, Mizo words taken for acoustic analyses were monosyllabic.

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Sixth, ***there was deterioration in tone discrimination across all languages for Mizo truncated tone contrasts, when compared with original Mizo contrasts.*** This change was very evident for falling-level-falling vs rising-falling tone contrast for all languages. Deterioration was more for non-tonal languages as compared to tonal languages. Within tone language speakers, deterioration was more for Manipuri speakers and within non-tone language, for Hindi speakers. Hindi speaker's discrimination reduced markedly for gradual-falling vs steep-falling, gradual-falling vs gradual-rising, and steep-falling vs gradual-rising. Sixth, ***no significant difference between genders*** was noticed on percent discrimination scores, which in contrary to the previous findings by Radhakrishnan, 2005.

The information obtained from this study will have several implications. The additional feature tone in a language poses challenge to a speech-language pathologist. S/he should have the knowledge of tone; know whether a speaker properly produces the tone, and how tonal patterns differ from one tonal language to other. Further, in a child with hearing impairment, or an adult with dysprosody, or aphasia, the task of teaching tones would be very important in a tool of a speech-language pathologist. Under these conditions the knowledge of tone and its perception becomes significant. FO contour will also serve as visual cues for teaching tones in such patients. The material of this study can be used to develop a "test of tone in Mizo" and the data obtained can be used as a normative. Also, speech language pathologist can be trained to identify and discriminate tones that would help in assessing and treating patients speaking tonal languages.

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## Appendix I: Binary forced choice response sheet

Name: Language: H/O any hearing, ENT, or neurological problem:
Age/Sex: Ph. No: E-mail:

| Mizo untruncated | | | | | | | | | % response | | | Manipuri truncated | | | % Res | Mizo truncated | | | | | | | | | % response | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set1 | | | Set 2 | | | Set 3 | | | | | | S4 | S5 | S6 | | Set 7 | | | Set 8 | | | Set 9 | | | | | |
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