# Perception of Manipuri tones by native and non-native speaker

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## Abstract

*The present study investigated Manipuri tones and perception of Manipuri tones by native and non-native speakers. One young adult female spoke 26 Manipuri words contrasting in tone. All these words were recorded, digitized and stored on to the computer memory. The lowest F0, highest F0, the height of the tone and the duration of the tones were measured using SFS software. For perception task six groups of subjects participated in the study. Each group had 20 subjects with 10 males and 10 females in the age range of 18-25 years (mean age = 20 years). Group I had Manipuri speakers, group II, III, IV, V and VI had Hindi, Kannada, Malayalam, Telugu and Tamil Speakers, respectively. 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. The result indicated six tones in Manipuri. The falling tone had a steep and a gradual fall pattern characterized by short and long tone durations. Further, the words contrasting for tones were also characterized by aspiration, different in vowel/consonant duration and vowel distortions. Perceptual analysis indicated that native speakers' tone discrimination was significantly better (96.5%) than non-native speakers (38.4%); also, tone discrimination was significantly better in females compared to males. Among non-native speakers, Tamil speakers performed best and Malayalam speakers the worst. The material of this study can be used as a* ***test of tone*** *in Manipuri and the data obtained can be used as normative. Also, speech pathologists can be trained to identify and discriminate tones that would help them in treating patients speaking Manipuri language.*

## Introduction

Speech perception is one of 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. 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 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 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.

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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, 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 investigators 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 mechanism 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, Syndal, 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, 1996; Lisker & Abramson, 1970; Goto, 1971; Snow & Hoejnagel-Hohle, 1978; Mac Kain, Best & Strange, 1981; Sheldon & Strange, 1982). Best (1995) also reported that infants and adults are able to distinguish some non-native contrasts. 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.

Many languages of Southeast Asia and Africa are tone languages. These languages use pitch to signal a difference in meaning between words (Avery, 1997). These pitch variations are an important part of the language, just as stress and proper word order are in any language. In these languages word meanings or grammatical categories such as tense are dependent on pitch level (Crystal, 1982).

Since tone languages are languages that use variant pitches, the concept of **pitch** should be understood. All languages that have sounds have pitch differences. In tone languages these pitch differences are used either to differentiate between word meanings or to convey grammatical distinctions. Physically changing the pitch of a sound can occur in two ways. The first is the stretching and tensing of the vocal folds: the tenser they are, the higher the pitch. The second is changing the pressure below the vocal folds, the sub glottal pressure: the more the pressure, the higher is the pitch (Catford, 1982).

The pitch of an utterance depends on the rate of vibration of the vocal cords, the higher the rate of vibration, the higher the resulting pitch becomes. The tauter the vocal folds the faster they vibrate and the higher the pitch of the perceived sound (Kataamba, 1971). In languages where pitch plays a role, some sequence of segments may have different meanings if uttered at different relative pitches. Pitch variations used in this way are called tones. Tone languages are languages that use pitch in this way (Sloat, 1978). The languages of southeast Asia (China, Burma, Indo-China and Siam) and some of the African languages (Igbo, Efik, Gonad, Bantu etc) are largely tonal. Also, the languages (Manipuri, Naga, Mizo) spoken in the North-Eastern parts of India are tonal.

Efforts have been made to investigate the production and perception of tone in the past. Research (Abramson, 1962; Hashimoto, 1972; Hombert, 1976; Garding & Lindell, 1977; Gandour, 1978; Gandour & Harshman, 1978; Gandour, 1983; Ching, 1990; Bauer & Benedict, 1997; Qian-Jie Fu, 1998; Ye & Connine, 1999; Lui, 2000; Lee, Chiu & Van Hasselt, 2002) have tried to investigate the type of tones, its perception and cues used by the native and non-native speakers for the perception, identification and discrimination of tones. Most of these studies are on Cantonese, Thai and Mandarian-Chinese languages. The results of theses 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.

**Tones** of several languages have been identified. Catonese (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**. **Taiwanese** have 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. Thai** (Bangkok) also have five contrastive lexical tones on long unchecked syllables (Gandour, 1975), traditionally labeled **mid, low, falling, high, rising.** Northern Kammu has three different kinds of fundamental frequency patterns **falling, level and level-falling** (Garding & Lindell, 1977). **Yoruba** has four tones labeled **high level, high, low falling rising and high rising** (Hombert, 1976). Thus in terms of tonal inventory, Cantonese has six lexical tones, Mandarin and Yoruba have four and Taiwanese and Thai both have five and Kammu has three.

The perceptual dimensions of tone have been identified as f0 (Fok, 1974 in Cantonese), direction and slope of f0 (Hombert, 1976 in Yoruba), integrated pitch values (Gandour, 1978 in Northern Kammu), Average pitch height, end point, length and extreme end point (Gandour, 1979), average pitch direction, slope of f0 and length (Gandour & Harshman, 1978 in Thai). These authors have used multi-dimensional scaling analysis. Gandour (1983) has found differences in native and non native perception of tones among listeners of Cantonese, Mandarian, Taiwanese, Thai and English.

Five studies have been conducted on **tone identification.** Ching (1984) investigated the identification of Cantonese tones and reported 32% identification. Qian et. Al (1998) studied tones of Mandarian and Chinese. Tone is important in Chinese speech recognition because the tonality of a monosyllable is lexically meaningful (Liang, 1963; Lin, 1988). Lui (2000) and Lee et al (2000) found 66% and 91% identification of Cantonese, Liu and Samuel (2004) reported 75-80% identification of Mandarian tones. Table 1 Summarizes review on tones, perceptual dimension of tones and tone identification.

Tones of Cantonese, Thai, Mandarian-Chinese and Yoruba languages have been identified. However, the tones of Manipuri, a tonal language, are not known. Therefore, the present study investigated the 'tone' patterns in Manipuri language and perception of Manipuri 'tones' by native tone language and non-native non tone language speakers. It was hypothesized that the tone discrimination ability will be poor in speakers of non-tonal languages compared to those of tonal languages. Manipuri is a language belonging to the Kuki-Chin group of the Tibeto-Chinese subfamily and is spoken in the North-Eastern part of India by about 6,21,244 speakers. Majority of Manipuri speakers are in Manipur, but some of the speakers are spread in Assam and in Tripura. Non-native languages included Hindi, Kannada, Malayalam, Telugu and Tamil. Hindi is an Indo-Aryan language spoken in north

India. Kannada, Malayalam, Telugu and Tamil are non-tonal Dravidian languages spoken in Karnataka, Kerala, Andhra Pradesh and Tamil Nadu, respectively.

**Table 1:** Summary of review on tones, perceptual dimension of tones and tone identification.

| **Number of tones** | | | | |
|---|---|---|---|---|
| **Author (year)** | **Language** | **Subjects** | **Method** | **No. of Tones** |
| Chao, 1947 | Cantonese | | | 6 |
| Cheng, 1973 | Mandarin | | | 4 |
| Zee, 1978 | Taiwanese | | | 5 |
| Gandour, 1975 | Thai | | | 5 |
| Garding & Lindell, 1977 | Northern Kammu | | | 3 |
| Hombert, 1976 | Yoruba | | | 4 |
| **Perceptual dimensions** | | | | |
| **Author (year)** | **Language** | **Subjects** | **Method** | **Perceptual Dimensions** |
| For, 1974 | Cantonese | | Perception of Contour tones | F0 |
| Hambert, 1976 | Yoruba | | Multidimensional scaling analysis | Direction of f0<br>Slope of f0 |
| Gandour, 1978 | Northern Kammu | | Tonal analysis | Integrated pitch values |
| Gandour, 1978 | 13 tones | 24 English listeners | Multidimensional scaling analysis | Average pitch height<br>End point, Length<br>Extreme end point |
| Gandour & Harshman, '78 | 13 tones | 50 listeners each from Thai, Yoruba & English | Multidimensional scaling analysis | Average pitch Direction of f0, End point, Length<br>Extreme end point |
| Gandour & Harshman, '78 | Thai | 114 Thai speakers | Multidimensional scaling analysis | Average pitch direction of f0, Slope of f0 length |
| Gandour, 1983 | 19 tones | 50 listeners each from Cantonese, Mandarin, Taiwanese, Thai & Eng | Multidimensional scaling analysis | Difference in native and nonnative perception and linguistic experience |
| **Tone identification** | | | | |
| **Author (year)** | **Language** | **Subjects** | **Method** | **Tone identification** |
| Liang, 1963 | Cantonese | | High pass filtered at 300 Hz; Discrimination | 94.6% |
| Ching, 1984 | Cantonese | | Discrimination | 32% |
| Qian, 1988 | Mandarin | | Discrimination | - |
| Lui, 2000 | Cantonese | | Discrimination | 66% |
| Lee et. Al., | Cantonese | 31 3-years olds | Discrimination | 91% |
| Liu & Samuel, 2004 | Mandarin | 10 listeners | Identification | 75-80% |

The information obtained from this study will have several implications. The additional feature tone in a language poses challenge to a speech-language pathologist. He/she should have the knowledge of tone and know whether a speaker properly produces the tones. Further, in a child with hearing impairment, or an adult with dysprosody, the task of teaching 'tones' would be very important in the tool of a speech language pathologist. Under these conditions the knowledge of 'tone' and its perception becomes significant.

## Method

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

**Experiment I: Acoustic analysis**

**Subject:** An 18-year old native Manipuri speaking adult female served as the subject for this study.

**Material:** Initially 13 Manipuri words differing in tone were collected. These words as spoken thrice by the subject were audio recorded, digitized at 8 KHz using a 12-bit A/D converter and stored onto the computer memory.

**Procedure:** All the words were subjected to acoustic analysis using SFS (Speech Filling System) software and the following parameters were extracted from the F0 contour.

F0 contours of the syllable were defined as rising, falling or level. An increase in F0 was considered as **rising**, a decrease as **falling** and no change in f0 as **level**. Figure 1 illustrates the three types of contour.

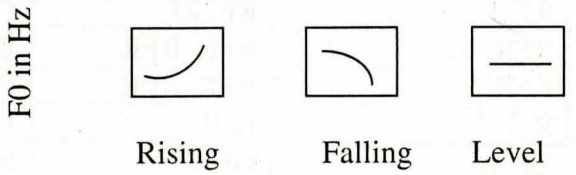


**Figure 1:** illustration of F0 contours

Transition of Tone (TT) was measured as the difference in F0 between the starting (A) and ending point (B) of the F0 contour. Tone transition (TT) = A ≠ B in Hz.

Transition Duration (TD) of tone was measured as the time difference between the starting and ending point of the F0 contour (in ms).

Speed of Transition of Tone (STT) was measured as the shift in F0 per unit time using the formula STT=TT/T Hz/ms.

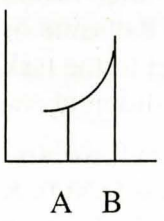


**Figure 2:** Illustrates transition of tone and transition duration

Those words not depicting a tone were deleted and the remaining were used for perceptual analysis.

**Experiment II: Perceptual analysis**

**Subjects:** Six groups of subjects participated in the study. Each group had 20 subjects with 10 males and 10 females in the age range of 18-25 years (mean age = 20 years). Group I had Manipuri speakers, group II, III, IV, V and VI had Hindi, Kannada, Malayalam, Telugu and Tamil speakers, respectively. Non-native speakers were matched with native speakers for age, gender and educational qualification. None of the subjects reported of any ear discharge, hearing or neurological problems.

**Materials:** Words selected from experiment I were considered. Minimal pairs contrasting in tones were formed. Words with two different tones were paired using signal edit program of

the SSL software (Voice and Speech Systems, Bangalore). A total of 15 tone pairs were prepared in this manner. Also words with same tones were paired to form 30 tone pairs. Table 2 shows the words with tone pairs.

**Table 2:** Material for the study (R- Rising, F-Falling, RF- Rising Falling, FR-Falling Rising, RFR- Rising Falling Rising, GF- Gradual Falling, SF- Steep Falling, L Level).

| Sl. No. | Word | Tone pair Different | Tone pair same | Tone pair Same |
|---|---|---|---|---|
| 1 | I | R, F | R, R | F, F |
| 2 | Thong | RF, F | RF, RF | F, F |
| 3 | Ka | R, F | R, R | F, F |
| 4 | Ching | R, F | R, R | F, F |
| 5 | Sing | FR, R | FR, FR | F, R |
| 6 | Tui | R, F | R, R | F, F |
| 7 | Li | RF, F | RF, RF | F, F |
| 8 | Li | RFR, RF | RFR, RFR | RF, RF |
| 9 | Li | RFR, F | RFR, RFR | F, F |
| 10 | Phi | R, F | R, R | F, F |
| 11 | Tuba | GF, SF | GF, GF | SF, SF |
| 12 | Chaba | GF, SF | GF, GF | SF, SF |
| 13 | Cha | GF, SF | GF, GF | SF, SF |
| 14 | Chek | L, F | L, L | F, F |
| 15 | Tauba | F, FR | F, F | FR, FR |

The inter word interval in a pair was 500 ms and the inter stimulus interval was 3 seconds. The 45 word pairs were iterated thrice and randomized to form 135 word pairs.

**Procedure**: 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-format. That is, after hearing a pair of words they have to indicate whether the two words in a pair were the same or different. Five trials were given prior to the experiment to familiarize the subject to the task. The responses of the native and non-native speakers were tabulated and percent different response was calculated.

**Analysis**: The data obtained was tabulated. For all the six groups percentage of 'same' and 'different' responses was calculated. One-way ANOVA was used to find out gender differences and Univariant ANOVA was used to find out group and gender interaction.

## Results and Discussion

### I. Acoustic characteristics of Manipuri tones

**Tone patterns**: Six tone patterns – (a) rising (6) (b) falling (15), (c) rising-falling (2), (d) falling-rising (2), (e) rising-falling-rising (1), and (f) level (1) were identified. Numbers in parenthesis indicate the number of such tones identified in the words used in this study. Falling pattern consisted of gradual and steep fall. Figure 3 shows the various tone patterns.

#### Transition of tone

**Rising pattern:** It had a mean lowest frequency of 249 Hz and mean highest frequency of 302 Hz. The average transition was 53 Hz and the transition duration was 200 ms.

**Falling pattern:** It had a mean lowest frequency of 182 Hz and mean highest frequency of 237 Hz. The average transition was 55 Hz and the transition duration was 150 ms.

**Rising-falling pattern:** It had a mean lowest frequency of 238 Hz and mean highest frequency of 318 Hz. The average transition was 160 Hz and the transition duration was 230 ms.

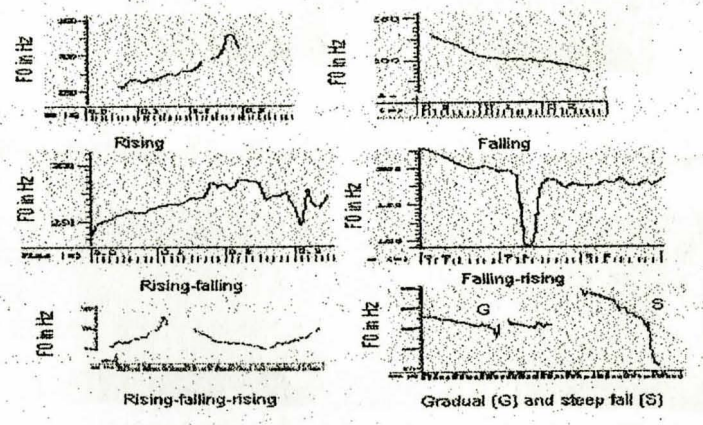


**Figure 3:** Various tone patterns in Manipuri.

**Falling –rising pattern:** It had a mean lowest frequency of 150 Hz & mean highest frequency of 225 Hz. The average transition was 150 Hz and the transition duration of 70 ms.

**Gradual falling pattern:** It had mean lowest frequency of 180 Hz & mean highest frequency off 225 Hz. The average transition was 44 Hz and the transition duration was 200 ms.

**Steep falling patterns:** It had a mean lowest frequency of 177 Hz and mean highest frequency of 258 Hz. The average transition was 81 Hz and transition duration was 160 ms.

**Rising-falling-rising pattern**: It had mean lowest frequency of 138 Hz & mean highest frequency of 280 Hz. The average transition was 120 Hz & the transition duration of 260 ms.

Rising-falling tone had the highest transition and gradual falling tone had the lowest transition. Falling-rising tone and rising-falling-rising tone had the shortest and longest transition duration, respectively. Table 3 shows the value of lowest FO, highest FO, Transition (TT) and transition duration (TD).

**Table 3:** Lowest FO, highest FO, TT (Hz) and TD(ms).

| Tone pattern | Lowest FO | Highest FO | TT | TD |
|---|---|---|---|---|
| Rising | 248.83 | 302.00 | 53.11 | 200.00 |
| Falling | 181.91 | 237.00 | 55.10 | 150.00 |
| Rising-falling | 238.00 | 318.00 | 159.50 | 230.00 |
| Falling-rising | 150.00 | 225.20 | 149.50 | 70.00 |
| Gradual falling | 180.00 | 224.60 | 44.30 | 200.00 |
| Steep falling | 176.60 | 257.60 | 81.00 | 160.00 |
| Rising-falling-rising | 138.00 | 280.00 | 120.00 | 260.00 |
| Level | 282.00 | | | |

There were other acoustic cues also which coexisted with the tone contrast. They were aspiration, consonant duration, stress on word initial consonant, lengthened vowel and word duration and distorted vowel. Figure 4 shows spectrograms depicting other acoustic cues coexisting with tone contrasts.

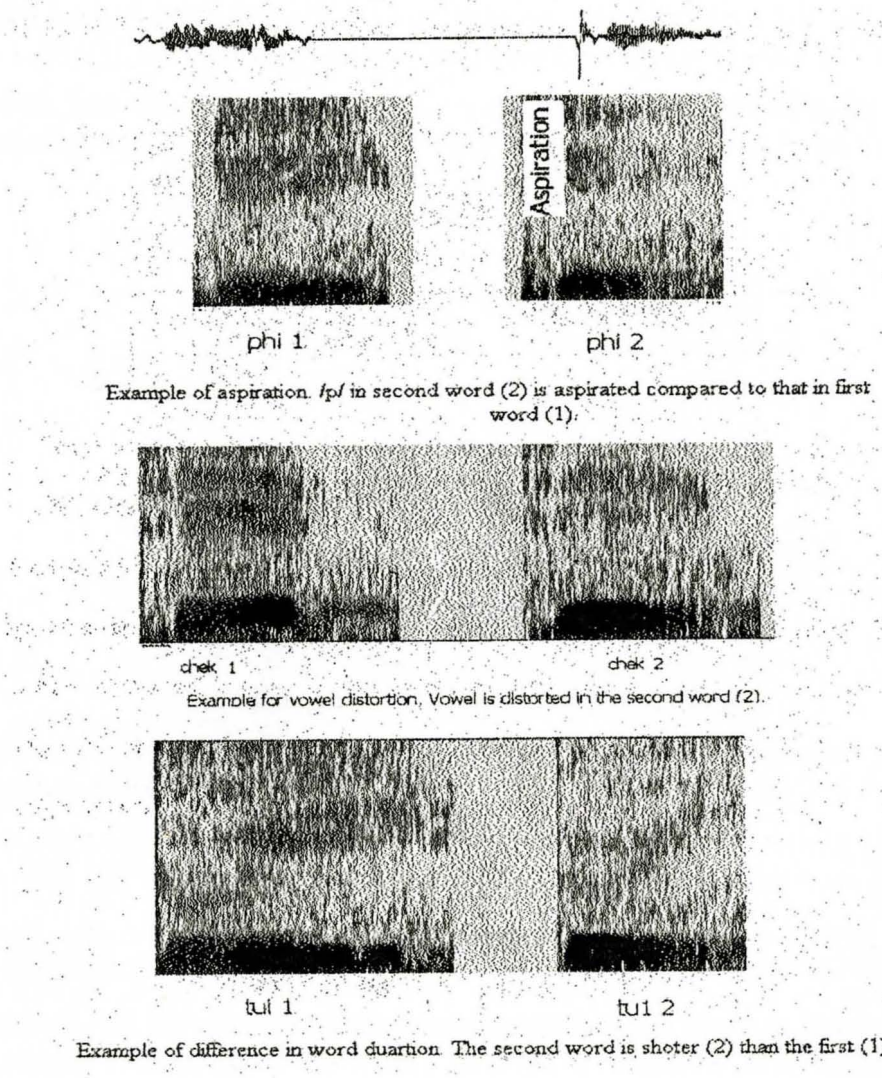


**Figure 4:** Acoustics cues other than tone contrasts in a minimal pair.

The results indicated that there were three simple tones (rising, falling, and level), two complex tones (rising –falling and falling-rising), and one compound tone (rising-falling-rising). The falling tone had steep and gradual fall that were characterized by short and long transition durations. Table 4 shows all tone contrasts obtained from acoustic analysis used in the study.

**Table 4:** Tone contrasts of the words used (R-Rising, F-Falling, RF-Rising falling, FR-Falling Rising, RFR-Rising Falling Rising, GF-Gradual Falling, SF-Steep Falling, L-Level).

| Sl. No. | Words | Tone Contrasts |
|---|---|---|
| 1 | I, Ka, Ching, Tui, Phi | R, F |
| 2 | Thong | RF, F |
| 3 | Sing | FR, R |
| 4 | Li | RF, F, RFR |
| 5 | Tuba, Chaba, Cha | GF, SF |
| 6 | Chek | L, F |
| 7 | Tauba | F, FR |

## II. Discrimination of Manipuri word pairs contrasting in tones

**Native Manipuri speakers:** Native Manipuri speakers scored an average of 97.5%. Within the group females obtained higher scores compared to males. But this was not significant. The discrimination scores varied with tone pairs and ranged from 87% to 100%. Table 5 shows the average percent correct scores in native Manipuri speakers.

**Table 5:** Percent correct scores in Manipuri males and females.

| Males | Females | Average |
|---|---|---|
| 97 | 98 | 97.5 |

**Native Manipuri speakers Vs non-native speakers**: Native Manipuri speakers had significantly ($F(1,9) = 7.14$ and 6.78, $P<0.00$ level for males and females, respectively) higher scores compared to non-native speakers. Females in non-native languages had significantly ($P=0.00$) higher scores compared to males. Among non-native speakers, Tamil speakers had highest scores and Kannada/Malayalam speakers had lowest scores. Table 6 shows the percent correct scores in all 6 groups of subjects.

**Table 6:** Percent correct scores in 6 groups of subjects

| Group | M | F | Average | Average |
|---|---|---|---|---|
| Manipuri | 97 | 98 | 97.5 | 97.5 |
| Hindi | 67 | 74 | 70.5 | |
| Kannada | 66 | 72 | 69 | |
| Malayalam | 65 | 73 | 69 | 71.5 |
| Telugu | 71 | 77 | 74 | |
| Tamil | 72 | 77 | 75 | |

**Discrimination of tone pairs**: Native Manipuri speakers discriminated the tone pairs significantly better than nonnative [$F(1, 9) = 43.1$ and 38.9, $p<0.00$ for males and females, respectively]. Significant difference between gender was found in all the five nonnative languages [$F(1, 79) = 22.3$, $p< 0.00$]. Females discriminated tone pairs significantly better than males. Among the non-native languages Tamil speaker's ability to discriminate tone was better and that of Malayalam speakers was poorest. Table 7 shows the tone discrimination scores on all the language tested.

**Table 7:** Percent different scores (Tone + other features).

| Group | M | F | Average | Average |
|---|---|---|---|---|
| Manipuri | 98 | 95 | 96.5 | 96.5 |
| Hindi | 35 | 44 | 39.5 | |
| Kannada | 29 | 46 | 37.5 | |
| Malayalam | 29 | 43 | 36 | 38.4 |
| Telugu | 33 | 45 | 39 | |
| Tamil | 33 | 47 | 40 | |

There were words in a pair that had features other than tone, these included aspiration, word duration, distorted vowel and frication duration and could have helped the subjects to discriminate a word pair. In order to see the effect of other features on tone discrimination, separate scores were provided for word pairs that had only tone and word pairs that had tone with other features. Table 8 shows percent different scores for word pairs that used only tone and compares it with word pairs that had tone with other features. Percent different score of Manipuri speakers reduced by 1.5% and that of non-native speakers reduced by 11.4% when

only tone was present, significant between group differences [F (1, 9) = 72.87 and 34.9, P< 0.00 for males and females, respectively] and gender differences among non-native speakers [F (1, 9) = 31.1, P< 0.00] were observed.

**Table 8:** Percentage different scores for word pairs with tone only (A) & tone with other features (B)

| Group | M | F | A | B | A-B | A-B |
|---|---|---|---|---|---|---|
| Manipuri | 97 | 93 | 95 | 96.5 | 1.5 | 1.5 |
| Hindi | 25 | 37 | 31 | 39.5 | 8.5 | |
| Kannada | 21 | 35 | 28 | 37.5 | 9.5 | |
| Malayalam | 21 | 33 | 27 | 36 | 9 | 11.4 |
| Telugu | 17 | 37 | 27 | 39 | 12 | |
| Tamil | 17 | 37 | 27 | 40 | 13 | |

**Manipuri language-Discrimination of word pairs**: Figure 5 shows the percentage different response in native Manipuri speakers. More than 87% of Manipuri speakers discriminated all tone pairs except for word pair 1.

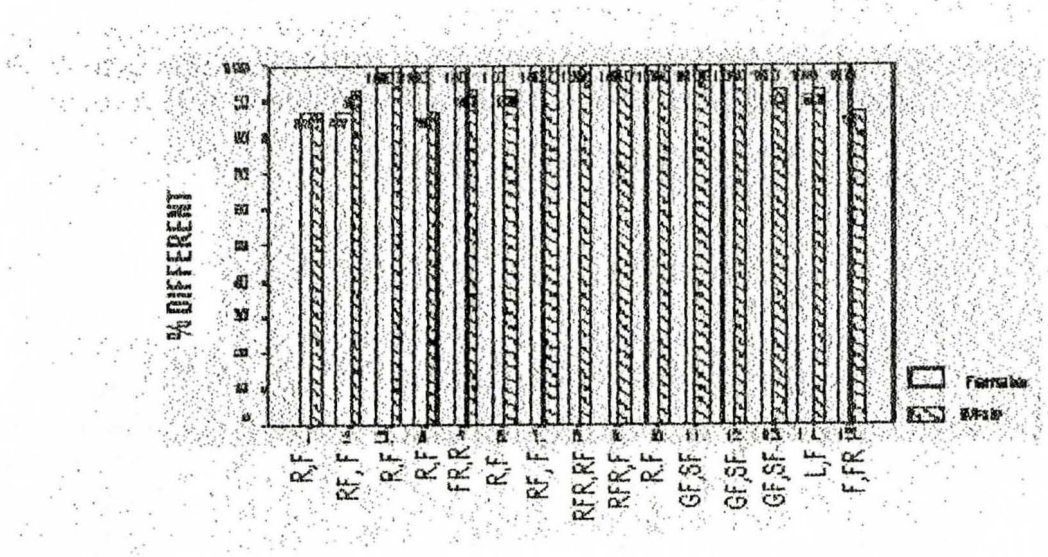


**Figure 5:** Percent different response for individual word pairs (Manipuri).

**Nonnative language-Discrimination of word pairs**: Among the various tone patterns, rising vs. falling, gradual fall vs. steep fall, falling vs. falling rising were the most difficult for non-native speakers. Interestingly, non-native speakers scored better when additional features such as aspiration or word duration accompanied such tone contrasts. In contrast, percent different scores were high for rise-fall-rise vs. rise-fall, rise-fall-rise vs. fall and gradual fall vs. steep fall patterns. All these three patterns had word duration as an additional cue. The word duration was longer in one of the words in a pair. Interestingly, Telugu speakers who had a score of 21.5% on gradual fall-steep-fall pattern obtained a score of 90% when the same pattern accompanied by addition cue word duration. Tamil speakers also had highest score (95%) on this tone contrast. Table 9 shows the worst discriminated and the best discriminated tone contrasts. Figures 6 to 10 show percent different scores for individual tone contrast words with additional cues other than tone are marked.

**Table 9:** Word discriminated (WD) and best discriminated (BD) tone contrasts in non-native speakers (H = Hindi, K= Kannada, M = Malayalam, Te = Telugu, T = Tamil)

| Tone pattern | WD | | | | | BD | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | H | K | M | Te | T | H | K | M | Te | T |
| Rising Vs Falling | + | + | + | + | + | | | | | |
| Gradual fall Vs Steep fall | + | | | + | | | | | + | + |
| Falling Vs Falling rising | + | | | + | + | | | | | |
| Rise-fall-rise Vs Rise-fall | | | | | | + | | + | | |
| Rise-fall-rise Vs Fall | | | | | | + | + | + | | |

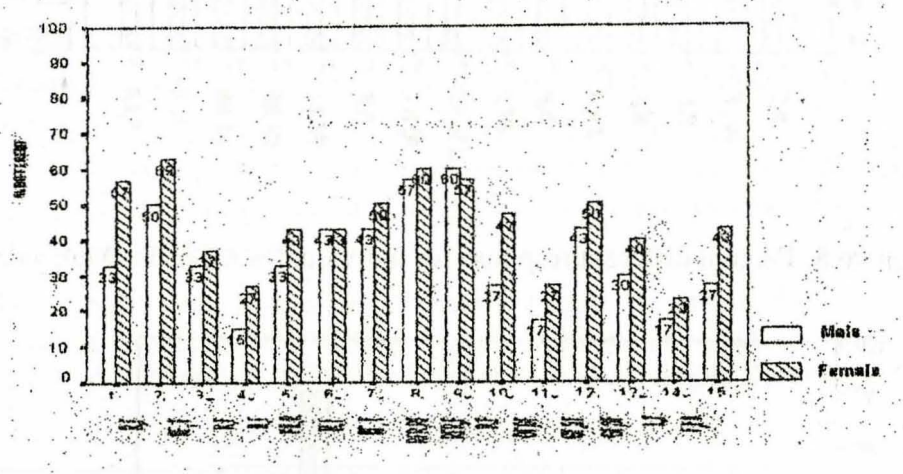


**Figure 6:** Percent different response for individual word pairs (Hindi).

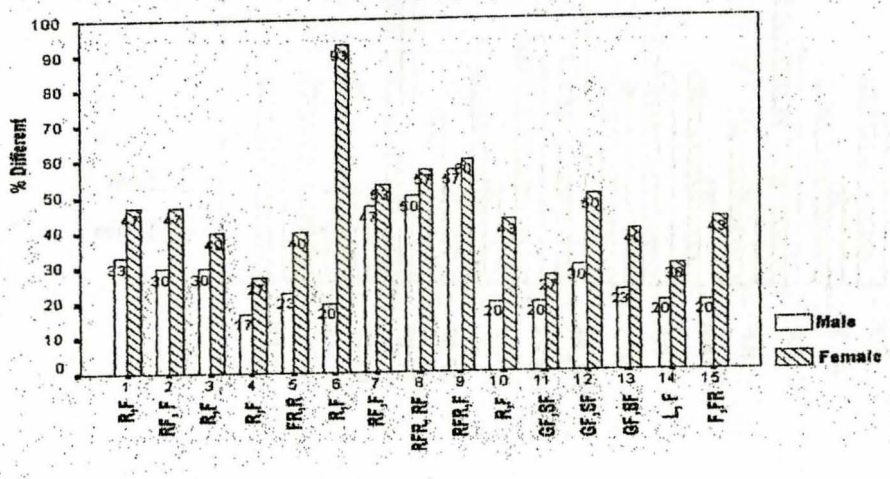


**Figure 7:** Percent different response for individual word pairs (Kannada).

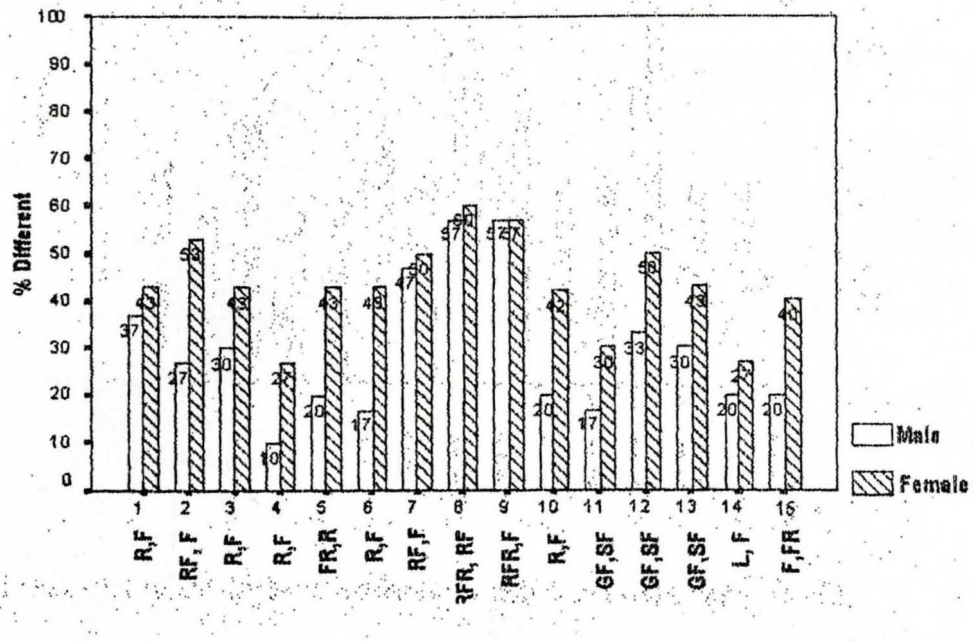


**Figure 8:** Percent different response for individual word pairs (Malayalam).

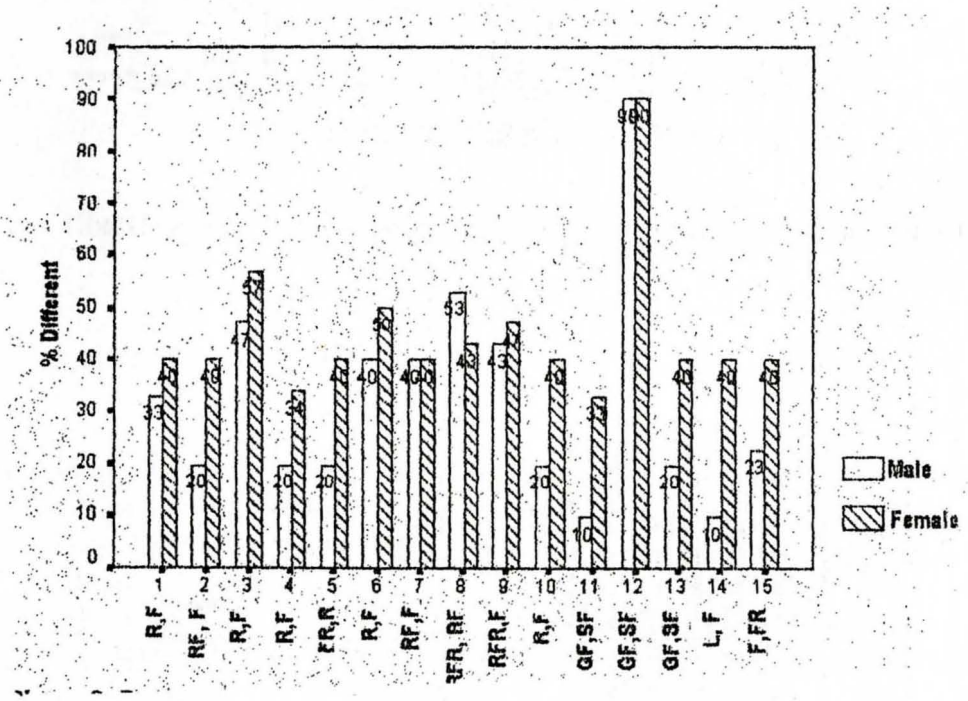


**Figure 9:** Percent different response for individual word pairs (Telugu).

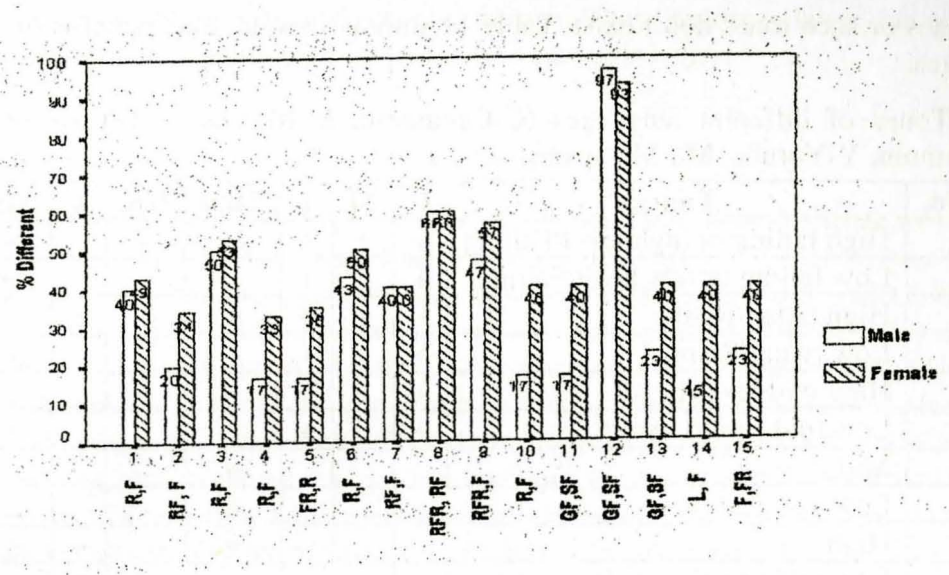


**Figure 10:** Percent different response for individual word pairs (Tamil).

Female Kannada speakers discriminated rising vs. falling tone contrast significantly better than any other group. They obtained a percent different score of 93%. Interestingly, this word pair had word duration and distorted vowel as additional cues. Table 10 shows % different scores on all tone contrasts.

**Table 10:** Percent different scores on all tone contrasts (R-Rising, F-Falling, RF-Rising Falling, FR-Falling Raising, RFR-Rising Falling Rising, GF-Gradual Falling, SF-Steep Falling, L-Level, A-Aspiration, WD-Word duration, FD-Frication Duration, DV-Distorted vowel).

| Tone pairs | H | | K | | M | | Te | | T | | Ma | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F |
| I (R, F) | 33 | 57 | 33 | 47 | 37 | 43 | 33 | 40 | 40 | 43 | 87 | 87 |
| Thong (RF, F) | 50 | 63 | 30 | 47 | 27 | 53 | 20 | 40 | 20 | 34 | 87 | 93 |
| Ka (R, F, WD, A) | 33 | 37 | 30 | 40 | 30 | 43 | 47 | 57 | 50 | 53 | 100 | 100 |
| Ching (R, F) | 15 | 27 | 17 | 27 | 10 | 27 | 20 | 34 | 17 | 33 | 100 | 87 |
| Sing (FR,R,FD,WD) | 33 | 43 | 23 | 40 | 20 | 43 | 20 | 40 | 17 | 35 | 100 | 93 |
| Tui (R,F,WD,DV) | 43 | 43 | 20 | 93 | 17 | 43 | 40 | 50 | 43 | 50 | 100 | 93 |
| Li (RF,F,WD) | 43 | 50 | 47 | 53 | 47 | 50 | 40 | 40 | 40 | 40 | 100 | 100 |
| Li (RFR,RF,WD) | 57 | 60 | 50 | 57 | 57 | 60 | 53 | 43 | 60 | 60 | 100 | 100 |
| Li (RFR,F,WD) | 60 | 57 | 57 | 60 | 57 | 57 | 43 | 47 | 47 | 57 | 100 | 100 |
| Phi (R,F,A) | 27 | 47 | 20 | 43 | 20 | 42 | 20 | 40 | 17 | 40 | 100 | 100 |
| Tuba (GF,SF) | 17 | 27 | 20 | 27 | 17 | 30 | 10 | 33 | 17 | 40 | 100 | 100 |
| Chaba (GF,SF,WD) | 43 | 50 | 30 | 50 | 33 | 50 | 90 | 90 | 97 | 93 | 100 | 100 |
| Cha (GF,SF,A,WD) | 30 | 40 | 23 | 40 | 30 | 43 | 20 | 40 | 23 | 40 | 100 | 93 |
| Chek (L,F,DV) | 47 | 43 | 20 | 43 | 20 | 40 | 23 | 40 | 23 | 40 | 100 | 93 |
| Tauba (F,FR) | 17 | 23 | 20 | 30 | 20 | 27 | 10 | 40 | 15 | 40 | 100 | 87 |

## Discussion

The results indicated several points of interest. First of all 3 simple tones, 2 complex tones and one compound tone were found in Manipuri 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. It is not known whether they consider it as combination

of simple tones or such tones don't exist. Table 11 summarizes the tone patterns of different tone languages.

**Table 11:** Tones of different languages (C-Cantonese, M-Mandarin, T-Taiwanese, NK-Northern Kammu, Y-Yoruba, Ma-Manipuri).

| Sl. No. | Tones | C | M | T | Thai | NK | Y | Ma |
|---|---|---|---|---|---|---|---|---|
| 1 | High falling or high level/Falling | + | + | + | + | + | | + |
| 2 | Low falling or low level/Falling | + | | + | | + | | + |
| 3 | High rising/Rising | + | + | + | + | | + | |
| 4 | Low rising/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 | | | | | | | + |

Second, apart from the tone, aspiration, lengthening of word, vowel distortion and frication in some words might give additional cues to non-native speakers. These additional features were phonemic in non-native languages which might have helped non-native speakers to discriminate tone pairs. However, aspiration is not phonemic in Tamil. Therefore, Tamil speakers might not have scored better with additional cue aspiration. Duration is a distinct feature in all non-native languages studies. Therefore, word duration might have served as an additional cue and thus the percent different scores might have improved when word duration difference existed along with tone difference.

Third, native speakers' tone discrimination was significantly better than non-native speakers. This might be because non-natives speaker's phonemic inventory does not have tone contrasts and these speakers do not use lexical tones. Therefore, non-native speakers are not attuned to tone. Fourth, among non-native speakers tone discrimination was significantly better in females compared to males.

Fifth, among non-native speakers Tamil speakers performed best and Malayalam speakers the worst. It has been opined that the tone distinctions emerged (Chao, 1948) due to loss of voicing in the consonant. Voicing is not phonemic in Tamil. This might probably be a reason for better tone discrimination in Tamil speakers.

Sixth, some tone contrasts (GF-SF, RFR-RF, RFR-F, R-F) were best discriminated and some (GF-SF, F-FR) worst discriminated by non-native speakers. First of all the best-discriminated tone contrasts had cues. Apart from this tone contrasts like rising-falling-rising may be well discriminated from falling because of the vast difference in the two tones i.e. one being a complex tone and the other being a simple tone. Longer transition duration might also have contributed to better discrimination in simple tones like rising and falling. In contrast, falling and falling-rising tones were poorly discriminated owing to reduced transition duration. Also, variation in frequency or tonal height contributed to better discrimination.

Finally, when additional cue such as word duration accompanied the tone, discrimination score increased in Tamil and Telugu speakers. Interestingly, 93% of female Kannada speakers could discriminate rising Vs falling contrast when accompanied with

additional cues word duration and vowel distortion. These results indicate that additional cues help non-native speakers in discriminating tone contrasts better.

## Conclusion

The results indicated several points of interest. First of all 3 simple tones, 2 complex tones and one compound tone were found in Manipuri language. Second, apart from the tone the subjects used aspiration, lengthening of word, vowel distortion and frication in some words that might give additional cues to non-natives speakers. Third, native speakers tone discrimination was significantly better (96.5%) than non-native speakers (38.4%). This might be because non-native speakers' phonemic inventory does not have tone contrasts and these speakers do not use lexical tones. Therefore, non-native speakers are not attuned to tone. Fourth, among non-native speakers tone discrimination was significantly better in females compared to males. Fifth, among non-native speakers Tamil speakers performed best and Malayalam speakers the worst. Sixth, some tone contrasts (GF-SF, RFR-RF, RFR-F, R-F) were best discriminated and some (GF-SF, F-FR) worst discriminated by non-native speakers. First of all the best-discriminated tone contrasts had additional cues. Longer transition duration also might have contributed to better discrimination in simple tones like rising and falling. In contrast, falling and falling-rising tones were poorly discriminated owing to reduced transition duration. Also, variation in frequency or tonal height contributed to better discrimination. These results indicate that additional cues help non-native speakers in discriminating tone contrasts better.

It is suggested that additional cues can be deleted by computer editing and the same experiment can be replicated. In the present study only one speaker was chosen for recording. Therefore, the results that 8 tones are represented in Manipuri may not be realistic. Acoustic data from a number of Manipuri speakers will definitely provide better information of the tonal characteristics in Manipuri. The material of this study can be used as a test of tone in Manipuri and the data obtained can be used as normative. Also, speech pathologists can be trained to identify and discriminate tones that would help them in treating patients speaking Manipuri language.

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