CROSS LANGUAGE PERCEPTION OF STOPS IN TAMIL AND MALAYALAM

M - 9519

A Dissertation submitted as part fulfilment of
final year M.Sc. (Speech and Hearing)
to the University of Mysore,
Mysore.

May 1997

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CERTIFICATE

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DECLARATION

I hereby declare that this dissertation entitled **"CROSS LANGUAGE PERCEPTION OF STOPS IN TAMIL AND MALAYALAM"** is the result of my own study under the guidance of Dr. Savithri S.R., Reader, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
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ACKNOWLEDGEMENT

First and foremost I extend my heartfelt gratitude to my teacher and guide ***Dr(Mrs.) SAVITHRI, S.R.,*** *Reader, Department of Speech Sciences, All India Institute of Speech & Hearing, Mysore, for her acceptance, guidance, timley help and invaluable suggestions.*

I extend my gratitude to ***Dr. (Miss.) S. NIKAM,*** *Director, All India Institute of Speech & Hearing, Mysore, for permitting me to conduct this study.*

Thanks to ***Dr. NATARAJA, N.P.,*** *Professor and Head of the Department of Speech Sciences for permitting me to use the speech science laboratory to conduct the study.*

Mummy *- Words can never express what you mean to me. Thank you for molding me into what I am to-day and for providing constant inspiration, support and encouragement. I love you.*

Chikku *"Sister is a friend, a sibling God chooses for sharing and its a bond that grows deeper as the years pass by".*

Saji uncle *- thank you for all that you have done for me.*

Special thanks to Uncle, Aunty and Pradeep for the help and support. Bindu and Skeena "Few ties are deep and profound" - our friendship being one of those. Mad-Maggie-Rat It has been nice knowing you {JLT) . Thanks to all my other friends who have helped me throughout.

Last but not the least thanks to all the subjects for their co-operation and patience without which the study would have been incomplete.

Thanks to Spaceage Electronic Typing, for their efficient work.

Dedicated to MUMMY and DADDY

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CHAPTER - I

INTRODUCTION

Cross-language speech perception represents a dynamic research area in which the ideas have grown and changed over the years. Cross-language perception in simpler terms refers to the perception of non-native contrasts by native listners.

Languages across the world vary in the type of speech sounds they use. A particular phone may be present in one language (Li) which may be absent/may occur as allophonic variation in the other (L2). This has captured the attention of various investigators. They have tried answering questions like do individuals exhibit unversality in perception of speech sounds or do the native language restrict the range of speech sounds which the native language users can perceive. If so, does adequate exposure / training help to perceive the non-native contrasts ? What are the developmental changes occuring in cross-language perception ? and so on.

Initial research [Lisker and Abramson (1970), Caramazza, Yeni-Komshian, Zuriff and Carbone (1973)] on cross-language , perception were with respect to the various contrasts which could be discriminated by non-native listeners. The focus gradually shifted over to the efficacy of using various training strategies to sensitize these individuals to non-native contrasts. These studies {Strange & Jenkins (1978), Pisoni, Lively and Logan (1982, 1983), Werker and Tees (1981, 1984), Flege (1989), Polka (1991), Pruitt (1993)} led to the conclusion that inability to discriminate the non-

native contrasts do not imply a sensory loss, rather a perceptual reorganisation resulting from linguistic exposure (Werker and Tees 1981, Best 1988, 1990, 1992). Current work in cross-language speech perception is increasingly theory motivated.

While some studies use parameters such as VOT (Lisker & Abramson, 1970, Caramazza, Yeni-Komshian, Zuriff and Carbone, 1973; Strange and Jenkins, 1978; Pisoni, Lively Logan, 1982, 1983 Flege and Bohn, 1993). Aspiration (Werker and Tees, 1984), Release burst, (Flege and Hillenbrand, 1987), final closure voicing and burst (Flege 1989), place contrasts (Werker & Tees, 1984; Polka, 1991; Pruitt, 1993) for consonants, some use synthetic/natural vowels (Flege, Monro and Fox, 1994).

In the Indian context only one study has been conducted. Himanshu, (1996) in his study of cross-language vowel perception in Hindi and Bengali found that the Hindi monolingual listeners use more perceptual dimension of vowels than native Bengali monolingual. Learning a second language did not increase the dimensionality of bilingual Bengali listeners and perception of Hindi vowels reflected the categories of their native language. The results of these studies indicate the influence of native language on speech perception.

India, a country with diverse linguistic groups, offers greater scope for research in cross-language speech perception. This would help in understanding the perceptual skills of bilinguals and multilinguals, the extent to which the native language and subsequent exposure to other languages would reorganise their perceptual skills. This again has implications in teaching second language to adults and children.

In this context the present study was planned. The aim of the study was to investigate the perception of stop consonants by native Tamil, Malayalam and Bilingual speakers. (Tamil as first language and Malayalam as second language). Tamil and Malayalam languages differ in Voicing and Aspiration. While both are phonemic in Malayalam, they are not in Tamil. These differences were used to investigate the cross-language differences with perception of stop consonants. Specifically stop consonants depicting voicing and aspiration differences as in the initial and medial positions of meaningful Malayalam / Tamil words were used. The responses of the native monolinguals of Tamil and Malayalam and bilingual speakers were elicited. If native language affect the perception, it would imply that Tamil monolinguals would perform poorly on voicing and aspiration contrasts and Malayalm monolinguals would perform better on the same.

CHAPTER II

REVIEW OF LITERATURE

Cross-language perception is a relatively recent area of research which throws light on the perception of non-native contrasts as well as the role of linguistic environment in speech perception in infants, children and adults. The studies on cross-language consonant perception are reviewed under the following headings:

Cross-language studies on perception of stops.

Theoretical explanations for cross-language differences in perception.

Variables in cross-language studies on consonants.

1) **Cross-language studies on Perception of Stops:**

a) Perception of voicing in stop consonants:

Lisker and Abramson (1970) carried out perceptual studies using synthetic stimuli varying in VOT. They used labial, apical and velar stop consonants. English, Thai and Spanish natives showed that their identification and discrimination function and boundaries were determined by their native language. In another study, Lisker and Abramson (1972) attempted to train native speakers of Russian to distinguish between the voiceless unaspirated and voiceless aspirated stops, a voicing distinction in English but not in Russian. Although Russian subjects learned to identify the end point stimuli (i.e., +10 ms and +60 m sec. in VOT) slightly better than chance, their performance was not same for both the stimuli. Though they could use two discrete labelling responses their performance on the task was

neither consistant nor reliable. Since no immediate feedback was provided after training trail, they probably had more difficulty in determining which specific acoustic attribute of the stimuli to attend selectively.

Caramazza, Yeni-Komshain, Zuriff and Carbone (1973) studied VOT as a linguistic cue to separate initial stop consonants in three groups of subjects unilingual Canadian, French and English and bilingual French-English speakers. Identification tasks were used Unilingual English Speakers had sharp monotic slopes in their perceptual functions, this being absent for unlingual French subjects. Bilinguals had steeper slopes but non-monotic, cross-over points in the intermediate position. This lack of monotonicity indicates that the first learned language interfered in their perception.

Strange and Jenkins (1978) attempted to modify voicing perception in adults. She trained a small number of college-age students to identify and discriminate differences in the lead region of VOT continum in which Thai Vd/vl unaspirate boundary occurs. Oddity discrimination task with immediate feedback, identification paradigm with delayed feedback and a scaling procedure was used. Strange found only small change in the perceptual categories, with performance improving in the target region of VOT continua where identification and scaling procedure was used. The subjects failed to generalise from one VOT series to another and the results were marked by high variability.

Pisoni, Lively and Logan (1982) studied the perception of stops differing in VOT in two different conditions by two groups of naive subjects. In the first condition, they used two response categories, corresponding to phonemes

|b| and |p|. In the second condition they were provided with three response alternatives |b|, |p|, |p^h|. They showed reliable 2 - category and 3 - category identification function.

In another experiment, they studied two additional groups of subjects using the same stimuli and in addition to identification function, discrimination (A X B) function was also carried out. They could discriminate stimuli in the voicing lead region despite being identified as belonging to same perceptual category. A discrimination training procedure with immediate feedback was carried out. Training was presented in a predictable order using only 3 stimuli one from each of the 3 voicing types (- 70 msec, Oms, + 10 msec). After training, those who met a predetermined criteria were tested for identification and discrimination function. The subjects were highly consistant in labelling the sounds in the voicing - lead region of the continuum. Steeper slopes in identification function was obtained. Thus, within a short period of time, native English speaking adults can reacquire the non-native contrast in voicing using simple lab training.

Pisoni, Lively and Logan (1983) in another training experiment, showed that knowledge about VOT perception gained through discrimination training on one place of articulation (eg: Labial) can be transferred readily to another place of articulation (Alveolars) without additional training. That is, the native subjects can learn very detailed and specific information about the temporal and spectral properties of VOT. This again lends support to the fact that, sensory-perceptual mechanism are not permanently modified or lost due

to linguistic experience,and there occurs a shift in listener's selective attention.

Werker and Tees (1984) studied English speaking adults ability to discriminate the Hindi contrast voiceless aspirate (t^h) Vs breathy voiced (d^h), They could not discriminate this contrast. But limited training of 25 trials was sufficient to facilitate the discrimination of this voicing contrast. This VOT boundary cross is, distinctive in English and hence it could be easily recovered.

Flege and Hillenbrand (1987) studied the differential effect of release burst on stop voicing judgement of native French and English listeners. Removing the release burst from the word final English /g/ tokens, influenced the voicing judgement of native French but not native English subjects. French natives gave more emphasis to release burst, as the stops are consistantly released in French.

Flege (1989) studied chinese subjects perception of English word final | t | - | d | from which word final closure voicing and release burst cues were removed. Performance of three Chinese groups - Cantonese, Mandarian and Shanghainese - were compared before, during and after the feedback training. Cantonese subjects were expected to perform best because their L_1 permits unreleased |p,t,k| in word final positions. Mandarian subjects were expected to perform poorly because their L_1 permits no word final obstruents. Shanghainese subjects were expected to perform at intermediate level. Results showed an increased sensitivity to these contrasts as a result of training. Specifically Contonese subjects focussed greater attention on end of

the CVC stimuli than Mandarian subjects which enabled them to use other acoustic cues, F_1 offset frequency for | t | - | d | contrasts.

Flege and Bohn (1993) studied language set effects in Spanish and English monolinguals and bilinguals. The stimuli used were short-lag Spanish | t |, Spanish | d | with lead VOT, short-lag English | d | and long-lag English | t |. A small phonetic context effect was observed for Spanish and English monolinguals and for the bilinguals. That is, Spanish | t | tokens were presented in Spanish and English, perceptual sets. A small language set' effect was observed for the monolingual and bilingual listeners. Since both the groups showed the same effects, a post-perceptual, language - independent decision strategy based on their language-dependent perceptual processing could have been employed.

b) Perception of Place of Articulation of Stop Consonants.

A number of cross-language studies have shown that, some of the non-phonemic constrasts presents greater perceptual difficulty than others. In particular the non-native contrasts involving phones that subjects experience as allophones of the native language phones are less difficult to differentiate than the ones involving place-of-articulation contrasts which are unlikely to have experienced as allophones.

Werker and Tees (1981) studied the Hindi place contrast of retroflex versus dental vioiceless unaspirated stops | t | - | <u>t</u> |. English adults were not able to discriminate this contrast even with additional training. Further, in 1984, Werker and Tees studied the discrimination of the same contrast as in the above study. In a brief laboratory training involving category change

procedure, it was found that subjects who had experience with Hindi language early in life before age 2 could readily perceive this contrast.

Polka (1991) studied English listeners perception of the retroflex Vs dental place distinction in Hindi in four different voicing contrasts - pre voiced |d| vs |d̲| ,voiceless unaspirated |t| vs |t| voiceless aspirated |t^hl vs (t^h) and breathy voiced |d^h| vs |d^h|. Percent errors in the AX discrimination task for the four contrasts increased in the order voiceless unaspirated, breathy voiced, voiceless aspirated and prevoiced. Differences in assimiluation strategy (which take both phonemic and articulatory phonetic factors) could amount for the variability in the perceptual difficulty among the four contrasts. Acoustic-phonetic factors also play an important role in the perception of both asimilated and non-assimilated contrasts.

Pruitt (1993) studied American - English listeners identification of Hindi retroflex and dental stops in varying voicing conditions. Results showed individual variability in the difficulty to discriminate the contrasts. This again depended on the speaker and vowel contexts. Also, increasing the stimulus variability did not affect the transfer to new stimuli.

Thus, the above studies show that some of the non-native contrasts, though not readily discriminated by adults can be easily taught in laboratory (eg: voicing) While certain other contrasts (eg: place) are more difficult to discriminate and require elaborate training procedure.

Flege, Monro and Fox (1994) in their study tried to determine the perceived dissimilarity of English and Spanish vowel changes as native speaker of Spanish gain experience in English and tested the role of auditory

difference, category status and typicality on vowel dissimilarity rating. The stimulus used was all the vowels of English and Spanish in minimal pairs and some non-words in the combination (p-t) . Three Spanish and three English monolingual speakers were made to speak each word containing vowels of Spanish and English respectively. Each of the word of each vowel category were paired with that of the words of other vowel. Three types of pair were made i.e., English-English, Spaish-Spanish and Spaish-English. There were nine examples of each token and in all 405 tokens. 60 subjects were divided in four groups. English (30 subjects divided randomly into EnA and EnB), Spanish (30 subjects divided on the basis of language experience - SA being non-proficient bilinguals, SB being proficient bilinguals with English as second language). The subjects had to rate the words in the token on a nine point scale with (1) as similar (9) as very dissimilar. This was followed by oddity discrimination test. ISI of 1.2 sec was used to encourage the usage of phonetic cue from long term memory. Correlational analysis showed little effect of L_2 experience in perceived dissimilarity of pair of English and/Spanish words. English speakers rated the English-English pairs as more dissimilar than Spanish speakers and Spanish speakers rated Spanish-Spanish pairs are more dissimilar than English Speakers. This proved the typicality hypothesis.

Himanshu (1996) studied the perception of vowels of Hindi and Bengali in Hindi-Hindi, Bengali-Bengali and Bengali-Hindi word pairs in the CVC combination (k-1). This was studied in Hindi and Bengali monolinguals and Bengali bilinguals with Hindi as their second language. Ninety normal

hearing subjects in the age range 20 - 43 years with thirty in each three groups were taken. Material consisted of 191 audio recorded token which were pairs of CVC monosyllablic minimally contrastive meaningful words. They contained 10 Hindi and 7 Bengali vowels as embedded between |k| and |1| (K-l). Interstimulus interval of I sec and intertoken interval of 5 sec. was provided. Tokens were presented binaurally to subjects and they were to dichotonomise this in to same or different. Percentage similarity and dissimilarity scores were obtained. The results showed that Hindi monolingual listeners use more perceptual dimension of vowel than native Bengali monolinguals or bilinguals. Bengali monolinguals and bilinguals performed similarly on all tokens. They obtained 100% different scores for Bengali-Bengali tokens and could not differentiate tense and lax vowels. Thus learning second language (Hindi) did not increase the vowel dimensionality of Bengali bilingual listeners. The psychological vowel space remained the same and perception of Hindi vowels by bilinguals reflected the categories of their native language.

The influence of language experience on speech perception is evident in the limitations that have been observed in adults discrimination performance with phonetic distinctions that do not contrast phonologically in their own language. These pattern of results led some to propose that differential phonetic experience may sharpen attention or psychoacoustic responsiveness to phonetic properties found in native language and may attenuate responsiveness to properties that are absent from that language (Diehl and Kluender 1989, Pisoni and lively 1991, 1993). Another account is with

regard to the maintainance of neural element wherein exposure to the particular phonetic features during the critical period is required (Eimas 1975, Aslin and Pisoni, 19'80). As it has been stated previously, adults' perception of non-native contrast can be improved by learning the other language (Best and Strange 1981) or by laboratory training (Pisoni et al 1982, 1991, 1993). Also, discrimination on non-native contrasts benefits from task manipulations that reduce the memory demands (Werker and Logan 1985). Thus a pure neural loss does not explain the pattern. Some do suggest that a differential phonetic experience shapes the higher-level processing of the auditory information contained in speech signal (Werker and Tees 1984).

2) **Theoretical explanations for cross-language differences in perception:**

Theoretically based explanations as to whiich of the non-native contrasts would be easy or difficult to discriminate has been provided. Burham (1986) suggested that there might be both fragile and robust non-native contrast. Fragile refers to those contrasts that are rare across the world's languages and are acoustically similar, whereas robust refers to contrasts that are widely distributed across the world's languages and are acoustically less similar. It is due to the loss of the fragile contrasts that difficulties arise in perception of non-native contrasts in adults.

Perceptual Assimilation Model (PAM) was proposed by Best. (1988) wherein the phonological status is the predictor of the discriminability of non-native contrast. There are four patterns in which two members of a given non-native contrast could be perceptually assimilated to the native phones, - *viz,*

Two category type where the members may be gesterally similar to two different native phonemes there by becoming assimilated to two categories.

Single category type wherein the non-native phones may be assimilated equally well or poorly to a single native category.

Category goodness type where the non-native pair may both be assimilated to the native phoneme, yet one may be more similar than the other.

Nonassimilable type whereby the non-native sounds may be too discriminable from the gestural properties of native categories to be assimilated to any category of native phonology. Hence discrimination performance for adults follow the order.

Two category > Non assimilable < = > category goodness > Single category.

Kuhl (1992) proposed the Native Language Magnet Theory (NLM) to describe how the innate factors and experience with a specific language interact in the development of speech perception. Exposure to language results in the formation of language specific magnets. Thus, the difficulty in discriminating the non-native sounds depend on their proximity to native language magnet that is the nearer it is to the native language magnet, the more it will be assimilated by it, making it indistinguishable from the native-language sound.

3) Variables in cross-language studies on consonant perception:

a) Testing Environment:

Nabelek and Donahue (1984) studied the effects of noise and reverberation on the performance of native English and native Hebrew

speakers. Modified Rhyme Test (MRT) was used. The performance of non-natives declined in noise and reverberation. Takata and Nabalek (1990) compared the native English speakers to native Japanese speakers in their performance in MRT. In conditions of noise and reverberation, Japanese speakers performed significantly poorer than native English.

b) Stimulus used:

This could be natural or synthetic stimuli. Caramazza et al (1973) and Williams (1977) failed to find a significant change in the voicing judgment as a function of language set. Flege and Eefting (1987) had native speakers of English and Dutch label the numbers of a VOT continuum ranging from |da| to |ta|. Here the language set effect was significant. Flege and Bohn (1993) reported of a small language set effect in Spanish and English monolinguals as well as bilinguals. The studies that failed to show an effect of language set.made use of synthetic stimuli wherein the full range of acoustic cues to stop voicing is absent.

c) Intersimulus Interval (ISI):

Werker and Tees (1984) studied the performance with variation in ISI in AX procedure. Native English speakers were required to discriminate two non-native contrasts Hindi (retroflex Vs dental) and Thompson (Unular Vs Velar) at ISI of 500 ms and 1500 msec. Discrimination was better with 500 ms ISI. Thus the availability of a memory trace following 500 ms delay may enable subjects to relinquish an exclusively phonemic processing strategy, and detect differences within phonemic categories.

d) Paradigms used:

Specific paradigms are used depending, on the research needs. The various paradigms generally used are:

1. Identification task.
2. AX or same/different task.
3. AXB method.
4. ABX task
5. Oddity task
6. Application of Signal detection theory.

In the identification task,the subject is required to identify the stimulus presented. It is easier than the other tasks and the memory demands are low.

AX or same / different task is a discrimination task. Here the subject has to indicate whether X is similar to A or different from A. Here again memory demands are less and is used to test the sensitivity to contrasts.

Category change criteria is also used wherein the subject has to indicate when there is a change in the stimulus from the previously presented background stimulus. Werker and Tees ('84) in their study on non-native contrast found that category change criteria is less sensitive than AX task.

AXB task has three sounds presented successively to the subjects. The subjects has to decide whether X (target stimulus) is more similar to A or to B. This procedure is used in studying assimilation processes.

ABX task requires the presentation of three sounds successively to the subjects wherein they are required to confirm X to either category A or B. (Used in studies of categorical perception)

Oddity discrimination task requires the subjects to identify the odd item out of the three stimulus presented. This requires high memory demands.

Recently 'Signal detection theory' has been applied to make more objective measures. Flege et al (1994) used SDT to minimize the lexical effects and range effects noticed in Japanese discrimination of |r| - | 1 | contrast. Takagi (1995) reported that the percentage of correct response is not an adequate measure of sensitivity and it changes as a function of response criteria. SDT provides an accurate measure of sensitivity when a finer assessment of sensitivity is required.

The review indicates the various cross-language studies in consonant perception in various linguistic groups. The present study was undertaken to investigate the perception of stop consonants of Malayalam and Tamil in Malayalam-Malayalam, Tamil-Tamil and Tamil- Malayalam word pairs in Malayalam and Tamil monlinguals and bilinguals.

CHAPTER III

METHODOLOGY

Subjects:

90 subjects were chosen for the present study. They constituted three groups - Tamil monolinguals, Malayalam monolinguals and bilinguals with Tamil as native language and Malayalam as second language.

Group I: This consisted of 30 native Malayalam normal speakers - 12 Males in the age range 19 to 38 years (Mean age 27.08 years) and 18 females in the age range 19 - 49 years. (Mean age 27.22 years).

Group II: This consisted of 30 native Tamil normal speakers: 18 males in the age range 19 to 47 years (Mean age 29.88 years) and 12 females in the age range 18-48 years (mean age 31.33 years).

Group III: This group consisted of 30 bilinguals, 11 males in the age range of 20 to 48 years (mean age 32.55 years) and 19 females in the age range of 19 - 48 years (mean age 32.74 years).

Material:

The stimuli consisted of 123 tokens consisting of two words forming a pair. Malayalam - Malayalam tokens were 59 in number, Tamil-Tamil tokens, 20 and Tamil-Malayalam tokens 44 in number.

There were 111 Malayalam and 56 Tamil words which formed these tokens. All these were meaningful words. These words had the stops

consonants in the particular language contrasted in the initial and medial positions. Table 1 shows the stop consonants in Tamil and Malayalam.

	Voiceless				Voiced		LAX	
	Unaspirated		Aspirated		Unaspirated			
Place of Articulation	Tamil	Mai	Tamil	Mai	Tamil	Mai	Tamil	Mai
Bilabial	**P**	P	-		b	b	P	P
Dental	*t*	t	-	**th**	d	d	**T**	T
Alveolar	*t*	t	-	-	d	d	-	-
Retroflex	ṭ	ṭ	-	ṭʰ	ḍ	ḍ	-	-
Velar	k	k	-	k"	g	g	K	K

Table 1: Showing the stop consonants in Tamil and Malayalam.

Tokens were formed by the combination of words, containing stops consonants, contrasting within (voicing and Aspiration) and across the place of articulation in both the languages. Table 2 shows the word pairs used in the study.

These pairs as written one each on a card were visually presented to a Tamil and Malayalam, adult normal (female) speaker. The speakers read the word list in their respective languages, into a mic at a distance of 10 cm. with an interstimulus interval of 5 sec. For the Tamil-Malayalam tokens both the subjects read the respective words. All the word pairs were audio-recorded which formed the material.

Method:

Instrumental Analysis:

The III Malayalam words and 56 Tamil words, forming the tokens were spectrographically analysed. The recorded words were fed to the DSP Sonograph 5,500 through the tape recorder and spectrograms upto 8 kHz at a

MALAYALAM - MALAYALAM

pani - p^hani
pa:nam - ba:nam
p^haram - baram
tarn - t^ham
takSan - dakSan
t^ham - dam
ta:ram - t^ha:ram
tankaram - dankaram
kadam - k^hadam
ka:lam - ga:lam
k^hagam - gajam
padam - tadam
pa: ram - tadam
padala - kadala
tarlam - ta:lam
tari - kari
ta:lam - ka:lam
paSa - daSa
pa:maram - da:maram
padam - gadam
talam - balam
tappi - dappi
ta:li - ga:li
ta:lam - ba:lam
ta:ram - darram
tarlam - garlam
ka:lam - barlam
kaSa - daSa
kayari - dayari
pam - t^ham
pam - t^ham
pani - k^hani
tani - p^hani
ta:ram - t^ha:ram
tadam - K^hadam
tarlam - p^harlam
tarn - t^ham
ta:kki - k^ha:kki
kadam - p^hadam
ka:na: - t^ha:na:
karram - t^ha:ram
bam - t^ham
bam - t^ham
bilam - k^hilam

dalam - p^halam
darram - t^ha:ram
daram - k^haram
dalakam - p^halakam
dambam - k^hambam
ganam - p^hanam
bakam - dakam
bimbam - dimbam
bandam - gandam
dimam - di:nam
damanam - gamanam
gajan - dajan
cheiKa - cheiTa
pa:Pam - pa:Tam
ko:Kam - ko:Pam

TAMIL- TAMIL

ba:nam - pa:nam
tanam - danam
ka:nam - ga:nam
padam - tadam
pa:r - ta:r
pa:tt - kartt
tanki - tanki
dargam - ka:gam
tan - Kan
pa:nam - da:nam
panam - ganam
ta:lam - garlam
trerd - gre:d
tank - bank
muTam - mudam
pa:nam - da:nam
panam - garnam
da:nam - ga:dam
kaPam - kaTam
ta:Pam - darPam

TAMIL- MALAYALAM

bamam - pa:nam
balam - p^halam
pa:lam - ba:lam
pa:lam - p^ha:lam
kadi - k^hadi
ka:lam - ga:lam
ga:nam - ka:nam
ga:nam - k^ha:nam
danam - tanam
padam - k^hadam
pall - tall
tadam - p^hadam
tadam - k^hadam
kalam - p^halam
ka:ram - t^ha:ram
kadam - padam
kalam - talam
kalam - talam
tatt - patt
ka:lam - ta:lam
tadam - k^hadam
parr - ta:r
ba:vam - pa:vam
balam - talam
ba:vam - ta:vam
balam - kalam
dadi - pa:di
da:vam - tarvam
da:ram - ka:ram
ga:nam - pa:nam
garli - ta:li
ba:ram - t^ha:ram
ba:ram - k^ha:ram
dam - t^ham
damam - k^ha:nam
gandam - p^handam
gam - t^ham
balam - dalam
bimbam - dimbam
barni - garni
damam - garnam
kaPam - kaTam
ko:Pam - ko:Kam
va:Tam: - va:Kam

Table 2 : Word pairs used in the study

band width of 300 Hz and wave forms were obtained. Using the curser VOT and the first three terminal frequencies were obtained for the stop consonants forming each of the word in both the languages. For the stops consonants contrasting in the medial position, closure duration and the first three terminal frequencies were obtained.

Using the wave form, VOT was measured as the time difference between the onset of the articulatory release and the onset of vocal fold vibrations (Fig. 1) and closure duration was measured as the time difference between the offset of voicing for the vowel and the onset of articulatory release (Fig.2). The terminal frequencies T_1, T_2, T_3 were measured as the frequency at the onset of the first three formants of the following vowel on the spectrogram (Fig.3)

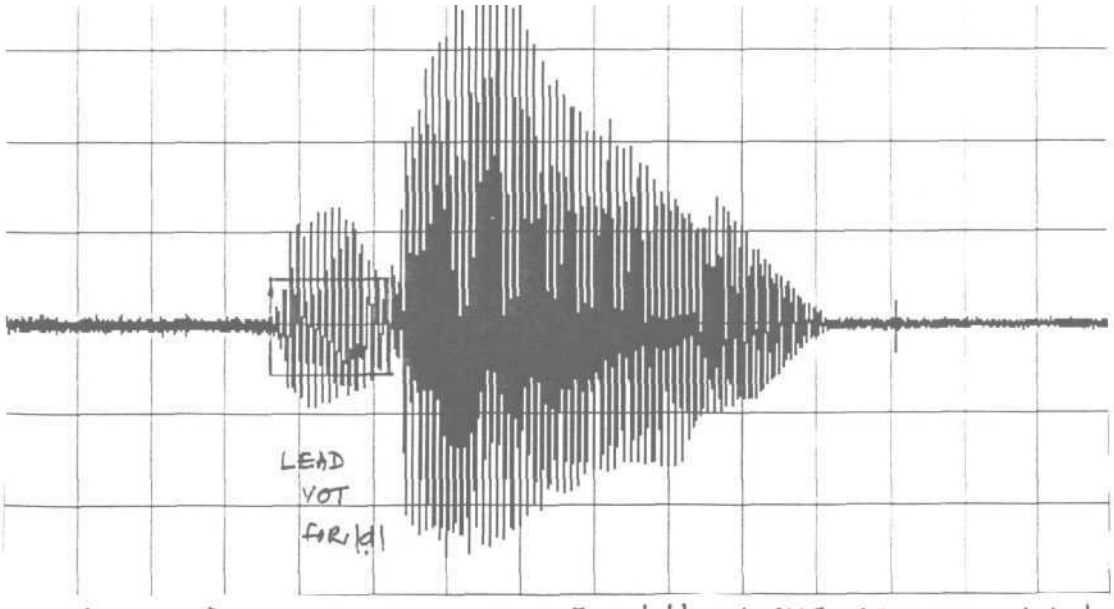


FIG: 1 : DEPICTING LEAD VOT FOR |ḍ| IN THE SYLLABLE |ḍa|

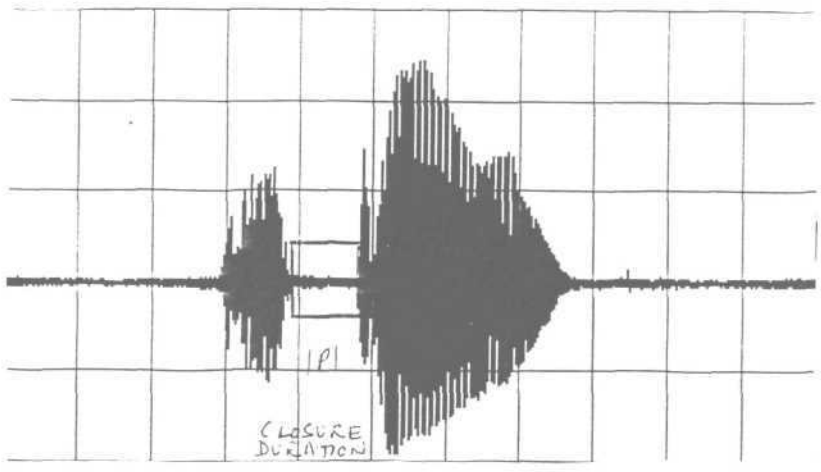


FIG: 2 : DEPICTING CLOSURE DURATION FOR /p/ IN THE WORD |apa|

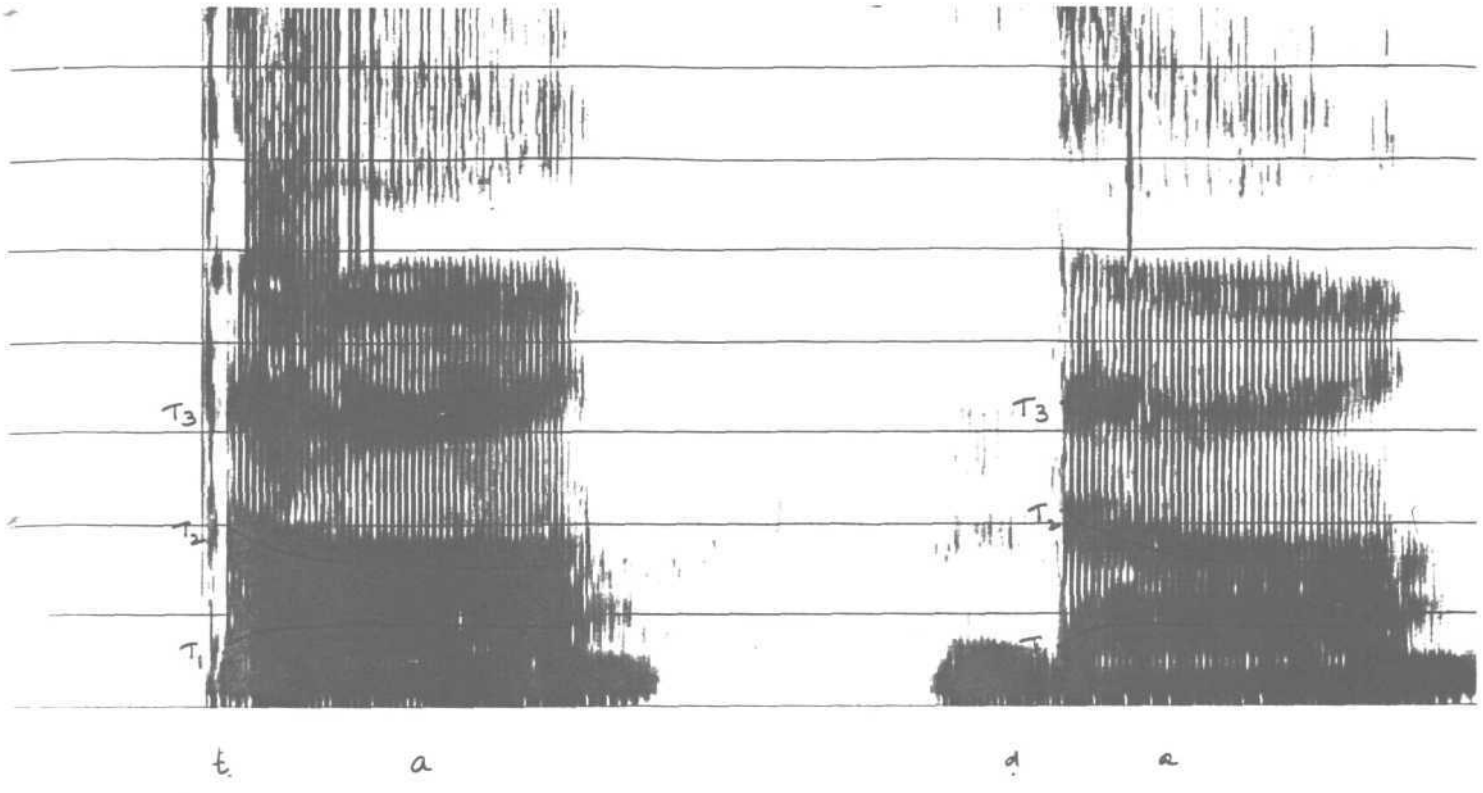


FIG: 3: DEPICTING THE MEASUREMENT OF TERMINAL FREQUENCY FOR |t| and |d|

Perceptual Analysis:

All listeners were tested individually and the stimuli was presented binaurally, through headphones at comfortable listening levels. Using a binary forced choice method (AX task) they were instructed to record on the response sheet whether the stops in the words forming the tokens wre the same or different.

Analysis:

The data obtained for the 3 groups were tabulated and analysed as percent same and percent different responses. Also, the average VOT, T_1, T_2 and T_3 and closure durations were tabulated.

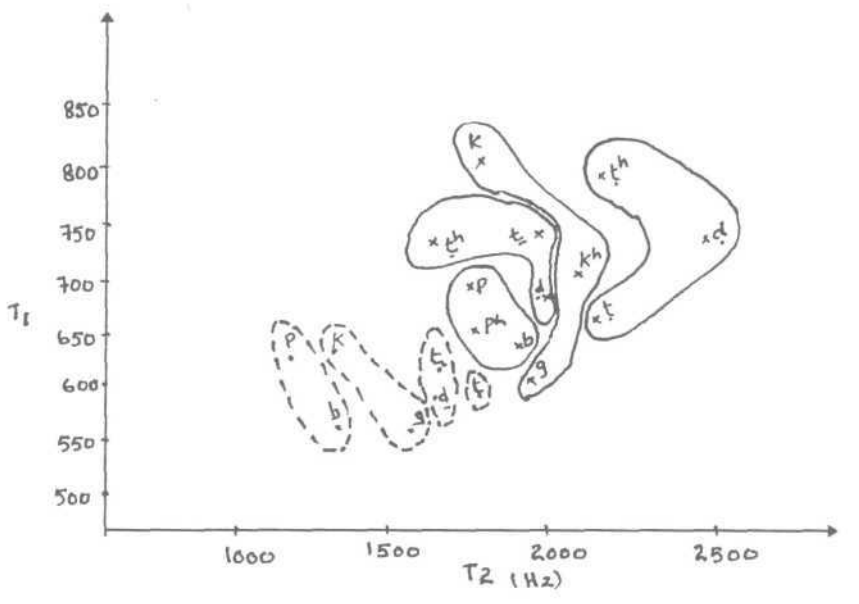
CHAPTER IV

RESULTS AND DISCUSSION

Results:

1. Acoustic Analysis:

It was observed that T_1 and T_2 were higher in Malayalam and they were overlapping for the stop consonants in the velar and dental place of articulation. The T2 was highest for retroflex and lowest for bilabials in both Malayalam and Tamil. The results of acoustic analysis are shown in Tables 3,4,5 Fig. 4. Shows the terminal frequencies in the stop consonants in Malayalam and Tamil.



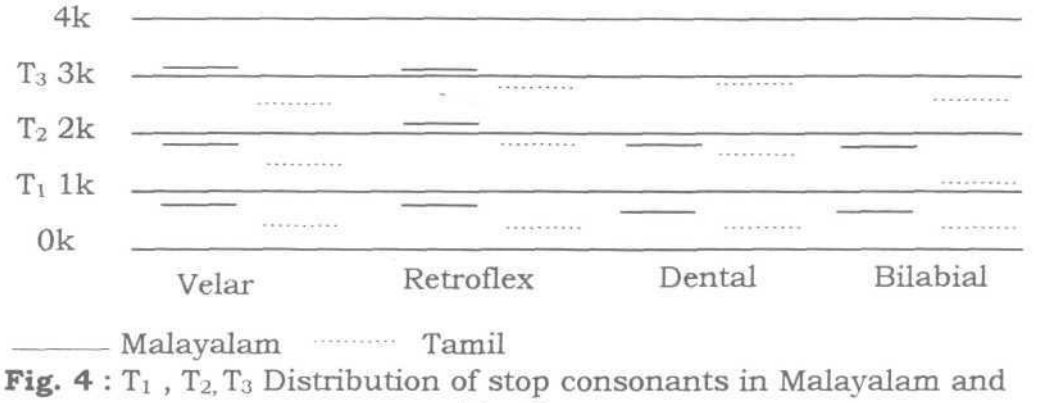


Fig. 4 : T_1 , T_2, T_3 Distribution of stop consonants in Malayalam and Tamil

CONSONANT	Ti (in Hz)	T_2 (in Hz)	T_3 (in Hz)
|k|	809	1809	3196
	644	1476	2568
|k"|	712	2108	3324
|g|	604	2000	3328
	560	1653	2680
|ṭ|	660	2140	3067
	616	1936	2880
|ṭʰ|	800	2140	3140
|ḍ|	751	2358	3396
| t_ |	756	1973	3197
	624	1680	2950
| t͟ʰ	740	1560	2580
|d̲|	680	2053	3333
	587	1667	2940
|p|	703	1667	3047
	640	1350	2635
|pʰ|	653	1667	2991
|b|	653	1960	3280
	554	1434	2760
Medial			
|K|	613	1827	3133
	560	1480	2740
|T|	460	1947	3147
	550	1810	2990
|P|	500	1480	3180
	560	1427	3027

Table 3: Terminal frequencies for the stop consonants in Malayalam and Tamil [depicted in the second line]

	Velar	Retroflex	Dental	Bilabial	Average
Voiced					
Malayalam	-91	-99	-107	-95	-98
Tamil	-95		-76	-109	-93.33
Voiceless unaspirated					
Malayalam	23	8	18	10	14.7
Tamil	26	8	10	7	12.7
Voiceless aspirated					
Malayalam	64	61	117	43	71.25

Table 4: Voice onset time (VOT) for stop consonants in Malayalam and Tamil.

Consonant	Closure duration (m sec)
|K|	81
	60
|T|	91
	65
|P|	76
	73

Table 5: Depicting closure duration for the stop consonants in Malayalam and Tamil [second Line]

VOT's for the various stops (Table 4) shows that voiced stops are characterized by lead VOT, voiceless by short lag VOT and voiceless aspirated by long lag VOT. Among the voiced stops in Malayalam, VOT was longest for dentals followed by retroflex, bilabial and velar. In Tamil, the order was bilabial, velar and dental. Within the voiceless, VOT was longest for the velar in both the languages. Among the voiceless aspirated, dentals had the longest VOT and bilabials had the shortest VOT. Though VOT was shorter in Tamil, not much difference was found between the VOTs across languages.

VOT contrast was good between the voiceless dental and other places of articulation but not between the retrofiex, velar and bilabial. Among the voiced stops, velar place contrasted with other places for VOT. However, the same was not observed between retroflex, dental and bilabial place of articulation. Thus, while VOT acts as a parameter to differentiate voicing, it may not be so for the place of articulation in Malayalam and Tamil.

The closure duration (Table 5) was longest for dental lax in Malayalam and was shortest for velar lax in Tamil. Closure durations were shorter in Tamil, though not significantly. Closure duration contrasted the place of articulation of dental with other places. However, the same was not observed between velar and bilabial place of articulation indicating the closure duration does not act as a parameter to differentiate place of articulation in Malayalam and Tamil.

II. Perceptual Analysis:

In the following figures group I represents Malayalam monolinguals, Group II represents Tamil monolinguals and group HI represents the bilinguals (with first language as Tamil and second language as Malayalam).

A. Malayalam - Malayalam Tokens:

1) Voicing contrasts:

Voicing contrast was well discriminated by Malayalam monolinguals and Bilinguals. The contrast was well discriminated for bilabial and velar followed by retrofiex and dental. However, voicing contrasts were poorly

discriminated by Tamil monolinguals. Bilinguals performed better than or equal to the Malayalam monolinguals in all the contrasts.

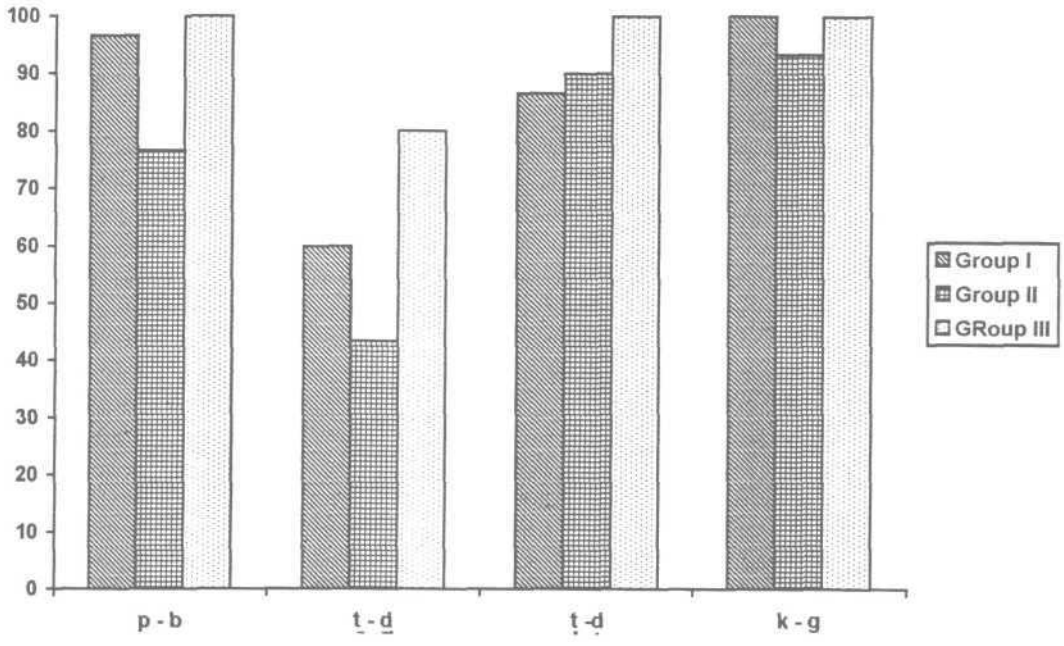


Fig. 5 : Percentage response for Mal-Mal tokens contrasting in voicing

2) Place contrast:

Malayalam -monolinguals performed better than the other two groups on all the contrasts except the dental-retroflex and bilabial-velar contrast (73.33%) for which the bilingual's performance was better. Tamil monolinguals performed poorer than the other two groups on all the contrasts except dental-retoflex (| d | -| d |) wherein they equaled the Malayalam monolinguals. Among the various place contrasts, bilabial with other places received the highest contrast and the poorest contrast was between dental and retroflex place of articulation.

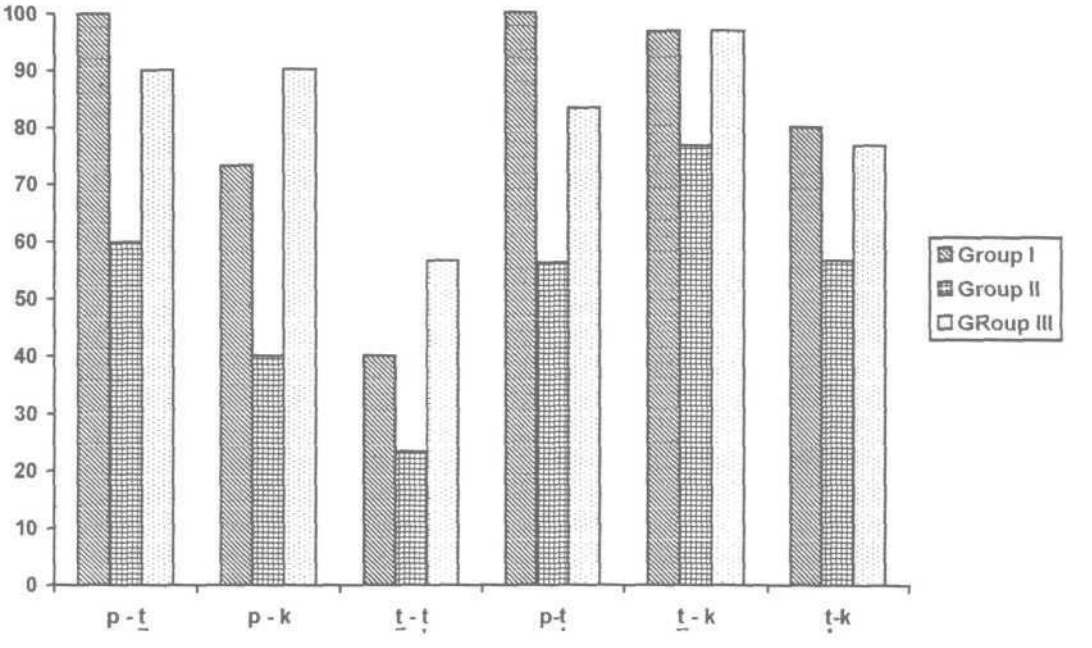


Fig. 6a : Percentage response for Mal-Mal tokens contrasting in place(voiceless).

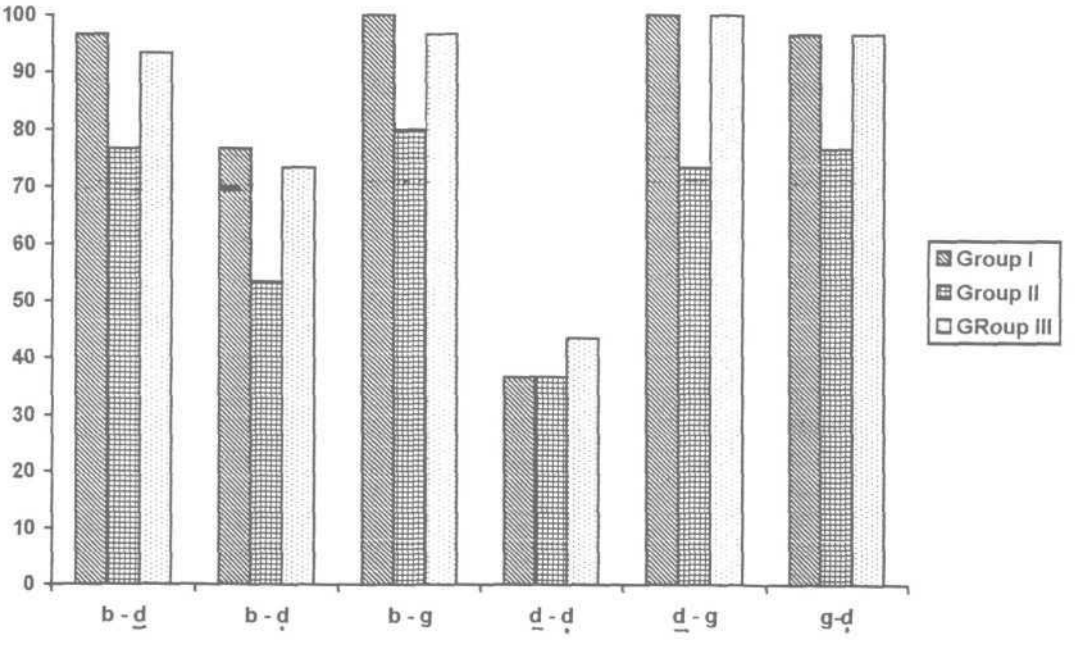


Fig. 6b : Percentage response for Mal-Mal tokens contrasting in place(voiced)

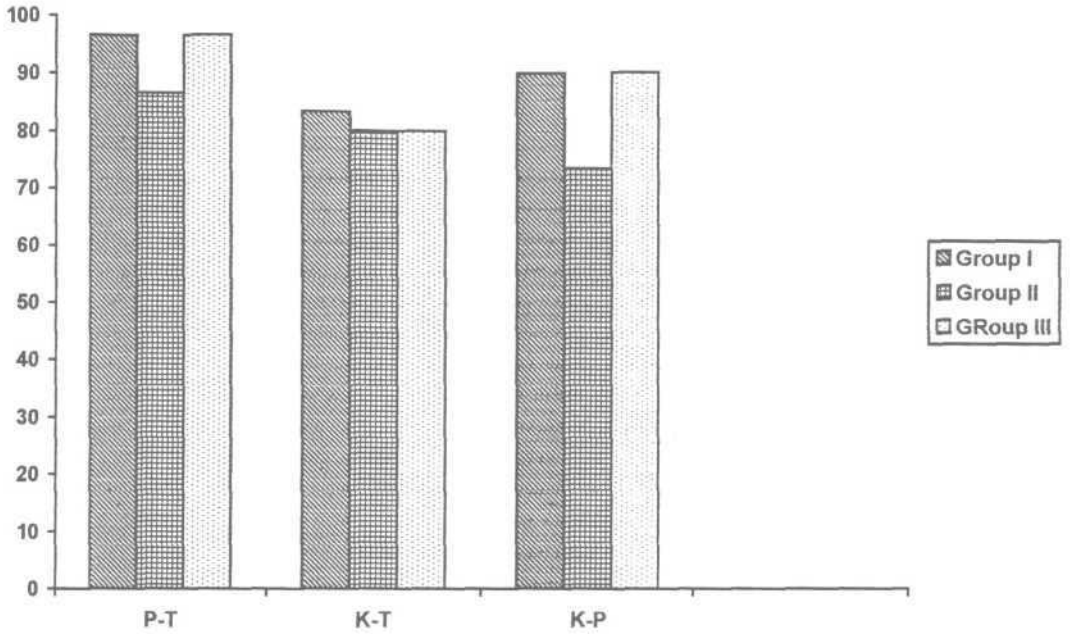


Fig. 6c : Percentage response for Mal-Mal tokens contrasting in place(lax)

3) Place and Voicing Contrast:

Malayalam - monolinguals performed better than the other groups on all the contrasts and Tamil monolinguals performed poorest of all. The highest scores were obtained for the bilabial vs others followed *by/velar* vs others; retroflex vs others and dentals vs others. The poorest contrast was between dental and retroflex.

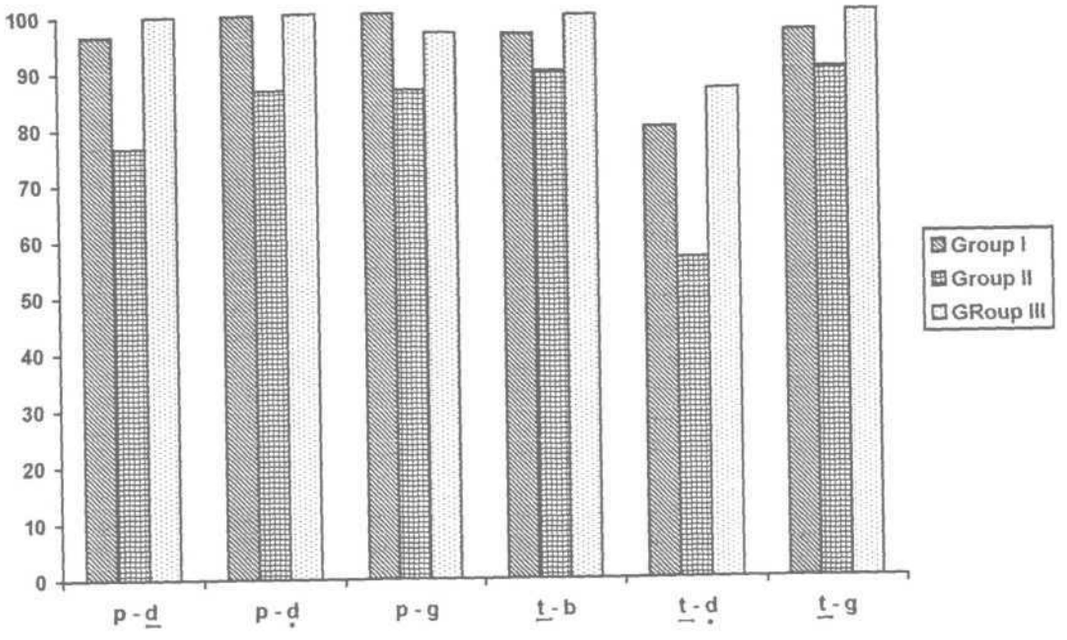


Fig. 7a : Percentage response for Mal-Mal tokens contrasting in place and voicing.

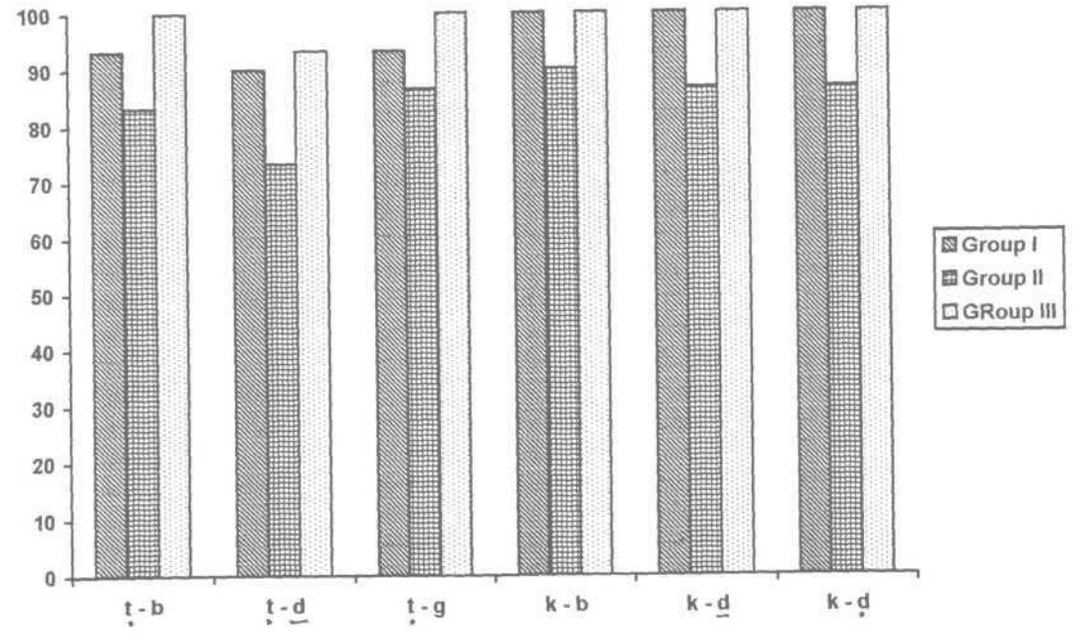


Fig. 7b : Percentage response for Mal-Mal tokens contrasting in place and voicing.

4) Aspiration Contrasts:

In the aspiration contrasts, bilinguals performed the best in all contrasts. Malayalam ayalam-monolinguals showed the best performance in the dental contrast followed by the velar and dental contrasts. Tamil monolinguals showed best performance in dental contrast and equaled the Malayalam- ayalam-monolinguals in the velar contrast. However, their performance was slightly better their Malayalam-ayalam-monolinguals in the bilabial-contrasts.

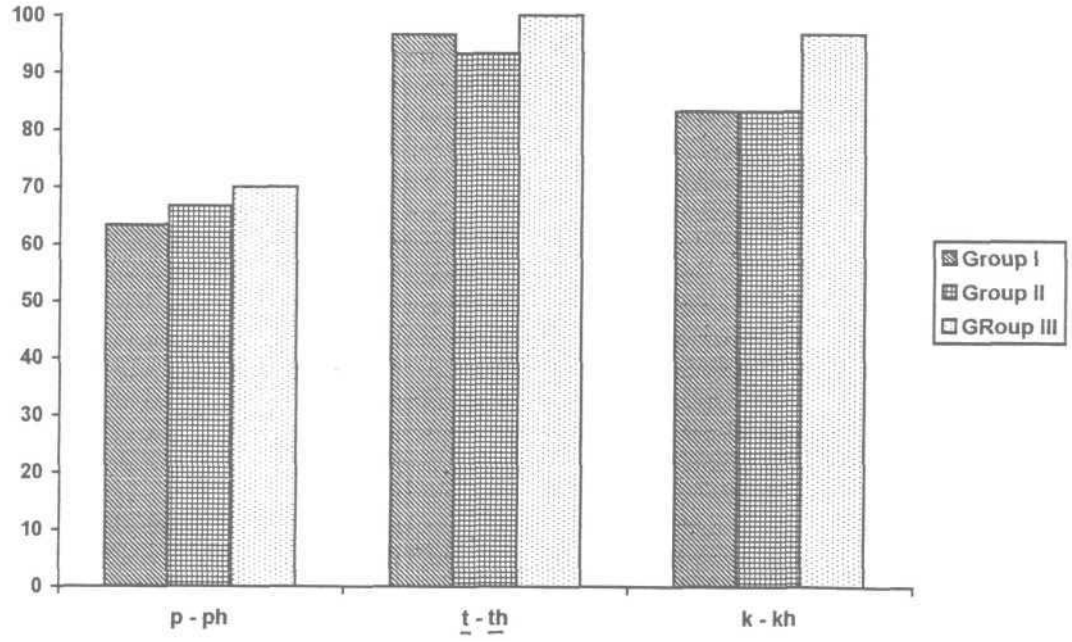


Fig. 8 : Percentage response for Mal-Mal tokens contrasting in aspiration

5) Aspiration and Voicing Contrast:

None of the groups exhibited good performance. The contrast was best exhibited by bilabial place followed by dental and velar places.

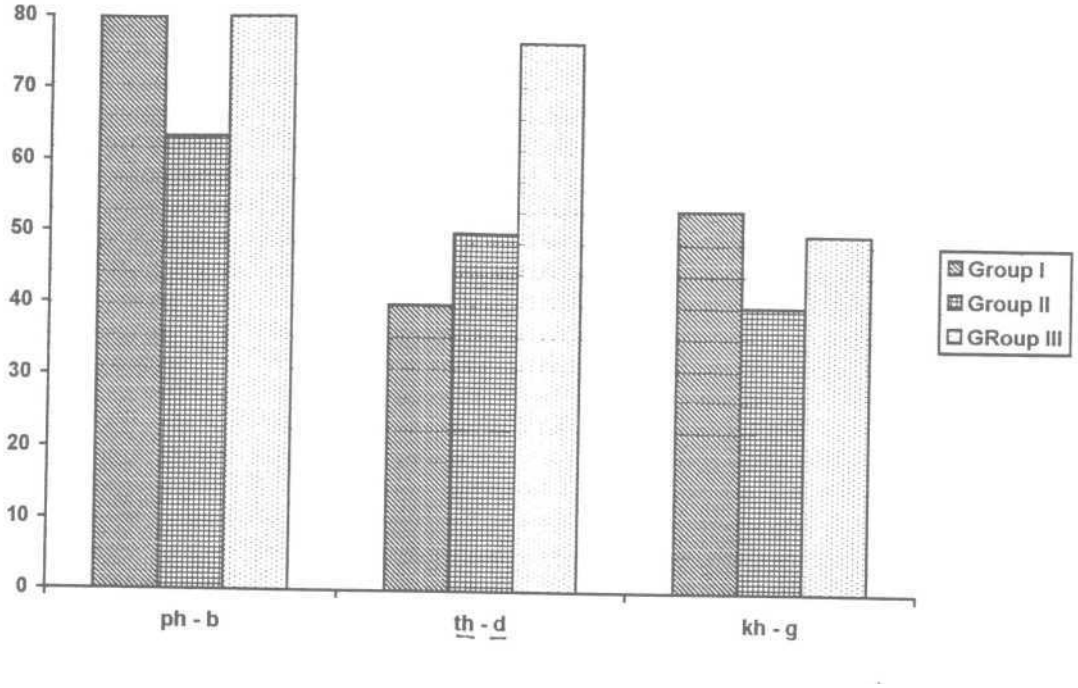


Fig. 9 : Percentage response for Mal-Mal tokens contrasting in aspiration and voicing

6) Aspiration and place contrasts:

Bilinguals performed better than the other groups. Overall performance in aspiration and place contrast was better than aspiration and voicing contrast. The responses were best for velar vs others followed by bilabial vs others, retroflex vs others and the responses were lowest for dental vs other place of articulation.

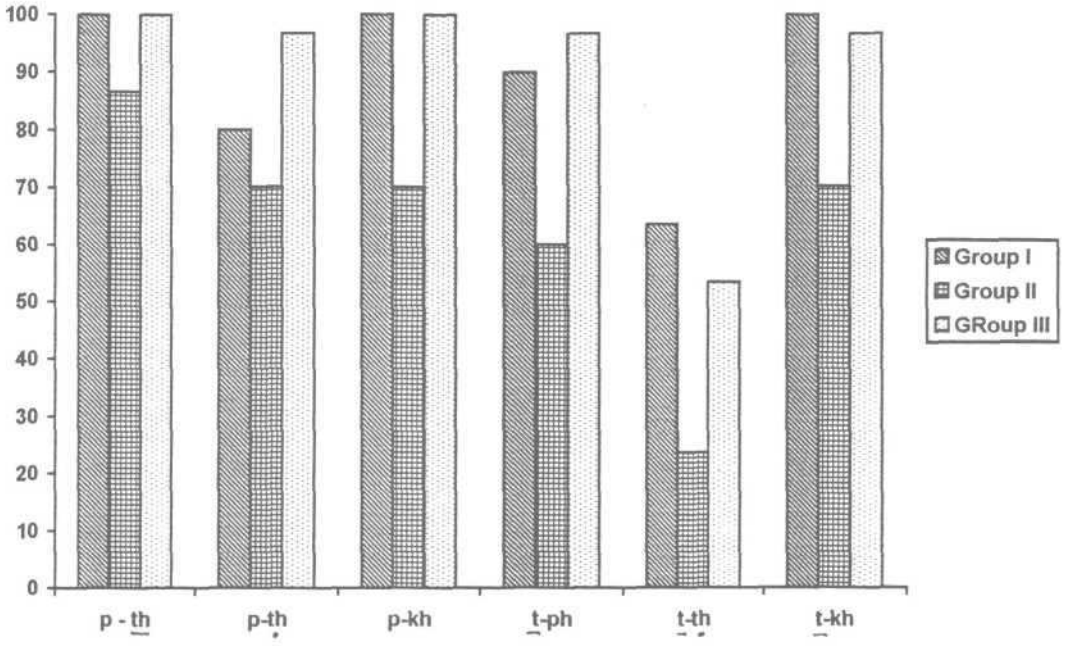


Fig. 10a: Percentage response for Mai-Mai tokens contrasting in aspiration and place.

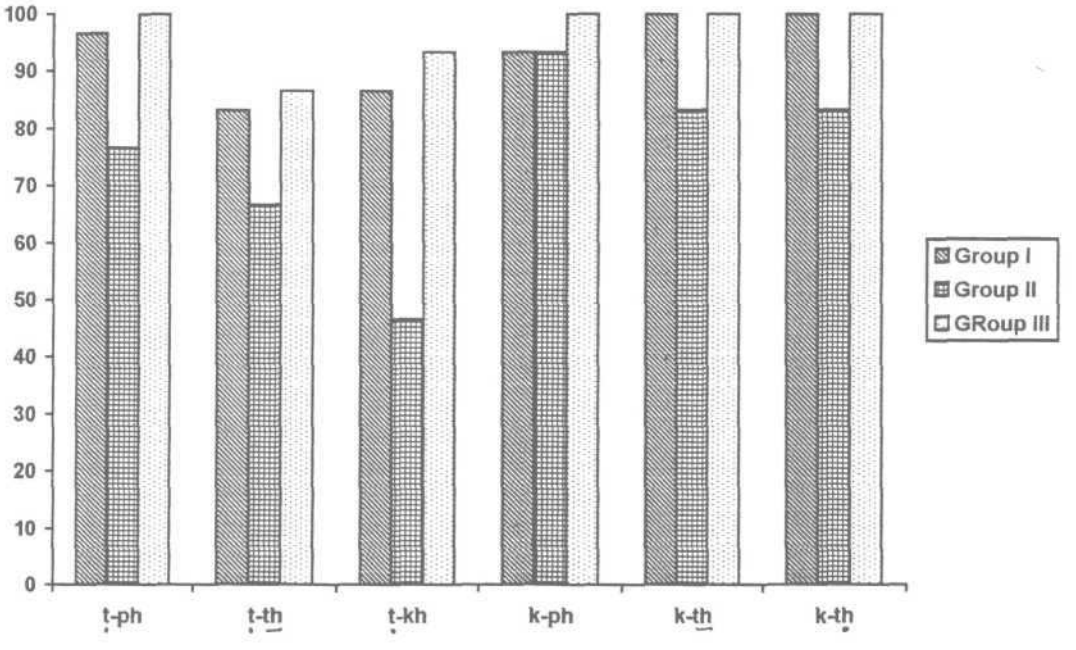


Fig. 10 b: Percentage response for Mal-Mal tokens contrasting in aspiration and place.

7) Voicing, Aspiration and Place Contrasts:

Malayalam-ayalam-monolinguals performed equal to or better than the bilinguals in all the contrasts except |d|-ph| and |b|-|t̪^{h}|. Tamil monolinguals performed poorer than the other two groups in all the contrasts except |d| - |p^{h}| where they equaled the performance of bilinguals. The lowest performance was in the contrast |d| - |p^{h}| (66.67%). The percent difference scores was highest for bilabial vs others followed by retroflex vs others and dental vs others.

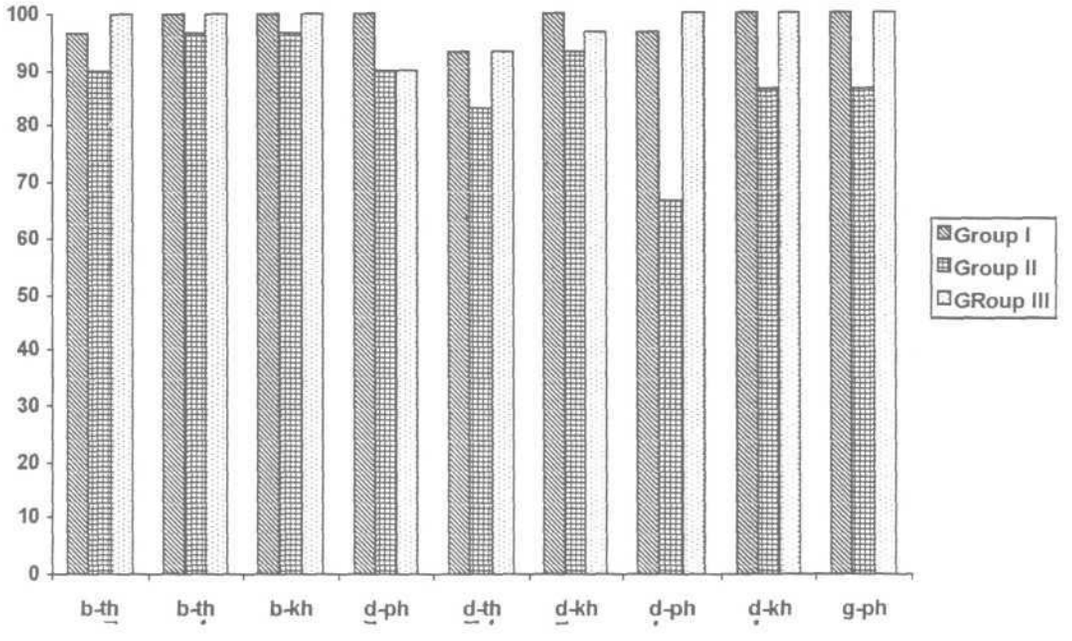


Fig. 11: Percentage response for Mal-Mal tokens contrasting in voicing, aspiration and place.

B. Tamil - Tamil Tokens

1) Voicing contrast:

Voicing contrast in Tamil tokens was well discriminated by all the three groups. However, the performance of Tamil monolinguals was poorer than the other two groups.

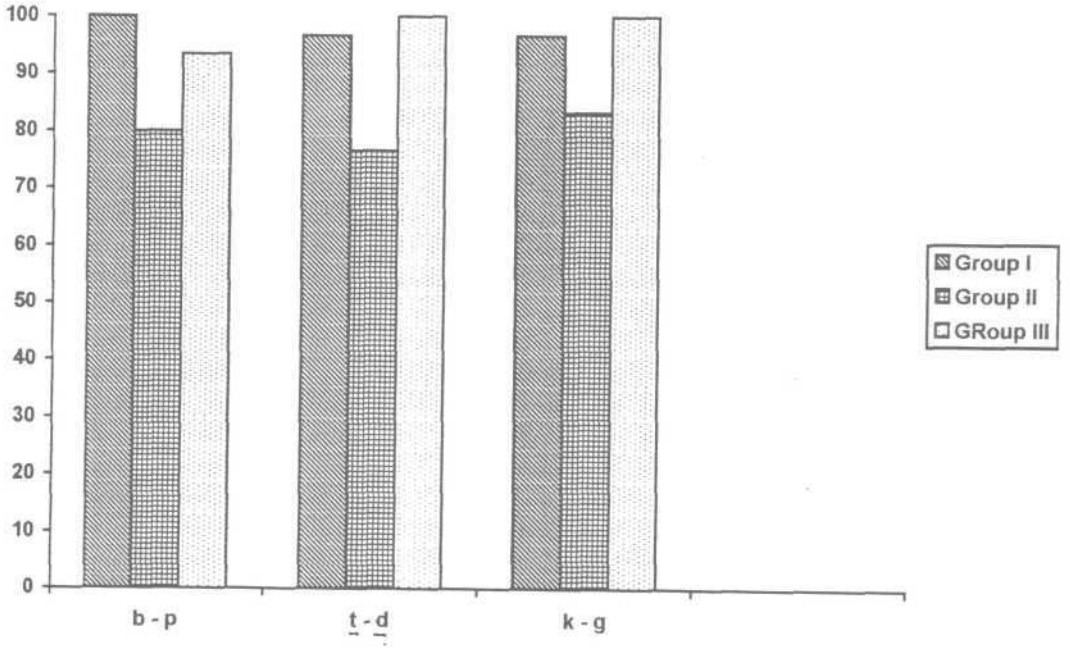


Fig. 12 : Percentage response for Tamil-Tamil tokens contrasting in voicing.

2) Place contrasts:

Tamil monolinguals performed poorer than the other two groups on all the contrasts. Percent different scores was highest for retroflex vs others followed by bilabial vs others and dental vs other place of articulation.

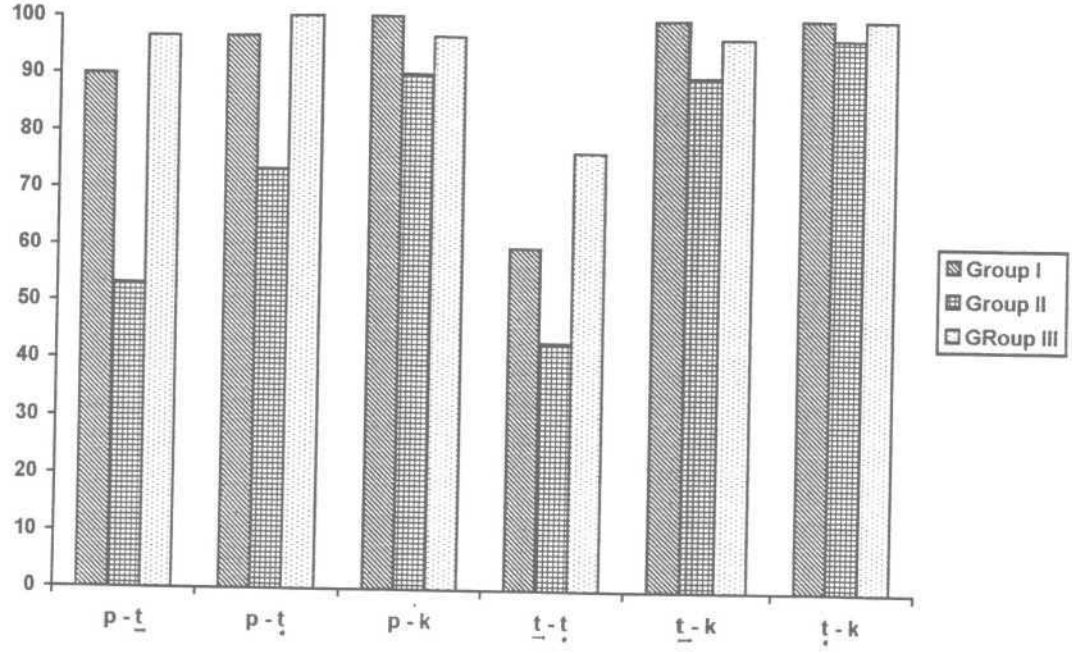


Fig. 13a : Percentage response for Tamil-Tamil tokens contrasting in place(voiceless)

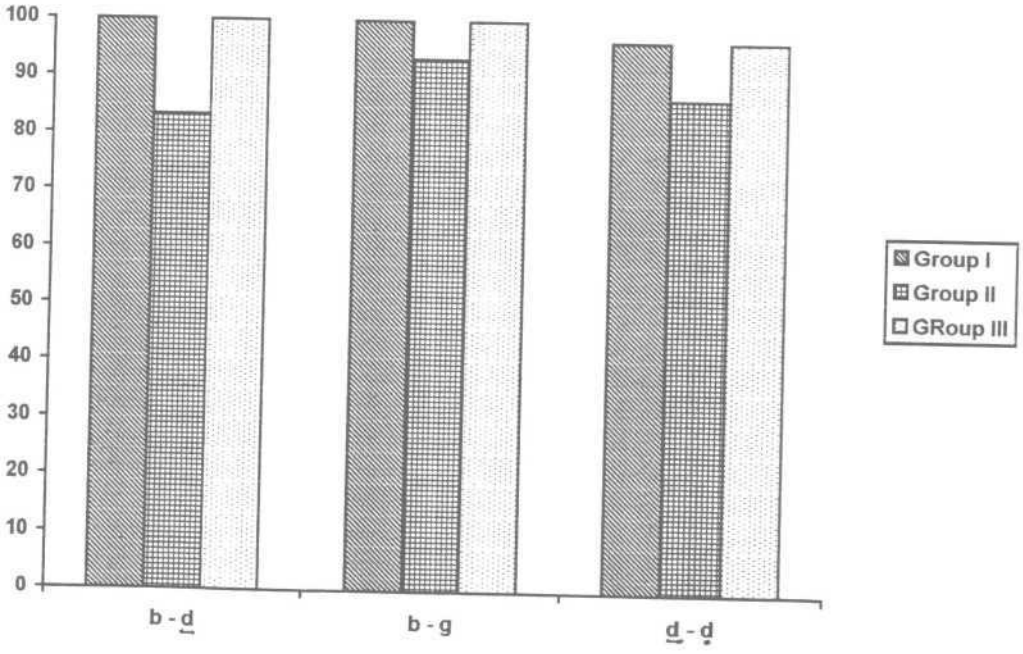


Fig. 13b : Percentage response for Tamil-Tamil tokens contrasting in place(voiced).

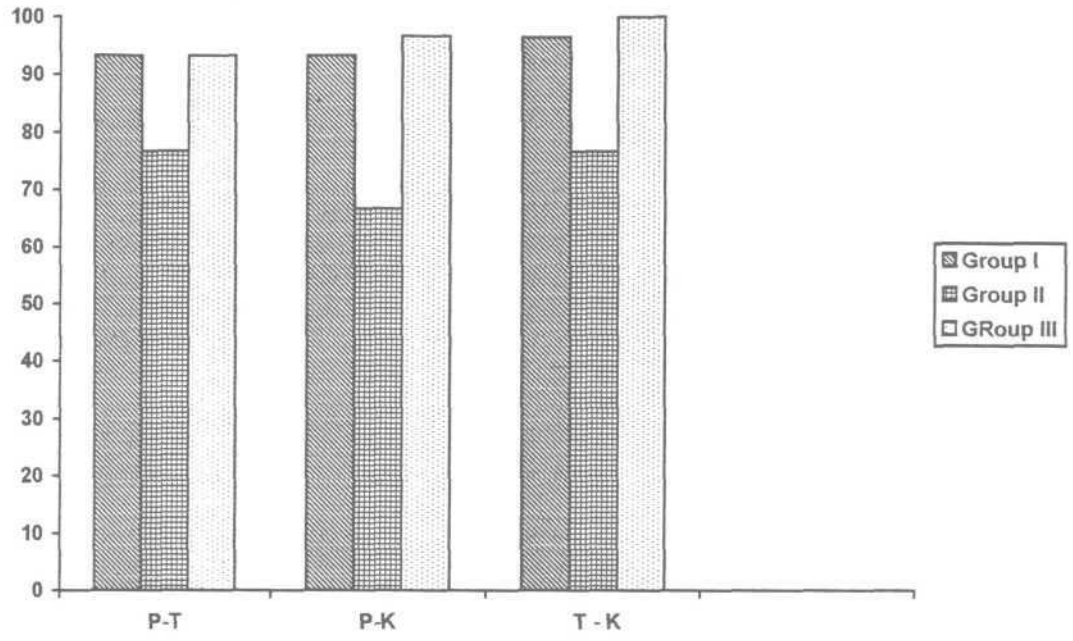


Fig. 13c : Percentage response for Tamil-Tamil tokens contrasting in place(lax).

3) Place and Voicing Contrasts:

Malayalam ayafeei-monolinguals and bilinguals obtained 100% scores on all the contrasts except |t| - |g| where monolinguals exhibited 76.67% and bilinguals 90%. Tamil monolinguals were slightly poorer than the other two groups on all contrasts. The percent different scores was highest for bilabial vs others followed by retroflex vs others and dental vs others.

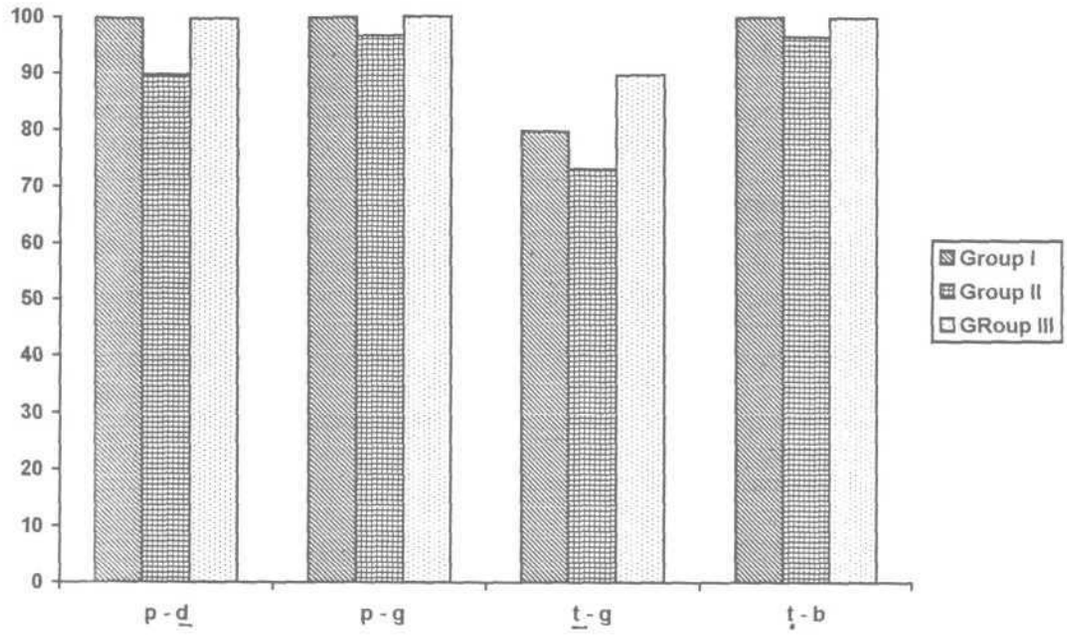


Fig. 14 : Percentage response for Tamil-Tamil tokens contrasting in place and voicing.

C. Tamil-Malayalam Tokens:

1) Voicing Contrasts:

In Tamil-Malayalam tokens contrasting in voicing, the performance of all the three groups were comparatively lower on the two contrasts (|g| - |k|and | |d| - |t|). Bilabial contrasts gave the highest response for all the groups and Malayalam monolinguals gave the poorest response to the dental contrast (|d| - |t|) has, 58% followed by velar contrasts (|g| - |k|)(66.67%). Tamil monolinguals performed poorer on all except |g| - |k| contrast where they equaled the Malayalam -monolinguals and |d|-111 Where they performed better than the other two groups. Bilinguals performed equal to or better than *thoi* monolinguals on all contrasts except |g| |k|.

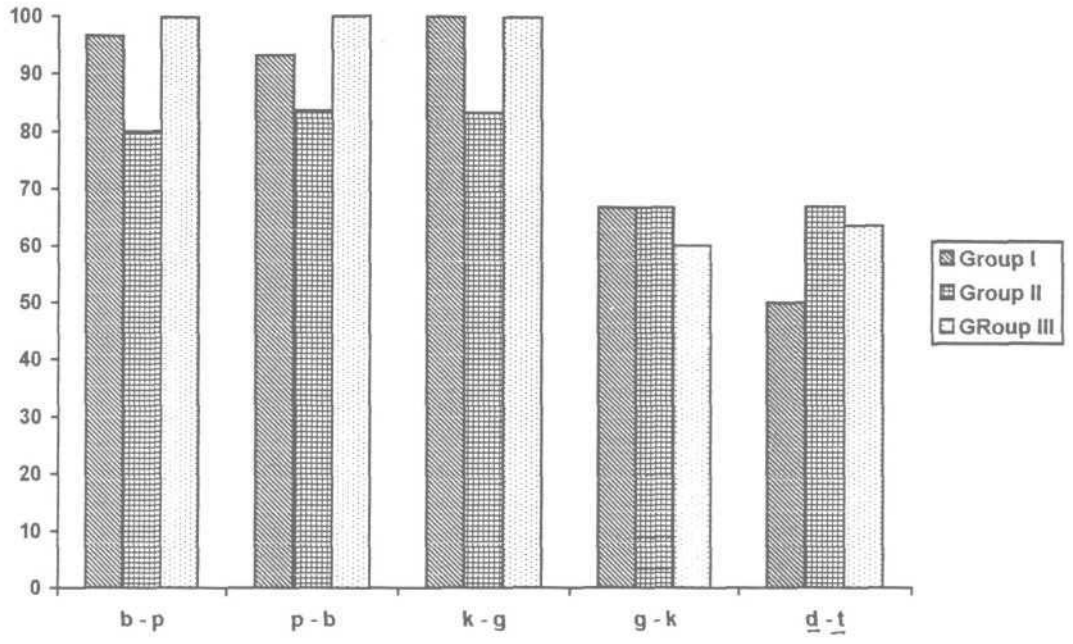


Fig. 15 : Percentage response for Tamil-Mai tokens contrasting in voicing

2) Place Contrasts:

Malayalam -monolinguals and bilinguals performed better than Tamil monolinguals on all the contrasts. The percent different scores in the voiceless category decreased from bilabial vs others to velar vs others and dental vs others. Among the voiced, the bilabial - retroflex was poorly contrasted by all the three groups. Also, the percent response was better for Tamil-Malayalam tokens compared to Malayalam -Malayalam or Tamil-Tamil tokens.

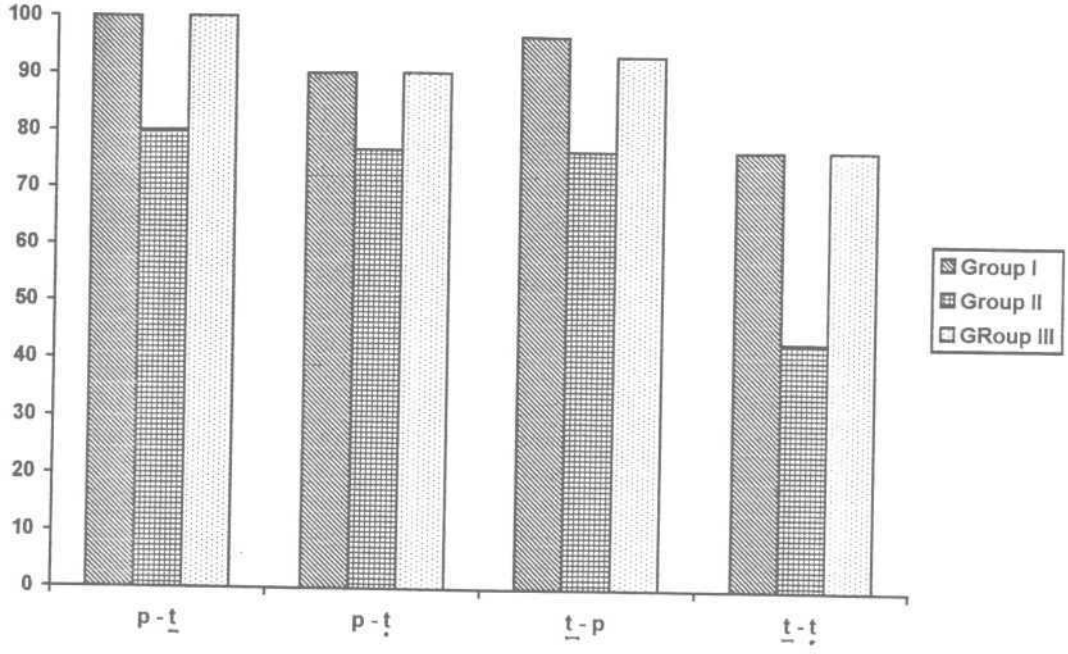


Fig. 16a : Percentage response for Tamil-Mai tokens contrasting in place(voiceless).

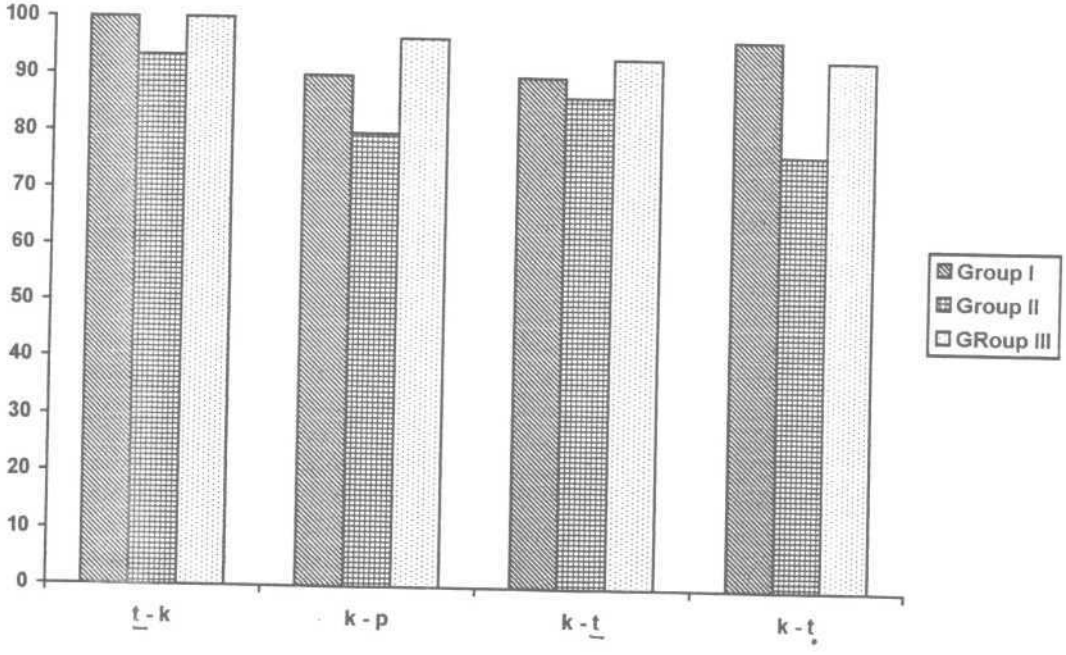


Fig. 16b : Percentage response for Tamil-Mai tokens contrasting in place(voiceless).

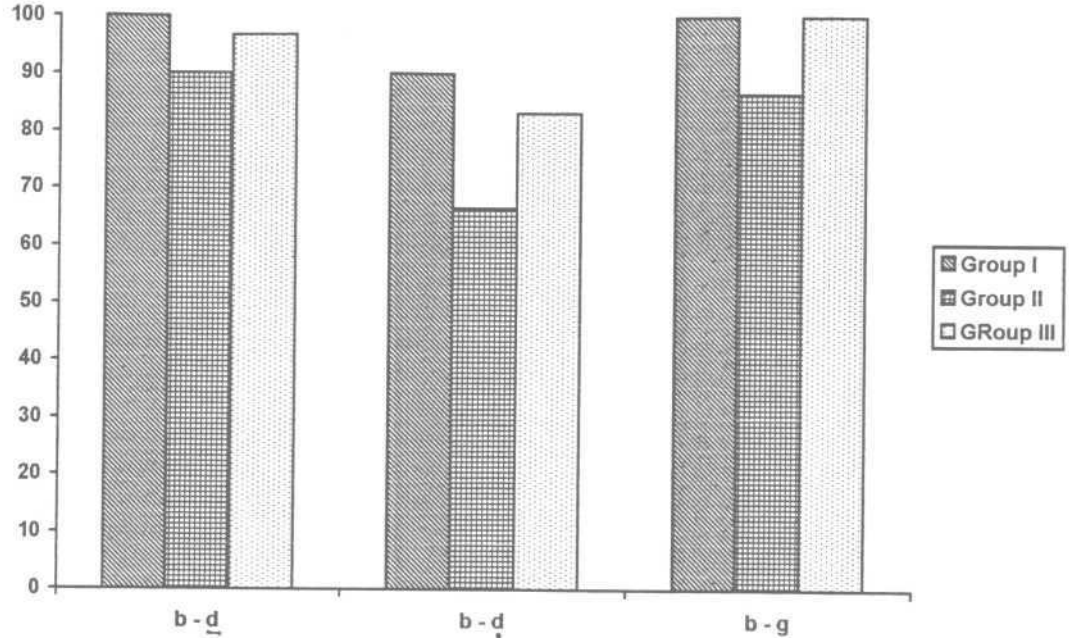


Fig. 16c : Percentage response for Tamil-Mai tokens contrasting in place (voiced).

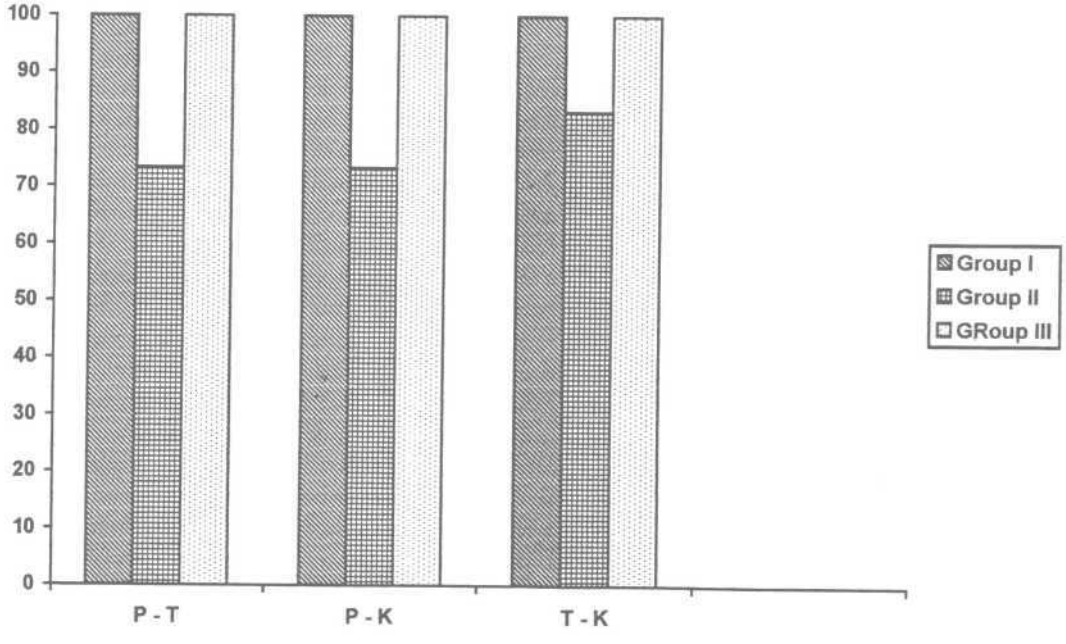


Fig. 16d : Percentage response for Tamil-Mai tokens contrasting in place(lax).

3) Voicing and Place Contrasts:

The performance of Tamil-monolinguals was poorer than the other two groups on all the contrasts except |d| - |p| Where they equaled the bilinguals. The percent score was highest for dental-velar contrast and was lowest for dental-retroflex contrast.

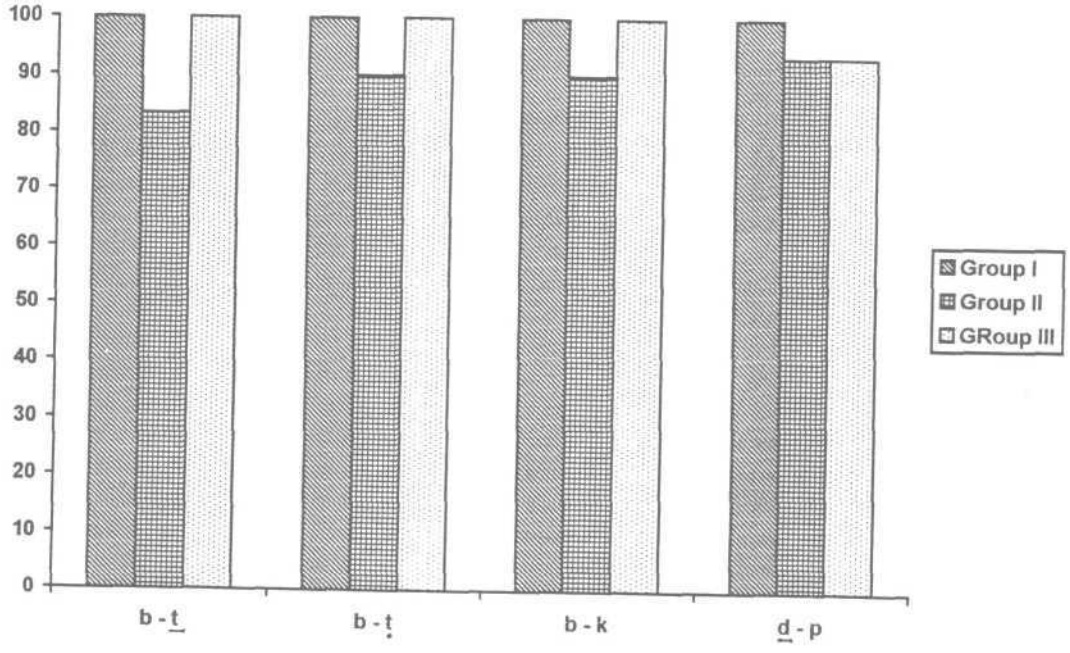


Fig. 17a : Percentage response for Tamil-Mai tokens contrasting in voicing and place.

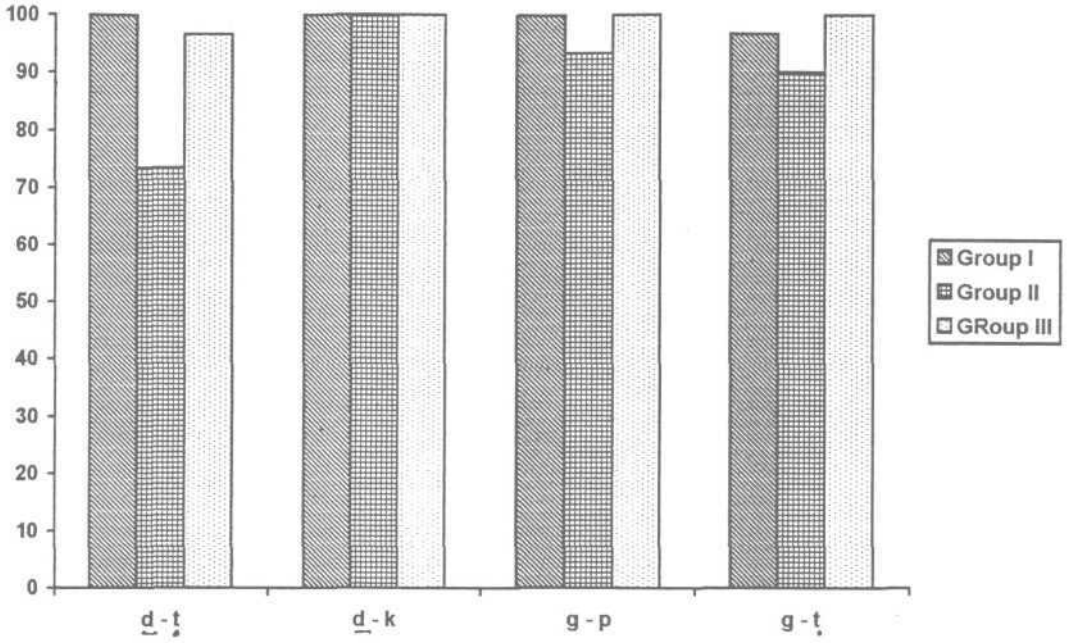


Fig. 17b : Percentage response for Tamil-Mai tokens contrasting in voicing-place.

4) Aspiration Contrasts:

Performance was better for the velar than the bilabials for all the three groups. Tamil monolinguals performed poorer than other two groups on both the contrasts.

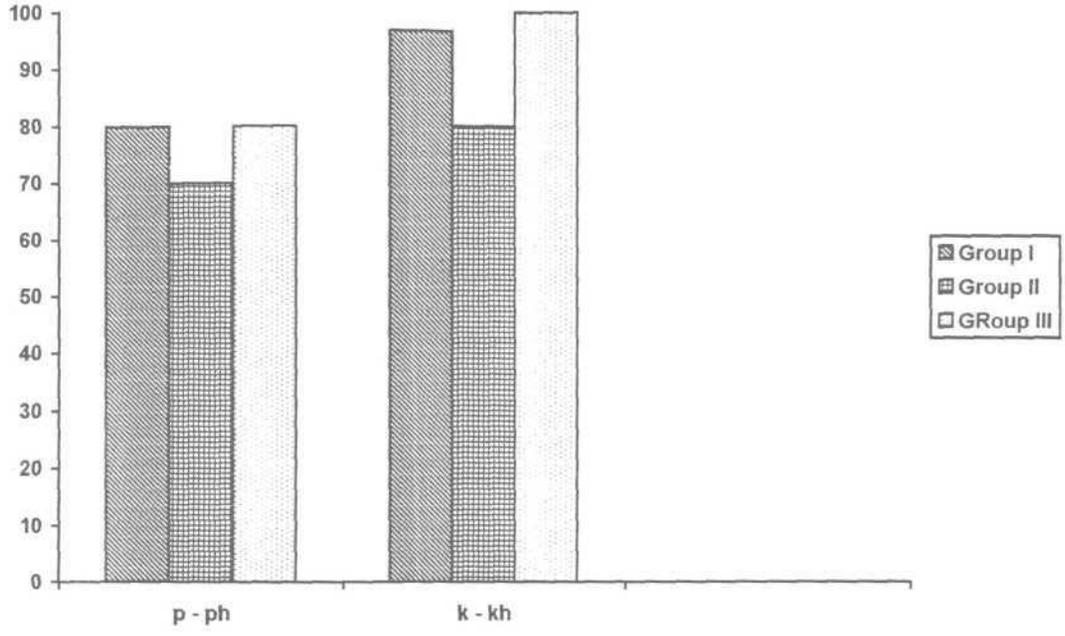


Fig. 18 : Percentage response for Tamil-Mai tokens contrasting in aspiration

5) Aspiration and Voicing Contrasts:

Malayalam -monolinguals scored 73.33% and 66.67% in the bilabial and velar contrasts respectively. Tamil-monolingualsscored 66.67% and 70% in these contrasts; their performance being better than Malayalam - monolinguals in the velar contrasts. Bilinguals scored 73.33% and 93.33% in the two contrasts respectively; their performance being equal to Malayalam monolinguals in bilabial contrast and better than the other two groups in velar contrasts.

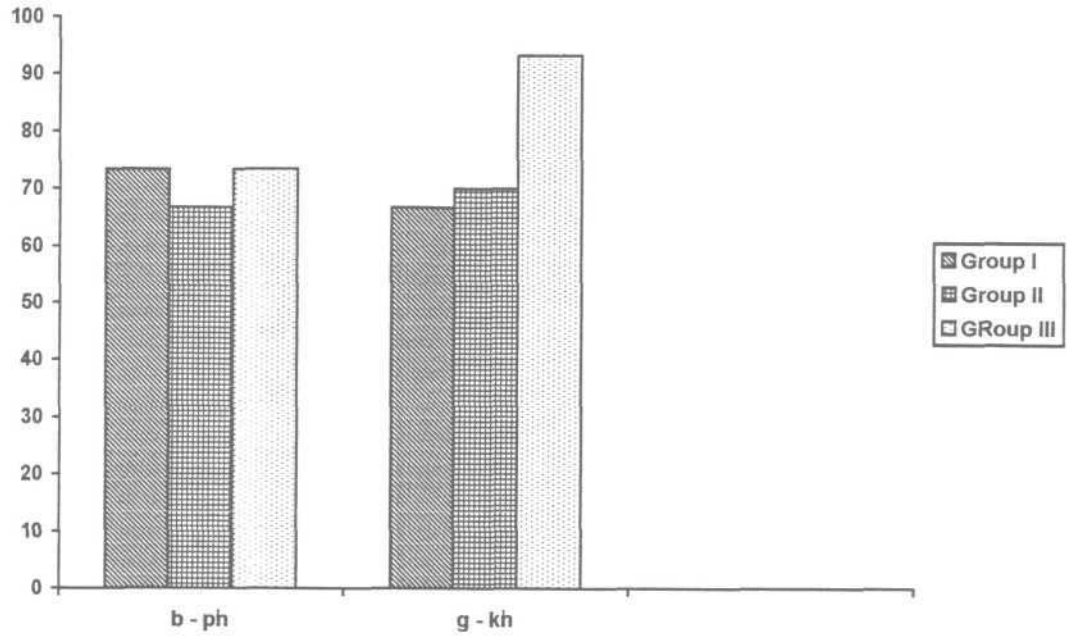


Fig. 19 : Percentage response for Tamil Mal tokens contrasting in aspiration and voicing.

6) Aspiration and Place Contrasts:

Tamil-monolinguals performed poorer than the other two groups on all the contrasts except |t| - |k^h| for which they equaled the bilinguals. Performance on aspiration and place contrast was better than the performance on aspiration and voicing contrasts.

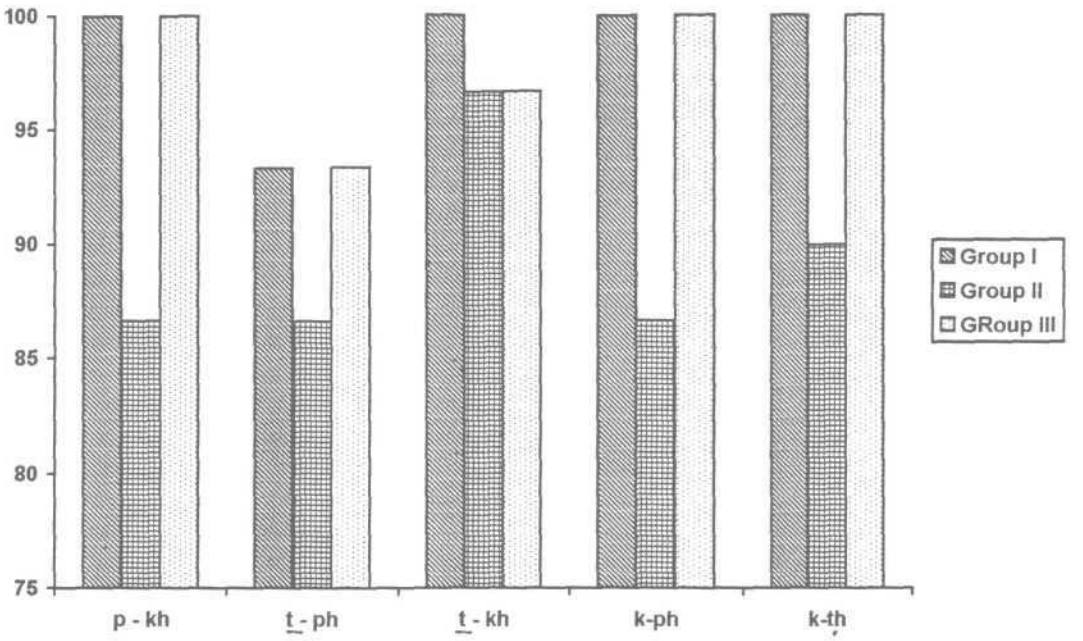


Fig. 20 : Percentage response for Tamil-Mai tokens contrasting in aspiration and place.

7) Voicing, aspiration and place contrasts:

Malayalam -monolinguals and bilinguals obtained 100% scores on all contrasts except |d|-|t^h| and |g|-|p^h|- Tamil monolinguals performed poorer than the other two groups on all the contrasts except |g| - |p^h|, where the three groups performed equally (90%). Percent scores were highest for bilabial vs others and lowest for dental vs retroflex.

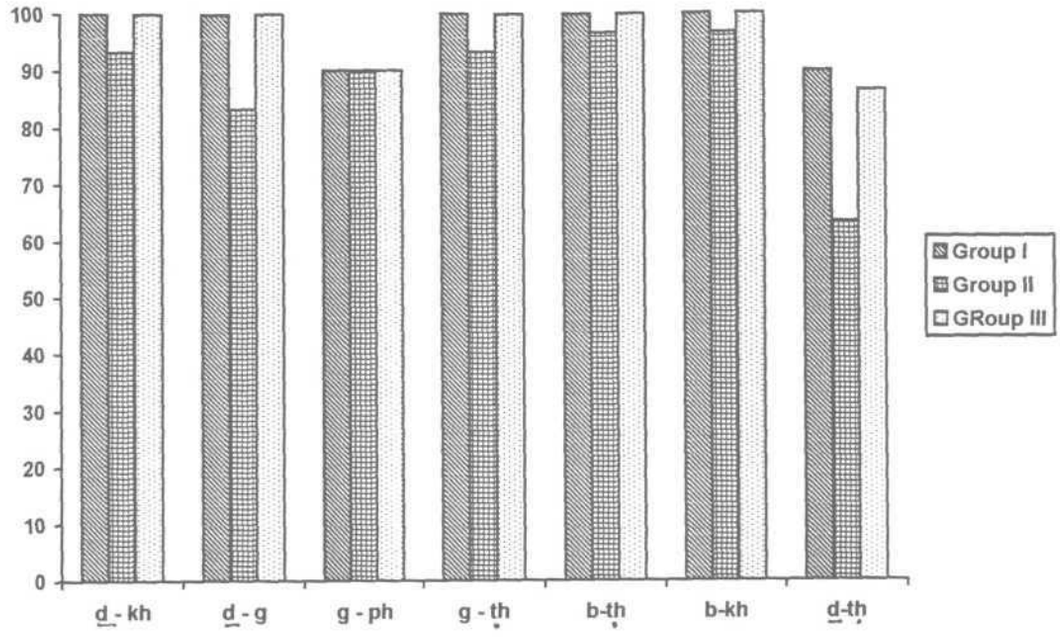


Fig. 21: Percentage response for Tamil-Mai tokens contrasting in voicing, place and aspiration.

Discussion:

The results revealed several interesting points. On the acoustic analysis, it was observed that the terminal frequencies of the stop consonants were higher in Malayalam and overlapping was found for velar and dental place of articulation. The higher terminal frequencies may be subject dependent and not language specific. In Tamil, VOT's appeared to be longer than in Malayalam and good contrast was found between voiced velar, voiceless dental with and other places of articulation. Also, voiced stops were characterized by lead VOT, voiceless stops by lag VOT and voiceless aspirated stops by long lag VOT. The results suggest that VOT differentiated voicing contrast but not place of articulation. For the closure duration, though the

dental stops contrasted with the other places of articulation, it did not appear to differentiate the place of articulation.

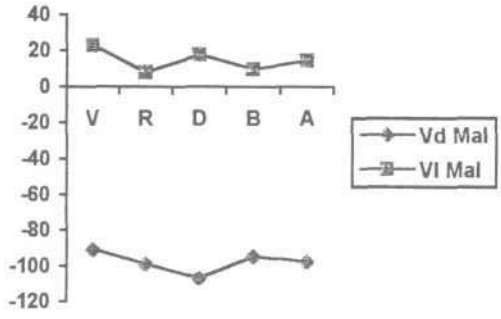
On perceptual analysis, interesting results, correlating with the production data were observed. Table 6 shows the performance of all the groups for all the tokens contrasting in voicing.

Tokens	Performance of groups in order	Best contrast	Poorest contrast
M-M	M,B,T	Bilabial	Dental
T-T	B.M.T	-	-
T-M	B,M,T	Bilabial	Dental

Table 6: Performance of subjects for voicing contrast
M= Malayalam , T = Tamil, B=Bilinguals.

It was noticed that the Malayalam monolinguals and the bilinguals performed better than the Tamil monolinguals. However, they could not differentiate the voicing contrast 100% of the time. The result is to be expected as Tamil does not have phonemic contrast for voicing. The present response obtained by the Tamil monolinguals can be attributed to the category goodness contrasts. According to Perceptual Assimilation Model (Best, 1988), the discrimination is good for strong category goodness contrasts.

The result that voicing contrast was good for bilabials and poor for dental may be correlated with the production data. (Fig. 22 and 23) Shows the difference in terms of VOT for Malayalam and Tamil stop consonants.



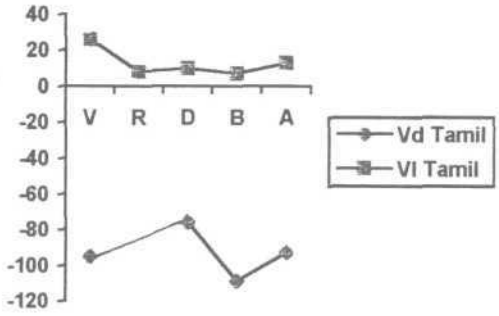


Fig. 22 **Fig.** 23

Difference in VOT for Malayalam and Tamil stop consonants.

It could be noticed that for Tamil, the difference in VOT is larger for bilabial and smallest for dental which is also reflected in the perception of voicing contrasts. However, the same does not seeni to hold for Malayalam where the difference in VOT is largest for dental and smallest for bilabials.
Table 7 : Shows the subject response for place contrasts.

Tokens	Performance of Groups in Order	Best contrast	Poorest contrast
M-M	M,B,T	Bilabial vs others	Dental vs Retroflex
T-T	M, B,T	Retroflex vs others	Dental vs Retroflex
T-M	M,B,T	Bilabial vs others	Dental vs Retroflex

Table 7: Subjects responses for place contrasts.

It could be observed that irrespective of the tokens, the Tamil speakers always performed poorer than the other two groups and the response was best for Tamil-Malayalam pairs. Inspite of good place contrasts in Tamil, Tamil monolinguals were very poor in contrasing place of articulation which cannot be explained. The good place contrast between bilabial and other

place of articulation may be attributed to the contrasting terminal frequencies for these places of articulation. While the bilabials exhibit low terminal frequecy, T2, others do not, which is contrasing. Also, interestingly the T_2 for retroflex were higher and closer to the dental stops both in Malayalam and Tamil which may be the reason for the poor contrast between dental and retroflex place of articulation. Table 8 shows the summary of performance of subjects for place and voicing contrasts.

Tokens	Performance of groups in order	Best contrast	Poorest contrast
M - M	M, B, T	Bilabial vs Others	Dental vs Retroflex
T- T	M, B, T	Bilabial vs Others	Dental vs Retroflex
T- M	M, B, T	Velar vs Dental	Dental vs Retroflex

Table 8: Summary of subjects responses for place and voicing contrasts.

The results reveal that the subjects could differentiate better when the place and voicing contrasts were combined than when place or voicing contrast were presented alone. A combination of cues appear to enhance the performance compared to a single cue condition. Also, the poor contrast between dental and retroflex place of articulation may be because of the nearness of T_2 of these places. The Tamil Velar stops and Malayalam dental stops are acoustically well separated which is reflected in the perception also.

Table 9 summarizes the subject's responses for aspiration contrast. On this, the bilinguals performed better than the other two groups and the Tamil-monolinguals performed better than Malayalam -monolingual for Malayalam - Malayalam tokens.

Tokens	Performance of groups in order	Best contrast	Poorest contrasts
M - M	B, T, M	Dental	Bilabial
T- T	-	-	-
T-• м	B, M,T	Velar	Bilabial

Table: 9 Subjects responses for aspiration contrasts.

As aspiration is not phonemic in Tamil/a low percent response is expected by Tamil speakers. However, according to the Perceptual Assimilation Model (Best 1988), those contrasts which are not present in a language are well perceived if they form strong category goodness contrasts. Aspiration, could be forming category goodness contrasts and hence discriminated well by Tamil-monolinguals.

The best aspiration contrast was for the dental place of articulation (t - t^h) and the poorest was for the bilabial (p - p^h) place of articulation which is well related to the production data on VOT (Fig.24).

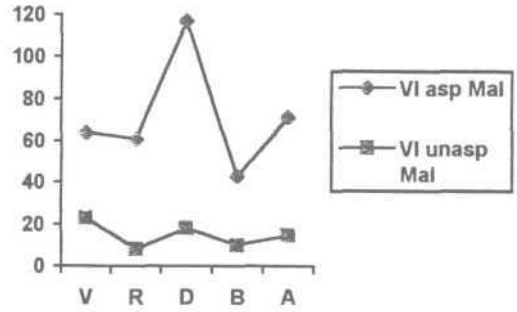


Fig. 24: Difference in VOT for Malayalam voicelesss aspirated and voiceless unaspirated stop consonants.

It could be noted from Fig. 24 that VOT difference between the dental aspirated and unaspirated is the largest and that between bilabial aspirated and unaspirated is the smallest which is reflected in good perceptual separation of the dentals for aspiration contrasts. Table 10 shows the summary of responses of the subjects for aspiration and voicing contrasts.

Tokens	Performance of groups in order	Best contrast	Poorest contrast
M - M	No specific order	Bilabial	Velar
T - T	-	-	-
T - M	No specific order	Dental	Bilabials

Table 10: Subjectiresponses for Aspiration and voicing contrast.

No specific group performed better on all the tokens. The best contrast for dental place of articulation can be explained by the large differences in VOT as indicated in the Fig.25.

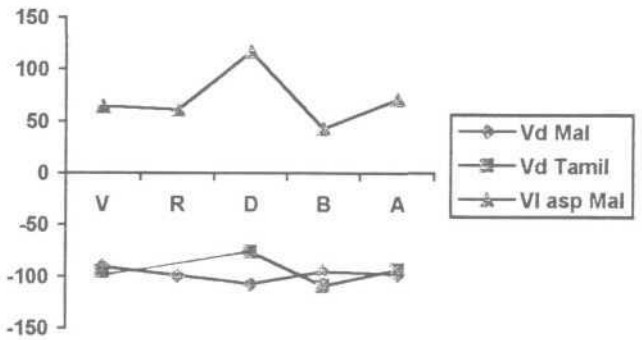


Fig. 25 : Differences in VOT for Malayalam voiceless aspirated, Tamil voiced and Malayalam voiced stop consonants

Table 11 shows the summary of responses of the subjects for aspiration and place contrast.

Token	Performance groups in order	Best Contrast	Poorest Contrast
M - M	B, M,T	Velar vs Dental Velar vs Retroflex Bilabial vs Dental	Dental vs Retroflex
T - T	-	-	-
T - M	M, B,T	Bilabial vs Velar Velar vs Bilabiar Velar vs retroflex	-

Table 11: Subjects responses for aspiration and place contrast.

These results show that subjects could differentiate better when the aspiration and place contrasts were combined than when aspiration or place was presented. Thus combined cues enhance their performance compared to a single cue. The poor performance in dental vs retroflex could be due to the nearness of T_2 of these places.

The responses of the subjects are summarised for voicing, aspiration and place contrasts in Table 12.

Token	Performance of groups in order	Best contrast	Poorest contrast
M - M	M, B, T	Bilabial	Dental vs Retroflex
T - T	-	-	-
T - M	M, B,T	Bilabial	Dental vsRetroflex

Table 12: Subjectsresponse for aspiration, voicing and place contrast.

On these contrasts, Tamil monolinguals performed poorest and the poor contrast between dental and retroflex places (for aspiration and voicing) can be attributed to the closeness in terminal frequencies of both these places of articulation.

In general Malayalam -monolinguals performed better than the other two groups in most of the contrasts. Table 13 summarises the group performance (best group as indicated by the capital letter) for all the contrasts. No group scored 100% on any one contrast. Also, it was interesting to note that Tamil monolinguals performed poorly even on Tamil-Tamil tokens.

Token contrasts	M-M	T-T	T-M
Voicing	M	B	B
Place	M	M	M
Voicing and place	M	M	M
Aspiration	B	-	B
Aspiration and voicing	No group	-	No group
Aspiration and place	-	-	-
Aspiration, voicing and place	M	-	M

Table 13: Summary **of the groups performing best on all the contrasts.**

The bilingual subjects performed better on voicing and aspiration contrasts which is phonemic in Malayalam ayalam. They were closer to the Malayalam monolinguals in their responses reflecting the influence of second language - Malayalam ayalam. The results support the Perceptual Assimilation Model proposed by Best (1988).

The data reflects advantage for Malayalam monolinguals and it is not clear as to why Tamil monolinguals performed poor on contrasts existing in Tamil. Semantic aspects of the words, the word frequency and familiarity could have influenced the judgements to an extent. Further, synthetic tokens could be used for these studies wherein one or multiple parameters may be

manipulated to study the extent of various factors contributing to the judgements of the difficult linguistic groups. Further research is warranted in other Indian languages which may reflect the cross-language differences in perception.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was designed to investigate the cross-language differences in the perception of stop consonants in Tamil and Malayalam, by Tamil and Malayalam monolinguals and bilinguals. The two languages differ in voicing and aspiration. While both are phonemic in Malayalam they are not so in Tamil. Hence these differences were investigated.

The stimulus material consisted of 123 tokens consisting of two words forming a minimal pair. Of these, there were 59 Malayalam - Mala\ralam tokens 21 Tamil - Tamil tokens and 43 Tamil - Malayalam tokens. There was a total of 111 Malayalam and 56 Tamil words which formed these tokens. All of them were meaningful words. Each word had the stop consonants in the initial or medial position. These were read by adult female speakers in their respective languages which was audio-recorded. This formed the material.

90 subjects were chosen for the present study. They constituted three groups with 15 males and 15 females in each group — Tamil monolingual, Malayalam monolinguals and bilingual with Tamil as native language and Malayalam as second language. The subjects were presented with the stimulus binaurally through headphones and were instructed to record the responses as to whether the stops forming the token pairs were the same or different. The audio - recorded words were subjected to Acoustic analysis. The first three terminal frequencies (frequency at the onset of the first, second

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and third formats of the following vowel), VOT (time difference between the onset of the vocal fold vibration and the articulatory release) and closure duration (time difference between the offset of vocal fold vibration ad the onset of the burst) were measured using the waveform in the DSP sonograph 5500. The percent same or different scores were computed and the data was tabulated. The results of the analysis showed the following :

1. The perceptual data correlated with the production data.
2. On the voicing contrasts, Tamil monolinguals showed the poorest performanace, which is expected as voicing is not phonemic in Tamil.
3. Aspiration contrast was well discriminated by Tamil monolinguals. They could be forming strong category goodness contrast and hence easily discriminable.
4. Performance of the subjects improved when a combination of cues (aspiration and place, aspiration, voicing and place, place and voicing) was used than each of these in isolation.
5. Bilinguals performed better on voicing and aspiration contrasts which is phonemic in Malayalam. They performed closer to the Malayalam monolinguals reflecting the second language influence.
6. Tamil monolinguals performed poorer on all the contrasts, the reasons for which is not clear.

Thus, this study implies that learning the second language widens the perceptual dimension for the stops making them closer to the monolinguals. Further it was speculated that contextual cues would play a role in discriminating the contrasts.

It is suggested that synthetic tokens be used to study the influence of each of the parameter contributing to the judgement of the various linguistic groups. Further research, using synthetic tokens is recommended in other Indian languages.

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APPENDIX

		Group I		Group II		Grouyp III	
No.	Consonant Pair	S	D	S	D	S	D
1.	P - P^h	36.67	63.33	33.33	66.67	30	70
2.	p - b	3.33	96.67	23.33	76.67	-	100
3.	ph - b	20	80	36.67	63.33	20	80
4.	t - th	3.33	96.67	6.67	93.33	-	100
5.	t - d	40	60	56.66	43.33	20	80
6.	th-d	60	40	50	50	23.33	76.67
7.	ṭ - ṭ	76.67	23.33	100	-	93.33	6.67
8.	ṭ - ḍ	13.33	86.67	10	90	-	100
9.	k - kh	16.67	83.33	16.67	83.33	3.33	96.67
10.	k - g	-	100	6.67	93.33	-	100
11.	k^h - g	46.66	53.33	60	40	50	50
12.	P - t	-	100	46.67	53.33	16.67	83.33
13.	P - ṭ	-	100	40	60	10	90
14.	p - k	26.67	73.33	60	40	10	90
15.	t - ṭ	60	40	76.67	23.33	43.33	56.67
16.	t - k	20	80	43.33	56.67	23.33	76.67
17.	ṭ - k	3.33	96.67	23.33	76.67	3.33	96.67
18.	p - d	3. 33	96.67	23.33	76.67	-	100
19.	P - ḍ	-	100	13.33	86.67	-	100
20.	P - g	-	100	13.33	86.67	3.33	96.67
21.	t - b	3.33	96.67	10	90	-	100
22.	t - ḍ	20	80	43.33	56.67	13.33	86.66
23.	t - g	3.33	96.67	10	90	-	100
24.	t - b	6.67	93.33	16.67	83.33	-	100
25.	t - d	10	90	26.67	73.33	6.67	93.33
26.	t - g	6.67	93.33	13.33	86.67	-	100
27.	k - b	-	100	10	90	-	100
28.	k - d	-	100	20	80	-	100
29.	k - ḍ	-	100	13.33	86.67	-	100
30.	p -1'»	-	100	13.33	86.67	-	100
31.	p - t^h	20	80	30	70	3.33	96.67
32.	p -k"	-	100	30	70	-	100
33.	t- p»>	10	90	40	60	3.33	96.67
34.	t - t^h	36.67	63.33	73.33	23.67	46.67	53.33

		Group I		Group II		Grouyp III	
No.	Consonant Pair	S	D	S	D	S	D
35.	t - k^h	-	100	30	70	3.33	96.67
36.	t̪ - p^h	3.33	96.67	23.33	76.67	-	100
37.	k- $t̪^h$	16.67	83.33	33.33	66.67	13.33	86.67
38.	t̪ - k^h	13.33	86.67	53.33	46.67	6.66	93.33
39.	K - p^h	6.67	93.33	6.67	93.33	-	100
40.	k - t^h	-	100	16.67	83.33	-	100
41.	k- $t̪^h$	-	100	16.67	83.33	-	100
42.	b - t^h	3.33	96.67	10	90	-	100
43.	b - $t̪^h$	-	100	3.33	96.67	-	100
44.	b - k^h	-	100	3.33	96.67	-	100
45.	d - p^h	-	100	10	90	10	90
46.	d- $t̪^h$	6.67	93.33	6.67	83.33	6.67	93.33
47.	d - k^h		100	6.67	93.33	3.33	96.67
48.	d̪ - p^h	3.33	96.67	33.33	66.67	-	100
49.	d̪ - k^h	-	100	13.33	86.67	-	100
50.	g - p^h	-	100	13.33	86.67	-	100
51.	b - d̲	3.33	96.67	23.33	76.67	6.67	93.33
52.	b - d̪	23.33	76.67	46.67	53.33	26.67	73.33
53.	b - g	-	100	20	80	3.33	96.67
54.	d- d̪	63.33	36.67	63.33	36.67	56.67	43.33
55.	d - g	-	100	26.67	73.33	-	100
56.	g- d̪	3.33	96.67	23.33	76.67	3.33	96.67
57.	k - T	16.67	83.33	20	80	20	80
58.	P - T	3.33	96.67	13.33	86.67	3.33	96.67
59.	K - P	10	90	26.67	73.33	10	90

Tablel A(l) Percent same and different scores obtained for Group I, Group II, Group III on Malayalam-Malayalam tokens

		Group I		Group II		Group III	
No.	Consonant Pair	S	D	S	D	S	D
60	b - p	-	100	20	80	6.67	93.33
61.	t - d	3.33	96.67	23.33	76.67	-	100
62.	k - g	3.33	96.67	16.67	83.33	-	100
63.	P - t	10	90	46.67	53.33	3.33	96.67
64.	P - t	3.33	96.67	26.67	73.33	-	100
65.	p - k	-	100	10	90	3.33	96.67
66.	t - t	40	60	56.66	43.33	23.33	76.67
67.	t - k	-	100	10	90	3.33	96.67
68.	t - k	-	100	30	70	-	100
69.	p-d	-	100	10	90	-	100
70.	t - g	-	100	3.33	96.67	-	100
71.	t - g	20	80	26.66	73.33	10	90
72.	t - b	-	100	3.33	96.67	6.67	93.33
73.	t - d	3.33	96.67	16.66	83.33	6.67	93.33
74.	b - d	-	100	16.66	83.33	-	100
75.	b - g	-	100	6.67	93.33	-	100
76.	d - d	3.33	96.67	13.33	86.67	3.33	96.67
77.	P - T	6.67	93.33	23.33	76.67	6.67	93.33
78.	P - K	6.67	93.33	33.33	66.67	3.33	96.67
79.	T - k	3.33	96.67	23.33	76.67	_	100

Table A(2) Percent same and different scores obtained for Group I, Group II, Group III on Tamil-Tamil tokens

		Group I		Group II		Group III	
No.	Consonant pair	S	D	S	D	S	D
80	b - p	3.33	96.67	20	80	-	100
81.	b - p^h	26.67	73.33	33.33	66.67	26.67	73.33
82.	p - b	6.67	93.33	13.33	83.67	-	100
83.	p - p^h	20	80	30	70	20	80
84.	k - k^h	3.33	96.67	20	80	-	100
85.	k - g	-	100	16.67	83.33	-	100
86.	R - k	33.33	66.67	33.33	66.67	40	60

		Group I		Group II		Group III	
No.	Consonant pair	S	D	S	D	S	D
87.	g - k^h	3.33	66.67	30	70	6.67	93.33
88.	d - t	50	50	33.33	66.67	36.66	63.33
89.	p - k^h	-	100	13.33	86.67	-	100
90.	P - t	-	100	20	80	-	100
91.	t - p^h	6.67	93.33	13.33	86.66	6.67	93.33
92.	t- k^h	-	100	3.33	96.67	3.33	96.67
93.	k - p^h	-	100	13.33	86.67	-	100
94.	k- t^h	-	100	10	90	-	100
95.	k - p	10	90	20	80	3.33	96.67
96	k-t	10	90	13.33	86.67	6.67	93.38
97.	k - t	3.33	96.67	20	80	3.33	96.67
98.	t-P	3.33	96.67	2.33	76.67	6.67	93.33
99.	t - t	28.33	76.67	56.67	43.33	23.33	76.67
100.	t - k	-	100	6.66	93.33	-	100
101.	P - t	10	90	23.33	76.67	10	90
102.	b - p	3.33	96.67	20	80	-	100
103.	b - t	-	100	16.67	83.33	-	100
104.	b - t	-	100	10	90	-	100
105.	b - k	-	100	10	90	-	100
106.	d - p	-	100	6.67	93.33	6.67	93.33
107.	d - t	-	100	26.66	73.33	3.33	96.67
108.	d - k	-	100	-	100	-	100
109.	g - P	-	100	6.67	93.33	-	100
110.	g - t	3.33	90.67	10	90	-	100
111.	b - t^h	-	100	3.33	96.67	-	100
112.	b - k^h	-	100	3.33	96.67	-	100
113.	d - t^h	10	90	36.67	63.33	13.33	86.67
114.	d - k^h	-	100	6.67	93.33	-	100
115.	g . p^h	10	90	10	90	10	90
116.	g . p^h	-	100	6.67	93.33	-	100
117.	b - d	-	100	10	90	3.33	96.67

		Group I		Group II		Group III	
No.	Conson ant pair	S	D	S	D	S	D
118.	b - d	10	90	33.33	66.67	16.66	83.33
119.	b - g	-	100	13.33	86.67	-	100
120.	d - g	-	100	16.67	83.33	-	100
121.	P -T	-	100	26.67	73.33	-	100
122.	P - K	-	100	26.67	73.33	-	100
123.	T - k	-	100	16.67	83.33	-	100

Table A (3): Percent same and different scores obtained for Group I, Group II, Group III on Tamil-Malayalam tokens.

	GROUP - I		GROUP- II		GROUP -III	
Consonant pair	S	D	S	D	S	D
M - M						
|P| -| b |	3.33	96.67	23.33	76.67	-	100
| **t**| -|**d**|	40	60	56.66	43.33	20	80
|t| - |d|	13.33	86.67	10	90	-	100
| k | - |g|	-	100	6.67	93.33	-	100
T - T						
|b| - | p |	-	100	20	80	6.67	93.33
|t| - |d|	3.33	96.67	23.33	76.67	-	100
|k| - |g|	3.33	96.67	16.67	83.33	-	100
T - M						
| b | - | p |	3.33	96.67	20.00	80.00	-	100
|P|- | b |	6.67	93.33	13.33	86.67	-	100
|k| - |g|	-	100	16.67	83.33	-	100
|g| - |k|	3.33	66.67	33.33	66.67	40	60
|d| - |t|	50	50	33.33	66.67	36.66	63.33

Table A(4): Percent same and different scores obtained for Malayalam-Malayalam, Tamil-Tamil, Tamil-Malayalam tokens contrasting in voicing **for** Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M						
|P| - |P^{h}|	36.67	63.33	33.33	66.67	30	70
|t| - |t^{h}|	3.33	96.67	6.67	93.33	-	100
|k| - |k^{h}|	16.67	83.33	16.67	83.33	3.33	96.67
T - M						
|P 1 - |P^{h}|	20	80	30	70	20	80
|k| - |k^{h}|	3.33	96.67	20	80	-	100

Table A(5): Percent same and different scores obtained for Malayalam - Malayaalam and Tamil - Malayalam Tokens Contrasting in Aspiration for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M						
|P^{h}l - |b|	20	80	36.67	63.33	20	80
|t^{h}| - |d|	60	40	50	50	23.33	76.67
|kh| - |g|	46.66	53.33	60	40	50	50
T - M						
|b| - |P^{h}l	26.67	73.33	33.33	66.67	26.67	73.33
|g| - |kh|	33.33	66.67	30	70	6.67	93.33

Table A(6): Percent same and different scores obtained for Malayalam - Malayalam and Tamil - Malayalam Tokesn contrasting in voicing and aspiration for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M						
Bilabial-Bilabial						
P| - |P^{h}|	36.67	63.33	33.33	66.67	30	70
P| - |b|	3.33	96.67	23.33	76.67	-	100
P^{h}| - |b|	20	80	36.67	63.33	20	80
Bilabial - Others						
P| - |t|	-	100	46.67	53.33	16.67	83.33
P| - |t|	-	100	40	60	10	90
P| - |k|	26.67	73.33	60	40	10	90
P| - |d|	3.33	96.67	23.33	76.67	-	100

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
|p| "|d̤|	-	100	13.33	86.67	-	100
|p| - |g|	-	100	13.33	86.67	3.33	96.67
|p| - |t̲ʰ|	-	100	13.33	86.67	-	100
|p| - |t̤ʰ|	20	80	30	70	3.33	96.67
|p| - Ikʰ|	-	100	3.33	96.67	-	100
|b| - |tʰ|	3.33	96.67	10	90	-	100
|b| - |t̤ʰ|	-	100	3.33	96.67	-	100
|b| - |kh|	-	100	3.33	96.67	-	100
|b|-|d|	3.33	96.67	23.33	76.67	6.67	93.33
|b| - |d̤|	23.33	76.67	46.67	53.33	26.67	73.33
|b|-|g|	-	100	20	80	3.33	96.67
Medial position						
|P|-|T|	3.33	96.67	13.33	86.67	3.33	96.67

Table A(7): : Percent same and different scores for Malayalam-Malayalam Tokens forming Bilabial - bilabial and Bilabial - other contracts for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M						
Dental - Dental						
|t̲| - |tʰ|	3.33	96.67	6.67	93.33	-	100
|t̲| - |d̲|	40	60	56.66	43.33	20	80
|t̲| - |d̲|	60	40	50	50	23.33	76.67
Dental - Others						
|t̲| - |t̤|	60	40	76.67	23.33	43.33	56.67
|t̲| - |k̤|	20	80	43.33	56.67	23.33	76.67
|t̲| - |b̤|	3.33	96.67	10	90	-	100
|t̲| - |d̤|	20	80	43.33	56.67	13.33	86.66
|t̲| - |g̤|	3.33	96.67	10	90	-	100
|t̲| - |pʰ|	10	90	40	60	3.33	96.67
|t̲| - |t̤ʰ|	36.67	63.33	73.33	23.67	46.67	53.33
|t̲| - |kʰ|	-	100	30	70	3.33	96.67
|d̲| - |Pʰ|	-	100	10	90	10	90

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
|d| - |t̪ʰ|	6.67	93.33	16 67	83.33	6 67	93.33
|d| - |k**ʰ**|	-	100	6.67	93.33	3 33	96.67
|d| - |d̪|	63.33	36.67	63 33	36.67	56.67	43.33
|d| - |g|		100	26 67	73.33	-	100

Table A(8) : Percent same and different scores for Malayalam-Malayalam tokens forming Dental-dental and Dental-others contrast for Group I, Group II and Group III.

	Gruop I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M						
Retxoflex - Retroflex						
|ṭ| - |ṭ|	76.66	23.33	100	-	93.33	6.67
|ṭ| - |ḍ|	13.33	86.67	10	90	-	100
Retroflex - Others						
|ṭ| - |k|	3.33	96.67	23.33	76.67	3.33	96.67
|ṭ| - |b|	6.67	93.33	16.67	83.33	-	100
|ṭ| - |d|	10	90	26.67	73.33	6.67	93.33
|ṭ| - **|g|**	6.67	93.33	13.33	86.67	-	100
|ṭ| **|Pʰl**	3.33	96.67	23.33	76.67	-	100
|ṭ| - |t̲ʰ|	16.67	83.33	33.33	66.67	13.33	86.67
|ṭ| - |k"|	13.33	86.67	53.33	46.67	6.66	93.33
|ḍ| - **IPʰl**	3.33	96.67	33.33	66.67	-	100
141 - **Ikʰ|**	-	100	13.33	86.67	-	100

Table A(9) : Percent same and different scores for Malayalam-Malayalam tokens forming retroflex - retroflex and retroflex - others contrast for Group I, Group Iiand Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
M - M Velar - Velar						
|**k**| - |**kh**|	16.67	83.33	16.67	83.33	3.33	96.67
k| - |g|	-	100	6.67	93.33	-	100
J	46.66	53.33	60	**40**	50	50

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
Velar - Others						
|k| - |b|	-	100	10	90	-	100
|k| - |d̲|	-	100	13.33	86.67	-	100
|k| - |ḍ|	-	100	13.33	86.67	-	100
|k| - |p^{h}|	6.67	93.33	6.67	93.33	-	100
|k| - |ṭ^{h}|	-	100	16.67	83.33	-	100
|k| - |g^{h}|	-	100	16.67	83.33	-	100
|g| - |P^{h}!	-	100	13.33	86.67	-	100
|g| |ḍ|	3.33	96.67	23.33	26.67	3.33	96.67
Medial Position						
|K| - |T|	16.67	83.33	20	80	20	80
|K| - |P|	10	90	26.67	73.33	10	90

Table A (10): Percent same and different scores for Malayalam-Malayalam tokens forming Velar-Velar and Velar-other contrasts for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant Pair	S	D	S	D	S	D
Bilabial - Bilabial						
|b| - |p|	-	100	20	80	6.67	93.33
Bilabial - Others						
|P| - |t̲|	10	90	46.67	53.33	3.33	96.67
|P| - |ṭ|	3.33	96.67	26.67	73.33	-	100
|P| - |k|	-	100	10	90	3.33	96.67
|P| - |d̲|	-	100	10	90	-	100
|P| - |g|	-	100	3.33	96.67	-	100
|b| - |d̲|	-	100	16.66	83.33	-	100
|b| - |g|	-	100	6.67	93.33	-	100
Medial Position						
|P| - |T|	6.67	93.33	23.33	76.67	6.67	93.33
|P| - |K|	6.67	93.33	33.33	66.67	3.33	96.67

Table A\|II): Percent same and different scores for Tamil-Tamil tokens forming bilabial-bilabial and bilabial-others contrasts for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant Pair	S	D	S	D	S	D
Dental - Dental						
| t̪ | - |d|	3.33	96.67	23.33	76.67	-	100
Med. | t̪ | - |d|	3.33	96.67	16.66	83.33	-	100
Dental - Others						
| t̪ | - |t|	40	60	56.66	43.33	23.33	76.67
| t̪ | - |k|	-	100	10	90	3.33	96.67
| t̪ | - |g|	20	80	26.66	73.33	10	90
|d̪ | - |d|	3.33	96.67	13.33	86.67	3.33	96.67
Medial position						
|T| - |K|	3.33	96.67	23.33	76.67	-	100

Table A(12) : Percent same and different scores for Tamil-Tamil token contrasting in Dental-Dental and Dental-others contrastsfor Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
Retroflex - Others						
|ṭ| - |k|	-	100	30	70		100
|ṭ| - |b|		100	3.33	96.67	6.67	100

Table A(13): Percent same and different scores for Tamil-Tamil tokens contrasting in retroflex-retroflex and retroflex-others contrasts for Group I, Group II and Group III.

	Group I		Group I		Group III	
Cosnonant pair	S	D	S	D	S	D
Velar - Velar						
|k| - |g|	3.33	96.67	16.67	83.33		100

Table A(14): Percent same and different scores for Tamil-Tamil tokens forming velar-velar contrasts for Group I, Group II and Group III.

Consonant pair	Group I		Group II		Group III	
	S	D	S	D	S	D
Bilabial-Bilabial						
|b| - | p |	3.33	96.67	20	80	-	100
|b| - |p^h]	26.67	73.33	33.33	66.67	26.67	73.33
|p| - |b|	6.67	93.33	13.33	83.67	-	100
| p |• |p^h]	20	80	30	70	20	80
Bilabial - Others						
| p |" |k^h|	-	100	13.33	86.67	-	100
| p | | t |	-	100	20	80	-	100
|p| - |t|	10	90	23.33	76.67	10	90
|b| | t |	-	100	16.67	83.33	-	100
|b| |t|	-	100	10	90	-	100
|b| |k|	-	100	10	90	-	100
|b| |t^h|	-	100	3.33	96.67	-	100
|b| |k^h|	-	100	3.33	96.67	-	100
|b| • | d |	-	100	10	90	3.33	96.67
|b| - |d|	10	90	33.33	66.67	16.66	83.33
|b| - |g|	-	100	13.33	86.67	-	100
Medial position						
| P | |T|	-	100	26.67	73.33	-	100
|P- |K|	-	100	26.67	73.33	-	100

Table A(15): Percent same and different scores for Tamil-Malayalam tokens forming bilabial-bilabial and bilabial-others contrast for Group I, Group II and Group III.

Consonant pair	Group I		Group II		Group III	
	S	D	S	D	S	D
Dental - Dental						
Id | - |t|	50	50	33.33	66.67	36.66	63.33
Dental - Others						
| t | - |p^h|	6.67	93.33	13.33	86.66	6.67	93.33
| t | - | k^h |	-	100	3.33	96.66	3.33	96.67
|t| - |p|	3.33	96.67	23.33	76.67	6.67	93.33

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
|t̪| - |ṭ|	23.33	76.67	56.67	43.33	23.33	76.67
|t̪| - |k|	-	100	6.64	93.33	-	100
|d̪| - |p|	-	100	6.67	93.33	6.67	93.33
|d̪| - |ṭ|	-	100	26.67	73.33	3.33	96.67
|d̪| - |K|	-	100	-	100	-	100
|d̪| - |ṭk|	10	90	36.67	63.33	13.33	86.67
|d̪| - |k^h|	-	100	6.67	93.33	-	100
|d̪| - |g|	-	100	16.67	83.33	-	100
Medial position						
|T| - |K|	-	100	16.67	83.33	-	100

Table A(16): Percent same and different scores for Tamil-Malayalam tokens forming dental-dental and dental-other contrast for Group I, Group II and Group III.

	Group I		Group II		Group III	
Consonant pair	S	D	S	D	S	D
Velar - velar						
| k|- |k^h|	3.33	96.67	20	80	-	100
|k| - |g|	-	100	16.67	83.33	-	100
|g|-|k|	33.33	66.67	33.33	66.67	40	60
|g| - |k^h|	33.33	66.67	30	70	6.67	93.33
Velar - Others						
|k| - |p^h|	-	100	13.33	86.67	-	100
|k| - |ṭ^h|	-	100	10	90	-	100
|k| - |p|	10	90	20	80	3.33	96.67
|k| - |t̪|	10	90	13.33	86.67	6.67	93.33
|k| - |ṭ|	3.33	96.67	23.33	76.67	6.67	93.33
|g| - |p|	-	100	6.67	93.33	-	100
|g| - |ṭ|	3.33	96.67	10	90	-	100
|g| |p^h|	10	90	10	90	10	90
|g| - |ṭ^h|	-	100	6.67	93.33	-	100

Table A(17): Percent same and different scores for Tamil - Malayalam tokens forming velar-velar and velar-other contrast for Group I, Group II and Group III.