PERCEPTION OF TAMIL LATERALS AND TRILLS BY NATIVE AND NON-NATIVE SPEAKERS

Registration No. L0480004

A Dissertation Submitted in Part fulfillment of
Master's Degree (Speech Language Pathology)
University of Mysore
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ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI
MYSORE – 570 006

MAY – 2006

Submitting this piece of work of mine
To my
Mom, Dad
and
My Guide – Savithri ma’m

Certificate

This is to certify that this Dissertation entitled **"Perception of Tamil Laterals and Trills by Native and Non-Native Speakers"** is a bonafide work in part fulfillment for the degree of master of (Speech Language Pathology) of the student (Registration No. L0480004). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Declaration

This Dissertation entitled "**Perception of Tamil Laterals and Trills by Native and Non-Native Speakers"** is the result of my own study under the guidance of Prof. S. R. Savithri, Professor and Head, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysore

May, 2006 Register No. L0480004

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Today is the first day…
Of the rest of your life.
Dreams can be realized…
If U can attempt to achieve them…
Look at UR eyes, they are small,
But they see enormous things
There is crack in everything…
That is how the light gets in
Right now U can be
Angry, afraid, happy, peaceful, loving, or content…
Its UR emotional state and "Your Choice"
Why allow negative experiences and situation to maintain
A needless existence in ur life?

U are in control to "change"…
To "wait" until a situation changes or
To do something to change it
Why worry about anything
U can not change?
Leave it behind and move on.
If you look deeper at what U consider bad
U may discover something good as well
If U learn to have less expectations,
Then U will experience less disappointments
To free Urself from stress & anxiety …
Do not worry about Tomorrow
Tomorrow is a mystery.
Be content with what
God has blessed you with.
He will supply U with all U need..
Every exit is an entry…
Somewhere else.

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CHAPTER - I

Introduction

Cross - language perception is defined in general terms as the perception of non-native contrasts by native listeners. Several studies have been done in the recent past, to add insights to the area of cross - language perception.

Initial research (Lisker & Abramson, 1970) on cross – language adult speech perception was with respect to various contrasts that could be discriminated by non-native listeners. Studies by Goto (1971), Caramazza, Yeni-Komshian, Zurif & Carbone (1973), Miyawaki, Strange, Verbrugge, Liberman, Jenkins & Fujimura (1975), Strange & Jenkins (1978), MacKain, Best & Strange (1981), Pisoni, Aslin, Percy & Hennessy (1982), Flege (1984), Werker & Tees (1984) were also on similar lines. The results of these studies repeatedly led to the conclusion that in tasks approaching the demands of natural language processing, perception of non-native contrasts is often less accurate and efficient than perception of phonetic distinctions that convey meaning in the native language.

In contrast, developmental cross-language studies (Laskey, Syrdal-Laskey & Klein, 1975; Streeter, 1976; Trehub, 1976; Werker, Gilbert, Humphrey & Tees, 1981) have revealed that, unlike adults, infants 6 months or younger can differentiate nearly all phonetic contrasts that have been tested regardless of their relevance in the infants language environment.

Some developmental studies (Werker & Tees, 1984; Best, Mac Roberts & Sithole, 1988) had indicated that the influence of the native language on phonetic perception is evident by 10-12 months at least for some consonantal distinctions.

Thus, research has indicated that young infants can discriminate speech sounds across phonetic boundaries regardless of specific relevant experience, and that there is a modification in this ability during ontogeny such that adults often have difficulty discriminating phonetic contrasts, which are not used contrastively in their native language. This pattern of findings suggested that humans are endowed with innate auditory sensitivities, which enable them to discriminate speech sounds according to universal phonetic boundaries and that there is a decline or loss in this ability after being exposed to a language which contrasts only a subset of those distinctions.

Werker &Tees (1984) designed a study to determine whether this modification in perceptual ability represents a loss of sensorineural response capabilities or whether it shows a shift in attentional focus and or processing strategies. In experiment I, adult English subjects were tested on their ability to discriminate two non-English speech contrasts in a category-change discrimination task after first being predisposed to adopt one of four perceptual sets. In experiment II, III, & IV subjects were tested in an AX (same/different) procedure, and the effects of both limited training and duration of the inter-stimulus interval were assessed. Results suggested that the previously observed ontogenic modification in the perception of non-native contrasts involves a change in processing strategies rather than a sensorineural loss. Adult listeners can discriminate sounds across non-native phonetic categories in some testing conditions, but are not able to use that ability in testing conditions, which have demands similar to those required in natural language processing.

India being a multi-lingual country offers greatest scope for research in cross-language speech perception. This would help in knowing the perceptual abilities of bilinguals and multi-lingual and also know extent to which the native language and subsequent exposure to other languages would reorganize their perceptual skills. This would gain implications in teaching second language to adults and children.

Some studies have been conducted on Indian languages too. These include perception of vowels by Bengali and Hindi speakers (Himanshu Khanna, 1996), discrimination of stop consonants by Malayalam and Tamil speakers (Sreedivya, 1997), consonant perception by Malayalam and Hindi speakers (Jessy George, 2003) and discrimination of Malayalam laterals by Malayalam and Hindi speakers (Agarwal & Savithri, 2005). All these studies are on perception of speech sounds by speakers of two languages. Most of these studies use an AX design, where A is the first target phoneme and X is the second target phoneme. A 'same', 'different' response or a multidimensional status is used in these studies. In the study by Agarwal & Savithri, the stimuli were presented only once. Thus, bias may be involved in the response. In order to remove the response bias multiple presentations of the stimuli is required. In this context, the present study was planned. The objective of the present study was to investigate the native and non-native speakers' ability to discriminate Tamil laterals and Trills. Native speakers will include Tamil speakers and non-native speakers will include Hindi speakers.

Tamil is a language spoken by the native people of the state of Tamil Nadu, in South India. It is classified as a Dravidian language. (Ladefoged & Maddieson, 1996). It has three laterals - the alveolar /l/, the retroflex /l./ and the retroflexed palatal / l̃ / .In the production of the alveolar /l/, the tip of the tongue has contact with the alveolar ridge in such a way that there is complete blockage of air in the middle of the mouth. In the production of the retroflex /l./, the tip of the tongue is slightly curved and made to contact the middle of the palate. The air stream is completely blocked in the middle of the mouth. In the production of the retroflexed palatal /l̃ /, the tongue is curled back and the tip of the tongue is placed very near the roof of the mouth. Also, in Tamil there is a flap /r/ and a trill /r̃/. The flap /r/ is produced by a single quick flap of the tongue at the alveolar arch. The breath escapes through the tip of the tongue and palate. This is described as a voiced alveolar flap. The trill /r̃/ is produced by the rapid vibrations by the tip of the tongue against the middle of the alveolar ridge. This is described as a voiced alveolar trill (Rajaram, 1972).

Hindi is an Indo Aryan language spoken in the northern parts of India. Hindi has one lateral-alveolar /l/ and one alveolar flap /r/. Table 1 summarizes the laterals and trills in both the languages.

Language	Laterals			Trills	
	Alveolar /l/	Retroflex /l./	Retroflexed palatal / l̃ /	Alveolar flap /r/	Alveolar trill /r̃/
Tamil	+	+	+	+	+
Hindi	+			+	

Table 1: Laterals and trills in Tamil and Hindi languages.

Thus, Hindi listeners are not exposed to retroflex /l./ and retroflexed palatal / l̃ / laterals and alveolar trill /r̃/. Therefore, it was hypothesized (H_o) that there will be no significant difference between discrimination scores of speakers of two languages. Alternatively, it was hypothesized (H_1) that there will be significant difference between discrimination scores of speakers of two languages with Tamil speakers having a better discrimination scores compared to Hindi speakers.

CHAPTER – II

Review of literature

Research in cross-language perception is concerned with several general issues surrounding perceptual learning, and also throws light on the perception of non-native contrast as well as the role of linguistic environment in speech perception in infants, children and adults. Till date cross-language differences in perception of non-native contrasts, consonants, vowels and suprasegmental aspects are studied. However, keeping in view of the objective of the study the review of literature will be elaborated under following headings:

(1) Cross-language perception of consonants

(2) Variables in cross-language studies

(3) Theoretical explanation for cross-language differences in perception.

(1) Cross-language perception of consonants

Caramazza, Yeni-komshian, Zuriff & Carbone (1973) studied VOT as a linguistic cue in examining the perception and production of stop consonants in three groups of subjects, namely unilingual Canadian French, unilingual Canadian English and bilingual French-English speakers. Forty subjects were taken up for the study with 10 in each unilingual group and 20 in bilingual group, with ages ranging from 17-25 years. The materials used to test the perceptual ability consisted of three different continua of stop + vowel syllables. By splicing, five random sequences of each of the three basic continua (15 sequences) were produced and employed in the perception test. Materials used to assess the production consisted of common stop-initial English and French words, typed on 3 X 5 white cards. Nine words for each of the six stop consonants for each language were used, thus making a total of 54 English and French words each. The subjects were asked to read aloud a set of English or French stop-initial words containing either of two homorganic consonants and then asked to label the VOT variants for the same class of stops that they read. Results of perceptual task revealed that VOT is a strong perceptual cue in Canadian English, whereas speakers of Canadian French seem relatively insensitive to VOT as a categorical phonological cue. On the other hand, the bilingual subjects like the unilingual English speakers were not monotonic and perhaps are less sensitive to VOT variations than unilingual English speakers and utilize the acoustic cue more than unilingual French speakers. Also, it was noticed that bilinguals use the same phonetic criteria when perceiving voicing distinctions in French as well as English.

The results of production task complimented the findings of the perceptual task. VOT appeared to be an important variable for voicing distinctions in Canadian English but not in Canadian French. On the other hand the bilingual subjects produced voicing distinctions, which were clearly distinct for the two languages, but with voiceless consonants, they were more closely aligned with the unilingual French group. This lack of monotonicity indicates that the first learned language interfered with the perception and production.

This study suggests that the phonological processes the bilingual acquires for his second language are contaminated by properties accruing to his first language. Unlike the learning of a second vocabulary, the acquisition of second phonological system does not appear to be quantal. The process seems to consist of a gradual and continuous progression towards a target, which may never be attained. But when the similarity of the perceptual functions in the two language modes is contrasted with the difference shown for the production distributions in these language modes, the bilingual appears better able to adapt their production mechanisms than their perceptual mechanisms to the second language. This ability to switch mechanisms from one language to another states that, language switching is easier for production than for perception.

Werker & Tees (1984) conducted four different experiments to determine whether the decline in non-native speech perception represents a sensori-neural loss, a shift in attentional focus, or the use of language specific processing strategies. In experiment 1 authors investigated whether the ontogenetic reorganization in cross-language speech perception resulted in a decline in sensorineural responsivity (i.e., neural atrophy) or result of a change in attentional mechanisms and or processing strategies? Also if a decline cannot be accounted for by a neural atrophy, will an attentional manipulation enable adult English subjects to discriminate the non-English phonetic contrasts? Eight adult English-speaking subjects in the age range of 18 to 40 years were tested. The material consisted of two non-English place of articulation contrasts. The first contrast was Hindi voiceless, unaspirated retroflex versus dental place of articulation, /ṭa/ - /ta/, distinction. The second stimulus pair was Thompson glottalized velar with a glottalized uvular (or post-velar) place of articulation sounds, /kʼi/ - /qʼi /. The subjects were tested on their ability to discriminate multiple natural exemplars of the two non-native sound contrasts under four different perceptual set conditions i.e., (1) a native-language phonemic, (2) an acoustic categorizing, (3) a single-token phonetic, or (4) a within-category vocalic perceptual strategy. The results suggested that subjects have the sensori-neural ability to discriminate the acoustic parameters of the non-native phonetic contrasts, but they do not use that ability when required to discriminate full syllables. Thus it can be concluded that a simple neural atrophy explanation is not sufficient. Second, the results lead us to suspect that the ontogenetic decline cannot be explained by a shift in attentional focus since the perceptual set manipulation used in this experiment did not improve performance. Instead, these findings suggest that when subjects hear speech like sounds, a phonemic processing strategy is elicited, and that a more powerful manipulation that the attentional set induction used in to enable subjects to shift to different processing strategies.

Experiment 2 was designed to see if subjects could discriminate the full syllables if tested in a more sensitive testing procedure. Ten adult English-speaking subjects in the range of 18-35 were utilized. The same material as that of experiment 1 was utilized. Subjects were tested for AX discrimination task, by giving a form of training during the first block of 34 trials, followed by testing on three blocks of 34 trials. The results of this experiment supported the notion that the inability to discriminate non-native contrast cannot be explained by neural atrophy, but rather is best accounted for by the use of different processing strategies.

Experiment 3 was designed to determine if the familiarization (training) procedure used in experiment 2 facilitated accesses to a nonphonemic processing strategy. Ten naive, English-speaking subjects within the age range of 18-35 years were used. The same materials as of previous experiments were utilized. Subjects were tested in the AX procedure, similar to that of experiment 2, but no feedback was given during the first block of 34 trials. The results of this experiment indicated that subjects can discriminate the full syllable non-English contrasts when tested in an AX procedure even without being given any familiarization trials. It can be concluded that training is not the experimental variable to adopt a nonphonemic processing strategy, although training may improve performance.

In experiment 4, authors tested whether the evidence of discrimination obtained for full non-native syllables in experiments 2 and 3 was a function of the shorter ISI used in the AX than in the button-press task, rather than being the result of different testing procedures. Ten naïve subjects between the ages of 18 and 35 were tested on both speech contrasts in the AX procedure without being given training. Testing conditions were identical to those described before, except the ISI between stimuli within each trial was 1500 ms rather than 500 ms, and the interval between trials was 3000 ms rather than 2500 ms. Results indicated that there is a difference between the results obtained for full syllable discrimination using the AX procedure with a short (500 ms) and a long (1500 ms) ISI. Apparently a memory trace is available following the 500 ms delay, which has decayed after 1500 ms. This memory trace enables the subjects to relinquish an exclusively phonemic processing strategy, and detect differences within phonemic categories.

In summary, these results indicate that the previously observed age-related decline in cross-language speech performance is not the consequences of a neural loss. It was found that under some circumstances adults discriminate speech sounds according to the phonemic categories of their native language, and under other circumstances discriminate the same sounds according to phonetically relevant category boundaries used in another, but not their native language. The ineffectiveness of the attentional manipulation used in experiment suggests that a model of attentional allocation may not be adequate to explain these results and that an explanation based on task-invoked processing strategies may be more appropriate. Further research using additional perceptual set manipulations is required to disambiguate these two possible explanations, however.

Polka (1991) studied English listeners’ perception of retroflex versus dental stop consonant place distinction in Hindi produced in four different voicing contexts: prevoiced ([ḍ] *vs.* [d]), voiceless unaspirated ([ṭ] *vs.* [t]), voiceless aspirated ([ṭ^{h}] *vs.* [t^{h}]), and breathy voiced ([ḍ^{h}] *vs.* [d^{h}]. Four groups of 18 monolingual American English speaking subjects in the age range of 17-28 years were tested on one of the Hindi retroflex-dental contrasts. The audio recorded stimulus were presented binaurally and tested using the AX procedure by instructing the subjects to hear pairs of syllables that are containing either two different instances of the same consonant (same pairs) or instances of the two different consonants (different pairs) and respond ‘same’ or ‘different’ on a response sheet provided. Before responding in the task, subjects listened to a brief familiarization (12 AX pairs) followed by AX task without feedback. Results indicated the order of performance from least to most errors as voiceless unaspirated, breathy voiced, voiceless aspirated and prevoiced. Also it was suggested that differences in assimilation 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 played an important role in the perception of both assimilated and non-assimilated contrasts.

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

Several studies have documented the persistent difficulty experienced by Japanese learners of English in differentiating American English /r/ and /l/ perceptually as well as productively (Goto, 1971; Miyawaki, Strange, Verbrugge, Liberman, Jenkins & Fujimura 1975; Mochizuki, 1981; Sheldon & Strange 1982; Strange & Dittmann 1984; Underbakke, Polka, Gottfried & Strange 1988). However, performance levels and patterns of perception vary considerably both within and across studies as a function of differences in stimulus materials (Mochizuki, 1981; Strange & Dittmann 1984), perceptual tasks (MacKain, Best & Strange 1981; Mochizuki, 1981), the context in which the /r/ - /l/ contrast is examined (Mochizuki, 1981; Sheldon & Strange, 1982) and the linguistic experience of the subjects (MacKain, Best & Strange 1981; Miyawaki et al., 1975). In addition, most studies have reported individual differences that could not readily be accounted for by differences in stimuli, tasks, and experiential variables.

Yamada & Tohkura (1992) have explored interactions among stimulus materials, task variables, and individual differences in a set of studies of Japanese living in Japan, and Pisoni and his colleagues (Logan, Pisoni & Lively, 1991) have reported some results of a /r/ - /l/ training study with Japanese in the USA. Three conclusions were drawn from the results of these and earlier studies.

(1) Phonotactic Context Effect: The /r/ - /l/ contrast in prevocalic positions (syllable-initial and syllable-initial clusters) is much more difficult for Japanese learners to differentiate perceptually than /r/ - /l/ in postvocalic positions (Mochizuki, 1981;

Sheldon & Strange, 1982). Japanese have difficulty with post-vocalic /r/ - /l/. This is probably due to articulatory and acoustic differences between the allophones produced in prevocalic and postvocalic contexts. Improvement in /r/ - /l/l perception with training is also variable across phonotactic contexts; the perception of initial /r/ - /l/ may be particularly difficult to alter (Strange & Dittmann 1984; Logan et al., 1991).

(2) Multiple Acoustic Cues: While F3 onset and transition differences in prevocalic /r/ - /l/ are sufficient "cues" for native English speakers to distinguish phoneme categories, studies using synthetic speech materials indicate that Japanese learners of English rely more heavily on F2 transition information and temporal parameters of F1 which also vary systematically in natural speech (Underbakke et al., 1988, Yamada & Tohkura 1992). However, when synthetic speech containing multiple acoustic cues is used to assess perception consistency of identification and categoricalness of discrimination correlate well with Japanese ability to identify natural speech exemplars of the phonetic categories (Yamada & Tohkura 1992).

(3) Relation of American English Liquids and Glides to Native Japanese Categories: American English liquids /r/ and /l/ are phonetically dissimilar from Japanese /r/, the latter being phonetically realized most often as an alveolar flap /r/. Acoustically and perceptually, American English /r/ (and perhaps /l/) may be more similar to the Japanese (unrounded) glide /w/. This conclusion is supported by research using a synthetic /r/ - /l/ continuum in which Japanese subjects labeled stimuli with intermediate F2 and F3 values as "w" when allowed this response alternative (Yamada & Tohkura 1992).

Iverson & Kuhl (1996) studied the relative influence of phonetic identification and category goodness on the perception of American English /r/ and /l/. In this study they examined whether the perceptual space underlying /r/ and /l/ is shrunk near the best exemplars and stretched near the category boundary. Twenty-eight adult native speakers participated in the study. Eighteen /ra/ and /la/ tokens were synthesized and utilized for goodness identification and similarity scaling procedure. The results demonstrated that general auditory sensitivity, categorical perception, and the perceptual magnet effect all contribute to the perception of American English /r/ and /l/ tokens. Phonetic identification accounts for differences in sensitivity that are a function of distances from the /r-l/ boundary; it accounts for the stretching of the perceptual space in the F3 dimension for tokens that receive less than 100% /r/ or /l/ identifications. Goodness better accounts for sensitivity parallel to the /r-l/ boundary (in the F2 dimension), and near tokens that receive 100% /r/ or /l/ identification. Thus the study concludes that the perceptual magnet effect influences the perception of /r/ and /l/ by American listeners. Individual differences in identification and goodness lead to differences in perceptual similarity, supporting the claim that the distortion due to the perceptual magnet effect can be attributed to mental representations for phonetic categories. The perceptual magnet effect accounts for distortion of the perceptual space in addition to that explained by traditional categorical perception.

Sreedivya (1997) investigated cross language difference in the perception of stop consonants in Tamil and Malayalam by Tamil and Malayalam monolinguals. The two languages differ in voicing and aspiration. While both are phonemic in Malayalam they are not so in Tamil. Ninety subjects chosen for the study constituted of three groups with

15 males and 15 females in each group – Tamil monolinguals, Malayalam monolinguals and bilinguals with Tamil as native language and Malayalam as second language. The audio-recorded words were subjected to acoustic analysis. The first three terminal frequencies (frequency at the onset of the vocal fold vibration and the onset of the burst) were measured using the waveform in the DSP sonagraph 5500. The results of the analysis showed that perceptual data correlated with the production data. Tamil monolinguals showed the poorest performance on the voicing contrasts, which was expected, as voicing is not phonemic in Tamil. Aspiration contrast was well discriminated by Tamil monolinguals as they could be forming strong category goodness contrast and hence easily discriminable. 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. Bilinguals performed better in voicing and aspiration contrasts, which are phonemic in Malayalam. They performed closer to the Malayalam monolinguals reflecting the second language influence. This study implied that learning the second language widens the perceptual dimensions for stops making them closer to the monolinguals. Further it was speculated that contextual cues would play a role in discriminating contrasts.

In cross-language speech perception study done by Harnsberger (2001) on nasals, the abstract units such as phonemes or their context-dependent variant allophones were evaluated in a perceptual similarity test employing a broad range of non-native stimuli and listeners group. The subjects of the study included 18 Malayalam, 18 Marathi, 14 Punjabi, 14 Tamil, 16 Oriya, 17 Bengali and 18 American English speakers. The stimulus materials consisted of Malayalam nasal consonants produced at six places of articulation, bilabial, dental, alveolar, retroflex, palatal and velar. A forced-choice AXB classification test was administered, in which participants decided which was more similar to X, A or B. Unlike AXB discrimination, A, B and X in a classification test are tokens from three rather than two stimulus types. Prior to testing, participants were instructed to indicate which nasal consonant, in the first or the third stimulus, was more similar to the nasal consonant appearing in the second stimulus by circling a number on an answer sheet, even if all three stimuli sounded relatively distinct from one another. The results of the multidimensional scaling analysis revealed substantial effects of linguistic experience on the organization of perceptual spaces that cannot be accounted for by abstract units such as phonemes or allophones. Suballophonic aspects of their perceptual categories defined the alveolar and the dental – retroflex nasal phoneme groups, instead of being easily classified by their nasal consonant inventory. In fact, the seven listener groups could easily be regrouped in terms of their arrangement of nasals in perceptual space according to attributes that are quite independent of their phonemic or allophonic inventory, such as the overall dispersion of nasals, different patterns of clustering of nasals (interdental – alveolar – retroflex, palatal – velar), and the similarity observed between the bilabial and retroflex nasals.

Overall, the results of this experiment point to the need for richer and more detailed descriptions of the perceptual categories of listener groups at sub allophonic levels of analysis. However, the results do not differentiate between candidate sub allophonic units, such as weighted features or episodic distributions. To test a feature – weighting model of language would first have to be determined by acoustic analyses of appropriate sets of stimulus materials. From such analyses, a large set of candidate cues would then need to be evaluated in a series of perception tests using edited natural stimuli or synthetic stimuli. The purpose of such tests would be the measurement of the weights placed on each cue in the identification of the phoneme by native listeners. If the cue weights for "equivalent" phonemes or contrasts in two languages were adequately described, a feature-weighting model of cross-language speech perception could then be tested by presenting non-native stimuli that are phonetically similar to these phonemes to native speakers of both languages.

Jessy George (2003) studied cross-language differences in the perception of Malayalam consonants by native, non-native and bilingual speakers. Malayalam consonants were studied, as Malayalam language is one of the languages, which has maximum number of consonants. Malayalam differs from Hindi in having lax consonants, more than one trill/lateral and dental vs. alveolar distribution. Ninety subjects were taken up constituting three groups, native Malayalam speakers, native Hindi speakers and bilinguals with Malayalam as the native language and Hindi as the second language. Each group consisted of 10 subjects in the age range of 5-6 years, 9-10years and 18-35years. The audio-recorded stimulus was presented binaurally, and subjects were instructed to indicate if the two words in a pair were the 'same' or 'different'. The results indicated that Malayalam monolinguals scored higher than Hindi monolinguals and Malayalam bilinguals. Among the native and bilingual listeners refinement in perceptual ability was seen across age group, suggesting that modification of the perceptual ability as a function of experience with the particular language. Also Malayalam monolinguals and bilinguals scored higher on perception of stop consonants and affricates compared to Hindi monolinguals. Hindi monolinguals perception of lax consonants was poorer compared to Malayalam monolinguals and bilinguals. This study implied that perceptual ability undergoes refinement with language experience. The authors speculated that contextual cues play a role in discriminating few contrasts for monolinguals and bilinguals.

Agarwal & Savithri (2005) investigated the Hindi listeners' ability to discriminate Malayalam lateral contrasts and the differences between adults and children in the ability to discriminate such contrasts. Malayalam language has 3 laterals – alveolar, retroflex and palatal – and Hindi has only the alveolar lateral. Forty subjects chosen for the study consisted of four groups with 10 subjects in each group. Group I and III consisted of native Malayalam and native Hindi speaking children in the age range of 4-6years. Group II and IV consisted of native Malayalam and native Hindi speaking adults in the age range of 19-21years. Two sets of stimuli with word pairs contrasting in laterals were prepared. The stimuli were audio-presented binaurally and the responses were recorded. Results indicated that native Malayalam speakers discriminated palatal-retroflex contrast better than retroflex-alveolar contrast. The non-native speakers discriminated retroflex-alveolar contrast better than palatal-retroflex contrast. Native Malayalam speakers discriminated both laterals better than non-native Hindi speakers and adults performed better than children. The results of this study do not support the Universal theory and appears that a new model or theory of cross-language perception needs to be proposed.

(2) Variables in cross-language studies on consonants

The review reveals that the results depend on several factors like the environment, Stimuli, interstimulus interval, perceptual paradigm and contextual cues. There is a Tetrahedral Model adapted to investigate the factors that influence perception of non-native contrasts. This Tetrahedral Model was first proposed by Jenkins (1979) to describe memory phenomena and states that the outcome of an experiment in any cognitive domain is a complex interaction of four variables: (1) subjects (abilities, interests, knowledge, purposes…), (2) orienting tasks (instructions, activities, apparatus…), (3) criterial tasks (recognition, problem solving, performance…), and (4) materials (sensory mode, physical structure, psychological organization and sequencing…). Table 2 lists some of the variables of each type that have been shown to influence the outcome of cross-language studies of speech.

Subject Variables	Native Language (L1) Experience Second Language (L2) Experience Age (Critical or Sensitive Periods) “Talent” for Language Learning (Individual differences)
Orienting (Training) Task Variables	L2 Instruction (Usage *vs*.. perception/production drills) Laboratory Procedures Discriminating tasks *vs.* identification tasks Physical identity discrimination *vs.* Categorial (name identity) discrimination Prototype *vs.* gradient (fading) techniques One *vs.* many contexts; one *vs.* many speakers Blocked *vs.* mixed contexts and speakers
Criterial Task Variables	Laboratory Procedures (as above) Memory Load Inter-stimulus interval (ISI) Stimulus uncertainty Transfer Tasks (Tests of generalization of training) “Novel” stimuli: New contexts, new speakers Perception *vs.* production performance “Native-Like” Performance Criteria
Stimulus Variables	Type of Contrast Vowel *vs.* consonants; voice *vs.* place contrasts Acoustic salience of information (temporal *vs.* spectral cues) Relation of Non-native Contrast to Native Categories Phonetic and Phonotactic Context Type of Stimulus Materials (Training and Testing) Synthetic speech (single *vs.* multiple acoustic cues) Natural speech (speaker intelligibility) Modified natural speech (e.g., truncation)

Table 2: Four types of variables that interact to determine the outcome of cross-language perception studies.

The Tetrahedral Model emphasizes that all four variables interact in complex ways to determine performance. Thus, there are no simple (or general) answers to questions concerning which non-native contrasts will present the most difficulty for second language learners or to questions about which training procedures will be most efficacious in modifying phonetic perception. Answers to these questions will depend upon the subjects' linguistic experience and "talent" for language learning; the acoustic and articulatory structure of the phonetic categories to be learned and their relation to native language categories; and how the criteria for perceptual learning and mastery are defined and performance is assessed. Which stimulus materials and which tasks are most effective in training language learners to perceive non-native contrasts will depend upon the subjects' initial level of performance, the contrasts to be learned, and the performance goals by which progress is measured.

The choice of stimulus materials and tasks also depends upon the experimenters' goals in conducting cross-language experiments. For instance, if the experimenter's purpose is an analytical assessment of whether native and non-native perceivers attend to different sources of acoustic information, then synthetic speech materials are ideal (Yamada & Tohkura 1992, Underbakke, Polka, Gottfried & Strange, 1988).

Alternatively, if the primary concern is to train subjects to form new phonetic equivalence categories, then natural speech materials containing the appropriate kinds of variation across speakers and contexts may be preferable (Logan, Lively, & Pisoni, 1991).

Several factors affect the results of the studies also. These include the following:

1) Environment of testing: There is some recent research showing that non-native listeners show more difficulty perceiving even relatively easy phones than do native listeners under certain testing conditions. Takata & Nabelek (1990) compared native English speakers to native Japanese speakers on their performance in the modified Rhyme test. Results indicated that though the two groups performed significantly more poorly than the native English speakers in conditions of noise and or reverberation. Not surprisingly, one of the more common errors for native Japanese listeners was r/l confusion.

2) Stimulus used: Stimuli used in the perceptual studies of vowels has been of two types: (i) Natural/synthetic, (ii) Isolated vowels/vowels containing syllables i.e., as the CV or CVC. Therefore overall stimuli becomes of 4 types: (a) Natural isolated vowels (Fischer-Jorgenson, 1973), (b) Synthetic isolated vowels (Vinegard, 1970), (c) Natural vowels containing syllable (Flege, 1990), and (d) Synthetic vowels containing syllables.

All the four kinds of stimuli are used and it is still a matter of controversy. Whereas argument in favor of use of synthetic vowels is that they are speaker independent, but the same thing can act as disadvantage as synthetic vowels do not take into account normalization aspects (Verbrugge & Rakerd, 1985). Advantage of using isolated vowels is in its pure form and does not have coarticulatory effects. Whereas CVC minimal pairs add more meaning to it by adding phonetic context and making vowel perception of ambiguous vowels more categorical (Rakerd, 1984;

Vinegard, 1970) and obviously CVC syllables make the coarticulatory and contextual variations near to constant (Rakerd, 1984).

3) Inter-Stimulus Interval (ISI): Inter-Stimulus Interval has been found to affect level of linguistic participation (Werker & Tees, 1984). Werker & Logan (1985) studied using Hindi and retroflex/dental stimuli in English speakers. They tested subjects for five blocks of trials on three ISI conditions, 1.5 sec, 0.5 sec and 0.25 sec. Results indicated sensitivity to non-native phonetic contrast in shorter ISI conditions, as subjects could discriminate non-native phonetic cues within retroflex or dental category at 500 ms ISI, whereas in ISI above 1500 ms, subjects used phonemic cues. Flege, Munro & Fox, (1994) suggest use of 1 sec to 1.2 sec as ISI so that subject is able to retrieve phonetic cues from memory.

4) Perceptual study tasks or paradigms used: Specific paradigms are used for specific research needs in cross-language vowel perception studies. Following paradigms have been used in the research reviewed (Flege et al., 1994; Werker & Tees, 1984; Fischer-Jorgenson, 1973).

    a) Identification tasks
    b) AX or similar/different or discrimination tasks
    c) AXB method
    d) ABX task
    e) Oddity task
    f) Rating procedures
    g) Multi dimensional scaling

Identification task involve identification of the stimulus by the subject in the stimulus presented. This is easier than the other tasks and memory requirements are low.

AX or similar/different or discrimination task is also one of the simple tasks. In this, subject has to indicate whether X i.e., the target phase is similar to A, i.e., reference phase or different. In this task also, memory demands are less and is almost appropriate to test sensitivity to the contrasts.

AXB task has A, X and B i.e., three sounds are represented successively to the subjects. A and B are standard stimuli, and X is the target stimulus. The subjects are required to judge whether X is more similar to A or to B. This is usually used to study assimilation and other processes.

ABX task has three sounds A, B and X which are presented successively to the subjects. A and B are the standard stimuli and X is the target stimulus. The subjects are required to confirm X to either A category or B category. This is used in categorical perception.

In the oddity discrimination, the subjects has to identify the odd item out of the three stimulus presented successively (triad) and encircle it. In case of ambiguity he/she is required to guess. It assesses identification indirectly and has high memory demands.

In the rating procedures, dissimilarity between two stimuli is rated on rating on rating scales, e.g., Flege et al., (1994) used a nine point scale with (1) as 'very similar' and (2) as 'very dissimilar'. This dissimilarity is rated on predetermined dimensions. Correlational analysis may be done which are helpful in obtaining weight age given to different dimensions and know which contrast is more readily discriminated. This procedure places high memory demands.

Multi-dimensional Scaling Analysis (MDS): The ratings are obtained and thus examined using MDS analysis. This technique is used to account for the perceived difference between pairs of stimuli by locating the stimuli within an 'n' dimensional perception space. The listeners mean ratings are entered into symmetrical matrices and then analyzed using ALSCAL, a program that assumes dissimilarity judgment for any of stimuli reflects underlying perceptual distance between them (Takane, Young & De Leruw, 1976). MDS are more sensitive to acoustic differences.

The tasks discussed above are used in different kinds of research requirements and shown to give variations in results. Therefore a proper method should be selected to meet the investigators requirement.

5) Contextual cues: Contextual cues can be of two types and increases identification of vowels (Rakerd, 1984). The contexts can be phonetic, phonological and acoustic (Werker & Logan, 1985). There are also some cues known as linguistic sentence context cues. House & Fairbanks (1953) show that vowel perception varies depending upon the identity of the consonant that precedes or follow it. Rakerd (1984) performed individual scaling analysis and the study revealed two ways in which

vowels in consonantial context can be said to have been perceived more linguistically meaningful dimensions of vowels were more integrated in perception when vowels were in context.

According to Flanagan (1972), experiments have demonstrated that intelligibility of words (vowels) is substantially higher in grammatically correct meaningful sentences than when words are presented randomly in isolation. The sentence context reduces number of alternative words among which listeners may decide.

Centmayer (1973) presented synthetic vowel sound in isolation as well as within certain spoken linguistic environment to study the effect of linguistic context on vowel perception. They found that a change from isolated vowel sound to vowels within spoken words reduces the region of physical ambiguity, i.e., discrimination becomes more categorical. They also concluded that subject's vowel boundary is not fixed but varies within a certain range. The contextual cues can completely over ride the instaneous boundary.

(3) Theoretical explanations for cross-language differences in speech perception

Theoretically based explanations specifying which non-native contrast would be easy or difficult to discriminate have been proposed by many researchers. Burnham (1986) suggested that there might be both fragile and robust non-native contrasts. Fragile refers to phonetic contrasts that are both rare across the world's languages and of particular importance, are acoustically similar and it is due to the loss of these cues that difficulties arise in perception of non-native contrasts in adults. Robust refers to contrasts that are widely distributed across the world's language and are acoustically less similar.

Flege (1990) proposed the Speech Learning Model, and hypothesized that phonetic similarity between L1 and L2 phonetic categories is predictive of L2 learning difficulty. He defines L2 phones as old, new, or similar, based on their (acoustic) phonetic "distance" from L1 phonetic categories. Old categories are L2 phone classes with boundaries that are nearly identical to L1 categories and present few problems perceptually or productively; language learners continue to use L1 equivalence classification strategies to process these L2 phones. New phones are dissimilar from all L1 categories and thus present perception and production problems initially. However, with experience, learners establish new equivalence classes, which result in accurate perception and unaccented production. Similar L2 phones are assimilated to L1 categories, which may facilitate perception and production initially. However, to the extent that there is a mismatch between L1 and L2 phonetic boundaries, perceptual confusions and "accented" production may persist.

Polka (1991, 1992) has highlighted at least three independent factors that need to be considered when making predictions concerning the discriminability of non-native contrasts among adults. These are functional phonetic status (phonemic contrast), substantive phonetic status (phonetic variation), and acoustic differences (the absolute amount of measurable acoustic difference between members of non-native contrast irrespective of phonetic status). She emphasized that all three of these factors need to be considered in assessing the discriminability of a non-native contrast for subjects of any age.

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 depends on their proximity to native language magnet, that is the nearest it is to the native language magnet; the more it will be assimilated by it, making it indistinguishable from the native language sound. The second factor accounts that L2 learners can establish new L2 phonetic category, if they detect phonetic difference between an L2 sound and nearest L1 sound. SLM predicts that greater the perceived phonetic distance between an L2 sound and the closest L1 sound is, the more likely it is that phonetic difference between the sounds will be detected and a phonetic category eventually established. The acquisition of phonetic categories is thought to make L2 segmental perception more native like because it enables the learner to base perception on L2 phonetic input without interference from prior learning.

Best (1995) has proposed that, for adults, language effects are evident for some contrast but not others because there are differences in the way in which the contrasting non-native phones relate to the native phonology. She has developed a perceptual assimilation model (PAM) that is able to account for some differences in an adult differentiation based on assimilation patterns. (Best 1990, 1993, 1994a). PAM indicates that phonological status is the predictor of the discriminability of non-native contrast. Best, MacRoberts & Sithole (1988) have proposed that there are at least four kinds of non-native contrasts in terms of phonological status; they are

a) Assimilable,
b) Non-assimilable,
c) Category goodness and
d) Two category.

Assimilable contrasts are those in which each member of the contrasts can be assimilated to an intermediate phone in a native language. These should be most difficult to discriminate (Example, glottal stop of Urdu to velar stop of Hindi).

Non-assimilable contrasts include phones that do not even sound at all like any possible phone from native language. These contrasts are predicted to be most easily discriminable. (Example, /f/ in English and its absence in Tamil).

Category goodness refers to a non-native contrast whose member can each be assimilated to an intermediate phoneme in the native language, as in assimilable, but one which will stand out as clearly a better instance of that category than the others (Example, l̃ of Tamil can be assimilated to ‘l.’ in Kannada, but never to ‘l’).

Two category refers to a non-native contrast that consists of two non-native phones each of which is assimilable to a contrasting phonemic category in the native language (Example, /ph/ and /bh/ of Hindi can be assimilated to /p/ and /b/ of English). According to ease of discrimination the four kinds of contrasts can be arranged as, Two category > Non-assimilable > Category goodness > Assimilable.

A Connectionist Model recently proposed by Behnke (1998) explains that language effects emerge later in development for some phonetic contrasts than for others. According to Behnke delays may occur either because general limitations in auditory processing during infancy make it difficult for infants to differentiate certain phonetic contrasts. Example, contrasts involving brief or low amplitude phones and or because differentiation of some contrasts may remain difficult until the child has gained lexical knowledge that serves to fine-tune phonetic processing.

The review indicates that native speakers may not perceive non-native contrasts. India being a multilingual country has greater potentials to answer such questions. In this context, the present study was planned to investigate the perception of Tamil laterals ant trills by native (Tamil) speakers and non-native (Hindi) speakers.

CHAPTER – III

Method

Subjects: Forty subjects participated in the present study. They constituted two groups, i.e., Tamil and Hindi bilinguals with Tamil and Hindi as their native language and English as their second learned language. Group I consisted of 20 native Tamil bilingual speakers (10 males and 10 females) in the age range of 18-25 years (mean age = 20.9years). Group II consisted of 20 native Hindi bilingual speakers (10 males and 10 females) in the age range of 18-25 years (mean age = 20.8years). All subjects had normal hearing, normal intelligence and did not have any history of ear discharge or earache.

Material: The stimuli consisted of 80 Tamil mono/bi/tri syllabic words (minimal pairs) with laterals and trills in word-medial and word-final positions. These words as uttered by a native 22-year old adult female speaker were audio-recorded. Care was taken to see that the F0 pattern was same in both the words. Four sets of stimuli with word pairs were prepared, with minimal pairs contrasting in laterals and trills. All four sets had 20 word pairs. In set I, each word pair had minimal pairs contrasting alveolar /l/ and retroflex /l./ in set II the contrast was between retroflex /l./ and retroflexed palatal /l˜/ set III had contrast between alveolar /l/ and retroflexed palatal /l˜/ and set IV had minimal pairs contrasting alveolar flap /r/ and alveolar trill /r ˜/

These word pairs were used to test the discrimination ability. In addition each word was paired with itself forming 40 word pairs in each set. These word pairs were used as catch trials. The word pairs were randomized in their corresponding sets and iterated thrice. The inter-stimulus interval used was 3 sec. Thus a total of 720 word pairs formed the material. For example if two words were CVlV - CVl.V then, the word pairs will be (a), CVlV - CVl.V, (b), CVlV – CVlV, (c), CVl.V - CVl.V. Table 3 shows the word pairs in all 4 sets.

Sl .No.	Set I	Set II	Set III	Set IV
1.	alagu-al.agu	al.agu-al̃agu	alagu-al̃agu	aram-ar̃am
2.	ali-al.i	al.i-al̃i	ali-al̃i	aran-ar̃an
3.	alai-al.ai	al.ai-al̃ai	alai-al̃ai	ari-ar̃i
4.	a:l-a:l.	a:l.-a:l̃	a:l-a:l̃	ariva:l-ar̃iva:l
5.	ilai-il.ai	il.ai-il̃ai	ilai-il̃ai	arundu-ar̃undu
6.	ulavu-ul.avu	ul.avu-ul̃avu	ulavu-ul̃avu	aria-ar̃ai
7.	ulai-ul.ai	ul.ai-ul̃ai	ulai-ul̃ai	iratal-ir̃atal
8.	oli-ol.i	ol.i-ol̃i	oli-ol̃i	irakkam-ir̃akkam
9.	kali-kal.i	kal.i-kal̃i	kali-kal̃i	irumbu-ir̃umbu
10.	kalai-kal.ai	kal.ai-kal̃ai	kalai-kal̃ai	irai-ir̃ai
11.	ka:li-ka:l.i	ka:l.i-ka:l̃i	ka:li-ka:l̃i	ural-ur̃al
12.	talai-tal.ai	tal.ai-tal̃ai	talai-tal̃ai	uravu-ur̃avu
13.	ta:l-ta:l.	ta:l.-ta:l̃	ta:l-ta:l̃	uri-ur̃i
14.	mulai-mul.ai	mul.ai-mul̃ai	mulai-mul̃ai	uru-ur̃u
15.	vali-val.i	val.i-val̃i	vali-val̃i	eri-er̃i
16.	valai-val.ai	val.ai-val̃ai	valai-val̃ai	kurangu-kur̃angu
17.	va:lai-va:l.ai	va:l.ai-va:l̃ai	va:lai-va:l̃ai	kurugu-kur̃ugu
18.	va:l-va:l.	va:l.-va:l̃	va:l-va:l̃	kurai-kur̃ai
19.	vila:-vil.a:	vil.a:-vil̃a:	vila:-vil̃a:	ku:rai-ku:r̃ai
20.	vilai-vil.ai	vil.ai-vil̃ai	vilai-vil̃ai	tirai-tir̃ai

Table 3: Word pairs used in the study.

Procedure: Subjects were tested individually. A discrimination task was selected. They were audio-presented the material through headphones at comfortable listening levels. They were instructed to identify the two words in a pair as ‘same’ or ‘different’ and record their response on a binary forced-choice response sheet, which was provided to them.

Analysis: The responses were tabulated and percent 'same/different' was calculated. ANOVA was used to find the significant difference between groups, gender and interaction effect between groups and gender.

CHAPTER – IV

Results and Discussion

In general, results indicated that native Tamil speakers discriminated significantly better than non-native Hindi speakers on all four sets. Table 4 shows percent different scores obtained by male and female speakers of both groups on all four sets.

	Native Speakers			Non-native Speakers		
	M	F	A	M	F	A
Set I (l – l.)	66	81	74	59	63	61
Set II (l. - l̃)	77	86	81	58	56	57
Set III (l - l̃)	80	91	85	72	78	75
Set IV (r - r̃)	79	83	81	46	38	42
Average	76	85	80	59	59	59

Table 4: Percent different scores in two groups across 4 sets of stimuli (M = Male, F = Female, A = Average).

Independent t-test did not show any significant difference between gender [t (18) =2.099, (p>0.05)] in both groups for all four sets. ANOVA showed a significant difference between groups [F (1, 36) =17.858, (p<0.05)]. Hence, independent t-test was done for all 4 sets between groups (i.e., native and non-native speakers) for males and females, separately. Results showed no significant difference between groups on Set I [t (18) =0.829, (p>0.05)] and Set III [t (18) =0.832, (p>0.05)] and a highly significant difference on Set II [t (18) =2.115, (p<0.05)] and Set IV [t (18) =4.622, (p<0.05)] for male subjects.

Similarly, for female subjects also, there was no significant difference between groups on Set I [t (18) =1.779, (p>0.05)] and Set III [t (18) =1.609, (p>0.05)]. But there was a highly significant difference on Set II [t (18) =5.025, (p<0.05)] and Set IV [t (18) =4.644, (p<0.05)]. Also, there was no significant interaction effect (gender X group) [F (1, 36) =0.534, (p>0.05)].

Examination of individual scores for both groups across four sets was done. Subjects were stratified into two groups having good discrimination (>70%) and poor discrimination (<70%).

In Set I (alveolar-retroflex lateral contrasts), 9 subjects (native) had poor discrimination and 11 subjects had good discrimination scores. Among non-native speakers, 12 subjects had poor discrimination and 8 subjects had good discrimination scores. Figure 1 shows the individual scores obtained by both groups for alveolar-retroflex lateral contrasts.

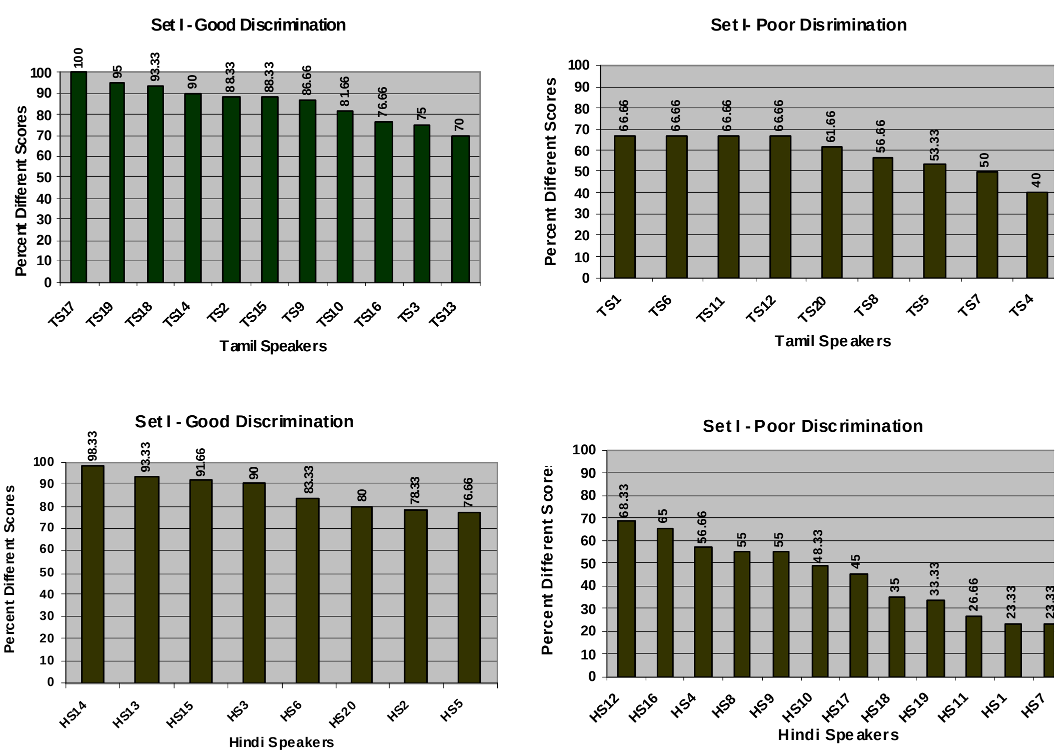

Figure 1: Individual scores obtained by both groups for alveolar - retroflex lateral contrasts.

In Set II, (retroflex-retroflexed palatal contrasts), 2 subjects (native) had poor discrimination and 18 subjects had good discrimination scores. Among non-native speakers, 15 subjects had poor discrimination and 5 subjects had good discrimination scores. Figure 2 shows the individual scores obtained by both groups for retroflex-retroflexed palatal contrasts.

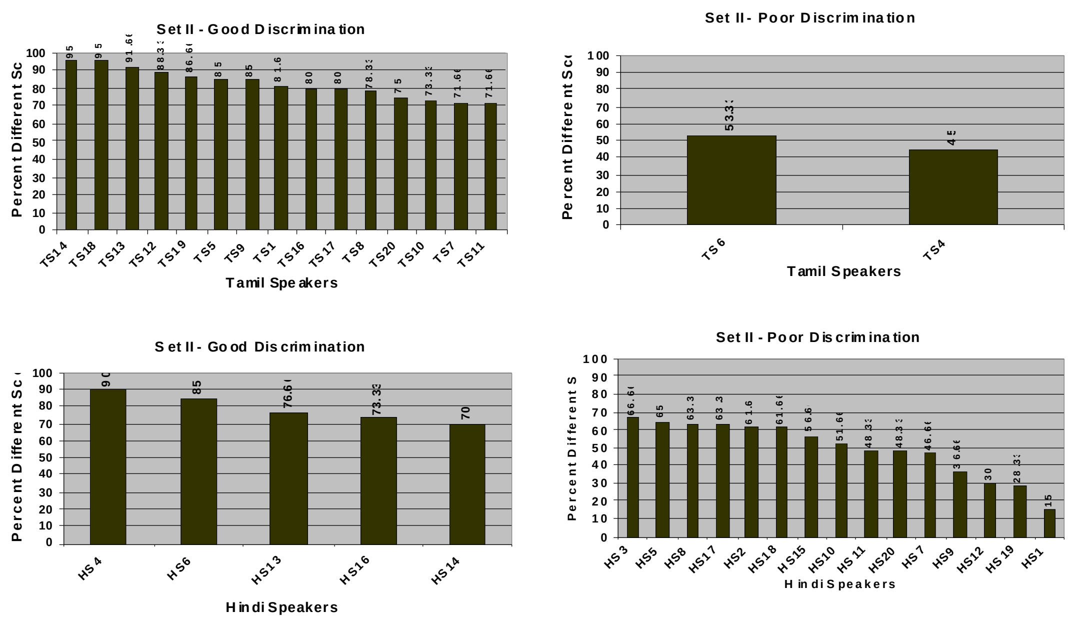

Figure 2: Individual scores obtained by both groups for retroflex - retroflexed palatal lateral contrasts.

In Set III (alveolar-retroflexed palatal lateral contrasts), 3 subjects (native) had poor discrimination and 17 subjects had good discrimination scores. Among non-native speakers, 6 subjects had poor discrimination and 14 subjects had good discrimination scores. Figure 3 shows the individual scores obtained by both groups for alveolar-retroflexed palatal lateral contrasts.

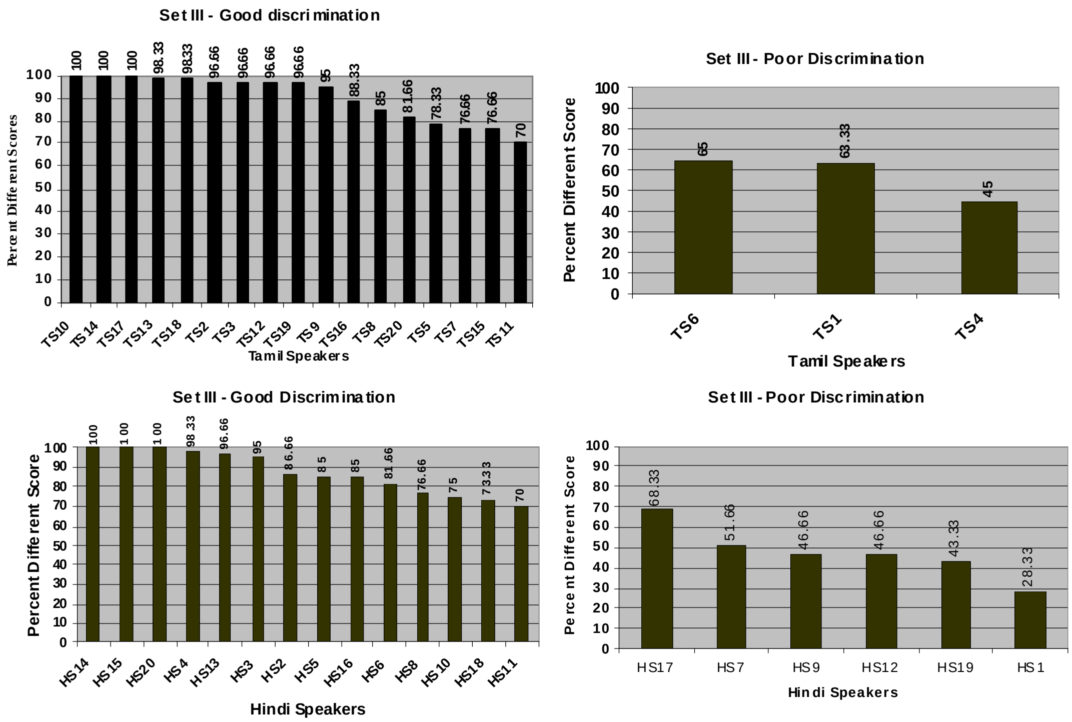

Figure 3: Individual scores obtained by both groups for alveolar - retroflexed palatal lateral contrasts.

In Set IV (alveolar flap-alveolar trill contrasts), 2 subjects (native) had poor discrimination and 18 subjects had good discrimination scores. Among non-native speakers, 17 subjects had poor discrimination and 3 subjects had good discrimination scores. Figure 4 shows the individual scores obtained by both groups for alveolar flap-alveolar trill contrasts.

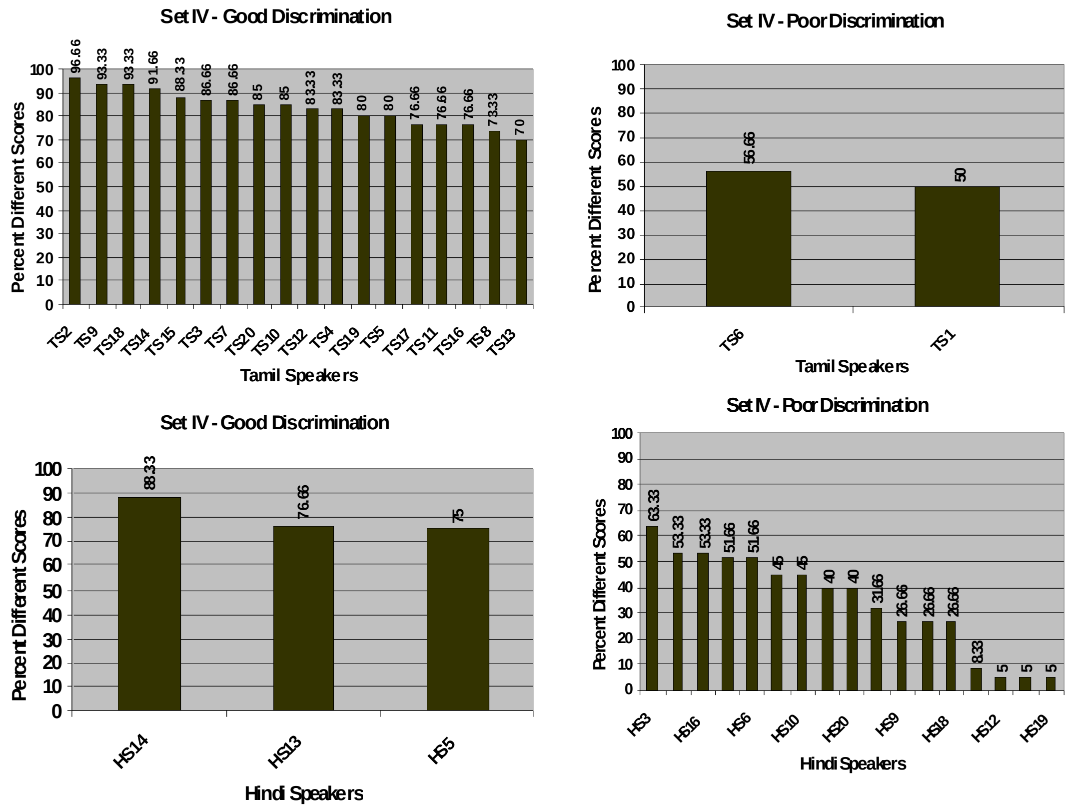

Figure 4: Individual scores obtained by both groups for alveolar flap - alveolar trill contrasts.

The results of the study indicated several points of interest. First of all the native speakers had significantly higher discrimination scores than the non-native speakers. This is in consonance with the earlier studies (Lisker & Abramson, 1970; Goto, 1971; Caramazza, Yeni - Komshian, Zurif & Carbone, 1973; Miyawaki, Strange, Verbrugge, Liberman, Jenkins & Fujimura, 1975; Strange & Jenkins, 1978; Best, MacKain, & Strange, 1981; Flege, 1984; Werker & Tees, 1984). This suggests that native Tamil speakers are fine tuned to the differences in laterals and trills as they continue to get exposed to these trills in native language.

Secondly, native Tamil Speakers scored higher on alveolar-retroflexed palatal lateral (85%) contrast followed by retroflex-retroflexed palatal lateral (81%) contrast, alveolar-retroflex lateral (74%) contrast and alveolar flap-alveolar trill (81%) contrasts. Non-native Hindi speakers scored higher on alveolar-retroflexed palatal lateral (75%) contrasts followed by alveolar-retroflex lateral (61%) contrasts, retroflex-retroflexed palatal lateral (57%) contrasts and alveolar flap-alveolar trill (42%) contrasts.

As native speakers, it is easy for Tamil speaking subjects to discriminate laterals and trills. However, in Hindi only alveolar /l/ and flap /r/ is present. Therefore, a phoneme that they can discriminate should have a very good contrast with alveolar /l/ and flap /r/. Among laterals, /l - l̃ / have F_1 at the same frequencies; but F_2 and F_3 are higher in / l̃/ compared to /l/. /l – l./ have F_1 and F_2 at same frequencies; but F3 higher in /l./ compared to /l/. /l. - l̃/ have F_1 and F_3 at same frequencies; but F_2 is higher in / l̃/ compared to /l./. Given that Hindi speakers are exposed to alveolar /l/, their discrimination score should be better in laterals contrasting alveolar /l/. i.e., /l – l./ and /l – l̃/. Among, these two pairs the contrast between /l/ and / l̃/ is high as they differ in F_2 and F_3. Hence Hindi speakers might have performed better on /l - l̃/ contrast followed by /l – l./ contrast, and poor on /l. - l̃/ contrasts as both do not occur in Hindi. Table 5 shows the formant frequencies of Tamil laterals and figures 5 and 6 show spectrograms and LPC frequency response of laterals in Tamil words.

	F1	F2	F3
/ l /	446	1330	2409
/ l. /	576	1479	3274
/ l̃/	660	2474	3200

Table 5: Formant frequencies of Tamil laterals.

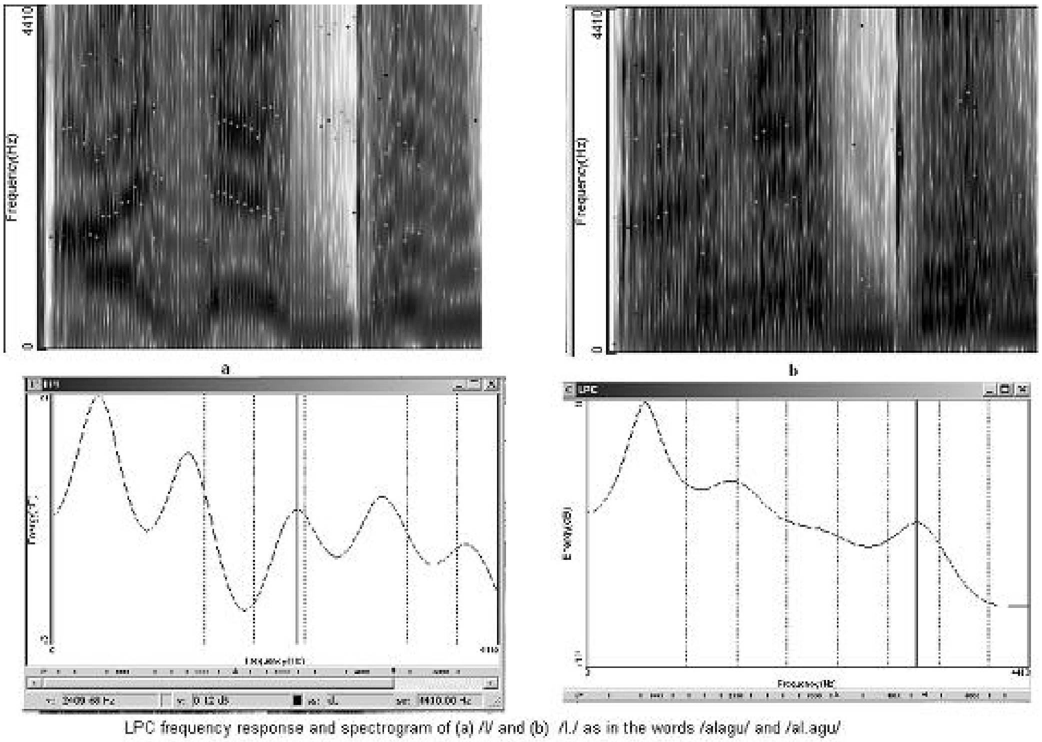

Figure 5: Spectrogram and LPC frequency response of (a) /l/ and (b) /l./ as in the words /alagu/ and /al.agu/.

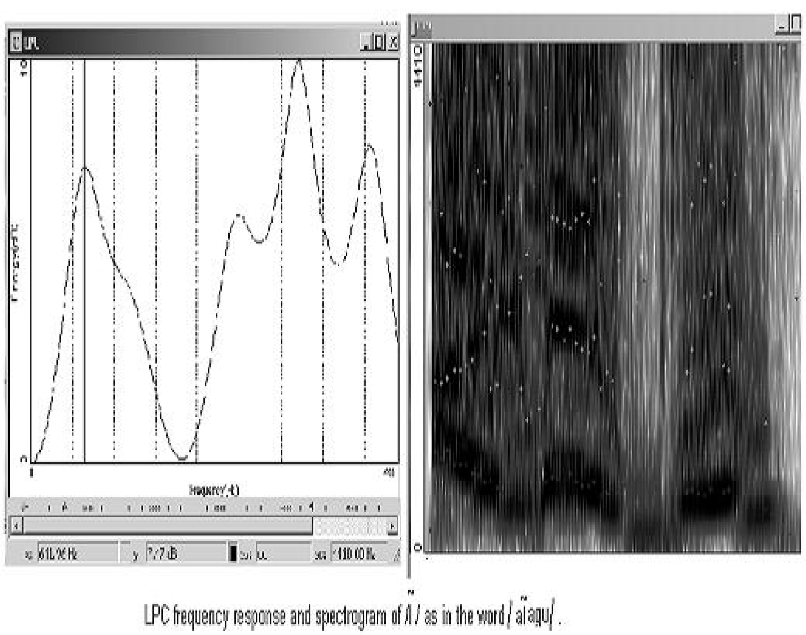

Figure 6: LPC and spectrogram of /l̃/ as in the word /ãlagu/

Flap /r/ and trill /r̃/ differ in F_2 and F_3. Alveolar trill /r̃/ had higher F_2 and F_3 compared to flap /r/. Therefore, the contrast between these two phonemes is good and non-native speakers also should have discriminated these phonemes. Poor discrimination score on this phoneme may be attributed to low F2 amplitude in flap /r/. Because of low F2 amplitude and prominent F_3 that coincides with F_2 of trill /r̃/, these two phonemes might be confused (see LPC frequency response in Figure 7). Also, a comparison of F_2 and F_3 of trills indicated that the alveolar trill (r̃) has higher F_2, F_3 and distantly spaced F_2- F_3 and those of the alveolar flap (r) has lower F_2, F_3 and distantly spaced F_2-F_3. Therefore, the acoustic difference between the alveolar flap and alveolar trill (r – r̃) is confusing which may perhaps be the reason for poor discrimination of these trills contrasts by non-native speakers. Table 6 shows the formant frequencies of Tamil trills and figure 7 shows spectrograms and LPC frequency response of trill in Tamil words.

	F1	F2	F3
/ r /	483	1125	2158
/ r̃ /	362	1944	3060

Table 6: Formant frequencies of Tamil trills.

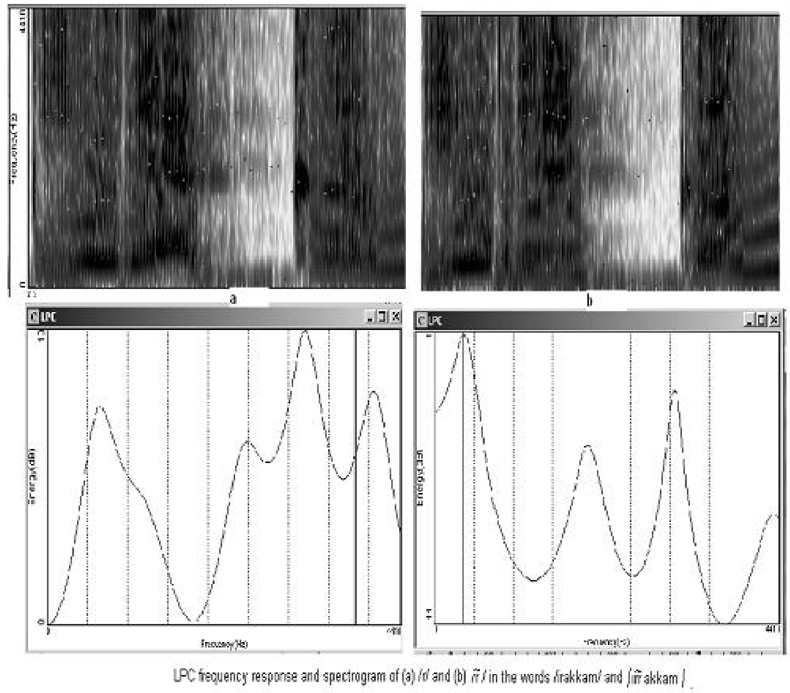

Figure 7: Spectrogram and LPC frequency response of (a) /r/ and (b) /r̃ /
as in the words /irakkam/ and /ir̃ akkam/.

The results support the earlier findings of poor discrimination of phonemes by non-native speakers. This implies that perceptual abilities undergoes refinement with language experience and can limit listeners' sensitivity to some non-native phonemic distinctions. Also the results support in validating the non-native contrasts in terms of its phonological status. The alveolar – retroflex lateral contrast would be an assimilable contrast, since it can be assimilated to an intermediate phone in the native language, whereas the alveolar – retroflexed palatal lateral contrast would be of category goodness type as it can be assimilated to an intermediate phoneme in the native language, as in assimilable, but one which will stand out as clearly a better instance of that category than the others. Thus the results support the studies of Best, MacRoberts & Sithole (1988). The results indicated that speakers of Hindi language have difficulty in perceiving differences in phonemes that are not present in their language and suggest that they are unable to perceive such phonemes as adults, but would require intensive training to perceive and produce them better.

Future research is warranted in perception of non-native contrast (laterals and trills) by speakers of other Indo-Aryan languages which may reflect the cross-language differences in perception. Also, studies can be done in developmental perception from infancy through childhood, so that one can infer the point of time at which the child shifts to perception of native phonemes. This will support the universal theory and the connectionist model, i.e., whether an infant can perceive all phonemes but looses such ability and is restricted to the perception of phonemes of language he is exposed to as he grows.

CHAPTER – V

Summary and Conclusions

Cross-language perception represents a dynamic research area in which the idea have grown and changed over the years. It has gained importance as they reveal subtle linguistic differences between the languages. The present study was designed to investigate the cross-language differences in the perception of Tamil laterals and trills by native (Tamil) and non-native (Hindi) speakers. In the present study Tamil laterals and trills were studied as Tamil language has three laterals (alveolar /l/, retroflex /l./ and retroflexed palatal / l˜/) and two trills (flap /r/ and a trill /r˜/). Hindi has only one lateral /l/ and one flap /r/.

The material consisted of 80 Tamil meaningful mono/bi/tri syllabic words (minimal pairs) with laterals and trills. These words were spoken by a native Tamil female speaker aged 22 years which were audio-recorded. The word were paired with the same words (same) and words (different) that differed in laterals/trills. The word pairs were contrasting in word-medial and word-final positions. Four sets of word pairs with 20 word pairs each were prepared. In set I, each word pair had minimal pairs contrasting alveolar /l/ and retroflex /l./, in set II the contrast was between retroflex /l./ and retroflexed palatal / l̃/, set III had contrast between alveolar /l/ and retroflexed palatal / l̃/, and set IV had minimal pairs contrasting alveolar flap /r/ and alveolar trill /r̃/.

These word pairs were used to test the discrimination ability. In addition, each word was paired with itself forming 40 word pairs in each set. These word pairs were used as catch trials. The word pairs were randomized in their corresponding sets and iterated thrice. The inter-stimulus interval used was 3 sec. Thus a total of 720 word pairs formed the material with each set consisting of 180 word pairs.

Two groups of subjects participated in the experiment. Group I consisted of 20 native Tamil speakers and group II consisted of 20 native Hindi speakers in the age range of 18-25 years. There were 10 males and 10 females in each group. All subjects had normal speech and hearing and had no neurological, organic, or psychological problems as reported. Subjects were tested individually. They were audio-presented the stimulus through headphones and were instructed to record whether the two words in a pair were the ‘same’ or ‘different’ on a force choice response sheet provided to them. Percent ‘same’ and ‘different’ responses were calculated and group as well as gender related differences were analyzed.

In general, results indicated that native Tamil speakers discriminated significantly better than non-native Hindi speakers on all four sets. Table 7 shows the average scores obtained by native and non-native speakers.

	Native Speakers	Non-native Speakers
Set I (l – l.)	74	61
Set II (l. - l̃)	81	57
Set III (l - l̃)	85	75
Set IV (r - r̃)	81	42
Average	80	59

Table 7: Average scores in two groups across 4 sets of stimuli.

Independent t-test did not show any significant difference between gender [t (18) =2.099, (p>0.05)] in both groups for all four sets. ANOVA showed a significant difference between groups [F (1, 36) =17.858, (p<0.05)]. Hence, independent t-test was done for all 4 sets between groups (i.e., native and non-native speakers) for males and females, separately.

Results showed no significant difference between groups on Set I [t (18) =0.829, ($p>0.05$)] and Set III [t (18) =0.832, ($p>0.05$)] and a highly significant difference on Set II [t (18) =2.115, ($p<0.05$)] and Set IV [t (18) =4.622, ($p<0.05$)] for male subjects.

Similarly, for female subjects also, there was no significant difference between groups on Set I [t (18) =1.779, ($p>0.05$)] and Set III [t (18) =1.609, ($p>0.05$)]. But there was a highly significant difference on Set II [t (18) =5.025, ($p<0.05$)] and Set IV [t (18) =4.644, ($p<0.05$)]. Also, there was no significant interaction effect (gender X group) [F (1, 36) =0.534, ($p>0.05$)].

Examination of individual scores for both groups across four sets was done. Subjects were stratified into two groups having good discrimination (>70%) and poor discrimination (<70%). In Set I (alveolar-retroflex lateral contrasts), 9 subjects (native) had poor discrimination and 11 subjects had good discrimination scores. Among non-native speakers, 12 subjects had poor discrimination and 8 subjects had good discrimination scores. In Set II, (retroflex-retroflexed palatal contrasts), 2 subjects (native) had poor discrimination and 18 subjects had good discrimination scores. Among non-native speakers, 15 subjects had poor discrimination and 5 subjects had good discrimination scores. In Set III (alveolar-retroflexed palatal lateral contrasts), 3 subjects (native) had poor discrimination and 17 subjects had good discrimination scores. Among non-native speakers, 6 subjects had poor discrimination and 14 subjects had good discrimination scores. In Set IV (alveolar flap-alveolar trill contrasts), 2 subjects (native) had poor discrimination and 18 subjects had good discrimination scores. Among non-native speakers, 17 subjects had poor discrimination and 3 subjects had good discrimination scores. Among the non-native speakers refinement in the perceptual ability was observed across the sets, suggesting that modification of the perceptual ability as a function of experience with the particular language. Hindi speakers had higher scores on perception of alveolar-retroflex and alveolar-retroflexed palatal pairs compared to retroflex-retroflexed palatal and alveolar flap-alveolar trill contrasts. Hindi speakers perception of retroflex and retroflexed palatal lateral was alveolar trill was poorer compared to Tamil speakers. This was expected as Hindi does not have retroflex lateral (l.) and retroflexed palatal lateral (l̃) and alveolar trill (r̃) in their phonemic inventory.

The results of the study indicated several points of interest. First of all the native speakers had significantly higher discrimination scores than the non-native speakers. This is in consonance with the earlier studies (Lisker & Abramson, 1970; Goto, 1971; Caramazza, Yeni - Komshian, Zurif & Carbone, 1973; Miyawaki, Strange, Verbrugge, Liberman, Jenkins & Fujimura, 1975; Strange & Jenkins, 1978; Best, MacKain, & Strange, 1981; Flege, 1984; Werker & Tees, 1984). This suggests that native Tamil speakers are fine tuned to the differences in laterals and trills as they continue to get exposed to these trills in native language.

Secondly, native Tamil Speakers scored higher on alveolar-retroflexed palatal lateral (85%) contrast followed by retroflex-retroflexed palatal lateral (81%) contrast, alveolar-retroflex lateral (74%) contrast and alveolar flap-alveolar trill (81%) contrasts. Non-native Hindi speakers scored higher on alveolar-retroflexed palatal lateral (75%) contrasts followed by alveolar-retroflex lateral (61%) contrasts, retroflex-retroflexed palatal lateral (57%) contrasts and alveolar flap-alveolar trill (42%) contrasts.

As native speakers, it is easy for Tamil speaking subjects to discriminate laterals and trills. However, in Hindi only alveolar /l/ and flap /r/ is present. Therefore, a phoneme that they can discriminate should have a very good contrast with alveolar /l/ and flap /r/. Among laterals, /l - l̃ / have F_1 at the same frequencies; but F_2 and F_3 are higher in / l̃/ compared to /l/. /l – l./ have F_1 and F_2 at same frequencies; but F3 higher in /l./ compared to /l/. /l. - l̃/ have F_1 and F_3 at same frequencies; but F_2 is higher in / l̃/ compared to /l./. Given that Hindi speakers are exposed to alveolar /l/, their discrimination score should be better in laterals contrasting alveolar /l/. i.e., /l – l./ and /l – l̃/. Among, these two pairs the contrast between /l/ and / l̃/ is high as they differ in F_2 and F_3. Hence Hindi speakers might have performed better on /l - l̃/ contrast followed by /l – l./ contrast, and poor on /l. - l̃/ contrasts as both do not occur in Hindi. Flap /r/ and trill /r˜/ differ in F_2 and F_3. Alveolar trill /r˜/ had higher F_2 and F_3 compared to flap /r/. Therefore, the contrast between these two phonemes is good and non-native speakers also should have discriminated these phonemes. Poor discrimination score on this phoneme may be attributed to low F2 amplitude in flap /r/. Because of low F2 amplitude and prominent F_3 that coincides with F_2 of trill /r˜/, these two phonemes might be confused (see LPC frequency response in Figure 7). Also, a comparison of F_2 and F_3 of trills indicated that the alveolar trill (r̃) has higher F_2, F_3 and distantly spaced F_2- F_3 and those of the alveolar flap (r) has lower F_2, F_3 and distantly spaced F_2-F_3. Therefore, the acoustic difference between the alveolar flap and alveolar trill (r – r̃) is confusing which may perhaps be the reason for poor discrimination of these trills contrasts by non-native speakers. Table 8 shows the formant frequencies of Tamil laterals and trills.

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