"CROSS-LANGUAGE DIFFERENCES IN VOVEL PERCEPTION"

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CERTIFICATE

This is to certify that the dissertation entitled "CROSS-LANGUAGE DIFFERENCES IN VOWEL PERCEPTION" is the bonafide work done in part fulfilment for the final degree of Master of Science (Speech and Hearing) of the candidate with Reg. No. M-9406.

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DECLARATION

I hereby declare that this dissertation entitled "CR0SS-LANGUAGE DIFFERNCES IN VOWEL PERCEPTION" is the result of my own study under the guidance of Dr. SAVITHRI, 5.R., Lecturer, 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.

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CHAPTER I

INTRODUCTION

In recent times, cross language perception have gained impetus for theoretically based research in the field of speech perception. Studies on cross-language perception unfold the difference in perception of non-native language (L_2) difference in a particular language speaking subjects and helps one to list the factors that are responsible for such differences and hence the theoretical assumption that what different cues or contrasts are used in the different languages that make them unique, and what happens to these cues or contrasts in case of bilinguals who use both the languages. Do they develop these contrast of non-native languages or can they manage with already existing contrasts of native language or they modify their phonetic and phonological contrasting abilities ? These guestions are answered with such research.

Languages differ in their phonological and phonetic inventories. For example, in a particular language L_1 two phones may occur, while in another language (L_2), the phones may not occur at all or , L_1 and L_2 may share two phones, but in L_1 the phones may be phonologically contrastive, while in L_2, they may occur in contextual or free variation rather than being used to distinguish meaning. Because of this variation across languages, several guestions have been asked about the potential role of linguistic experience in the perception of phonological categories. Are speakers universally sensitive to the parameters that distinguish phonological contrasts in ail languages, or does experience with the phonological categories of one's native language affect the perception of those contrasts ? For native speakers of languages who do not make use of particular speech sounds in a phonological contrast, is the perception of those sounds affected ? If so, can perception of a phonetic contrast be modified in adulthood through hearing a language that does employ the contrast ?

A number of studies have tried to answer these questions in the context of vowel perception. Scholes (1967) concluded that identification of vowels depends on the nature of vowel categories. Stevens et al. (1969) asked the American and Swedish to identify the tokens of two synthetic vowel continua and concluded that difference in vowel identification is significantly related to vowel inventory of native language. Terbeek (1977) found that language experience in monolinguals of five different languages does affect the vowel perception.

These studies (and others) have provided insight into cross language differences in vowel perception, revealing likely differences in perception that depends on the nature of listener's L_1 vowel inventory. Flege et al (1994) in their study opined that vowel dissimilarity changes little overall as adult Spanish listeners gain experience with English vowels, hence perception of vowel discrimination is not affected with experience in English i.e. the non-native second language.

India, being a multi-lingual country offers great potentials to answer the guestions on cross language research. In this context, the present study was planned. The purpose of this study was to investigate the perception of vowels of Hindi and Bengali as in Hindi-Hindi, Bengali-Bengali and Bengali-Hindi word pairs by monolingual Hindi and Bengali speakers and bilingual Bengali speakers who have learnt Hindi as second language.

Hindi has a larger number of contrasting vowel categories than Bengali. Therefore, it should be assumed that Hindi uses more phonetic features than Bengali to distinguish vowels (for example duration). Based on the above assumption, one might expect that the monolingual Hindi and Bengali speakers, perceive vowels differently. Specifically, one might expect native Hindi listeners to use more dimensions than native Bengali listeners and most important, one may also speculate that a Bengali listener who has learnt Hindi as a second language may perceive vowels more closely to Hindi listeners than his Bengali monolingual counter part.

REVIEW OF LITERATURE

Cross language speech perception is a relatively less researched area. This area, over the years, has provided solid outlet for theory based research. For long cross language differences in perception of non-native contrasts, consonants, vowels and suprasegmental aspects are studied and theoretical explanations are provided for the existing differences. The results of the cross language studies have indicated that adults have difficulty in discriminating non-native distinctions (Miyawaki et al., 1975; Strange et al., 1981).

Cross-language studies on consonant perception

Werker et al. (1981) compared English speaking adults and Hindi speaking adults on their ability to discriminate the English and Hindi voiced bilabial versus alveolar contrast /ba/ - /da/ plus two non-English, Hindi contrasts. The Hindi place of articulation distinction between retroflex and dental voiceless stop consonant /Ta/-/ta/ was selected as a potentially difficult non-English contrast and the Hindi voicing distinction between breathy voiced and voiceless unaspirated dental stops /d a/-/t a/. The retroflex/dental contrast was acoustically less salient than those in voicing contrasts. Stimuli were produced by Hindi speaker; Ax paradigm was used. Results indicated that while both English and Hindi listeners can detect English-Hindi /ba//da/ contrast, the Hindi listeners scored 100% on both native contrast and the English listeners scored 40% on potentially easy contrast and 10% on potentially difficult contrasts.

Two things could be concluded from this study, first there is an effect of experience on speech perception in that Hindi adult listeners did significantly better than English listeners at discriminating both non-English, Hindi speech contrasts. A1so, experiential effects are more pronounced on some contrasts than others.

Werker and Tees (l984) compared Nthiakampx speaking adults and English adults on their ability to discriminate the glotalized velar/uvular contrast that occurs in Nthlakampx. Nthlakampx could discriminate where as English speaking adults showed difficulty (only about 30% could discriminate).

Miyawaki et al. (1975) assessed perception of synthetic /r/ - /1/ continua by native Japanese, native bilingual Japanese speakers with English as their second learned language in adulthood and native American English speakers. The continuum varied on F_3 formant considered as primary cue for contrast in English. The results showed that where as English listeners were successful in categorical perception, the Japanese listeners both monolinguals and bilinguals were unable to do so and discrimination was nearly random. Mochizuki (l980) reported on the contrary. Strange et al. (1981) replicated the results of Miyawaki (1975) in their study using synthetic stimuli and identification, AXB and oddity discrimination tasks were used.

Explanations offered in these cross language differences

At first explanation to adults poor performance on non-native tasks was attributed to loss of perceptual discriminability due to lack of experience (Eimas, 1975; Strange and Jenkins, 1978). This ability is universal in infants (Aslin, 1981; Syrdal et al., 1975). But later developmental studies were performed by tVerker and Tees (1983), Werker and Tees (1984), Best and McRobert (1989) who attribute the difficulty faced by adults in non-native contrast to specific listening experience.

(With due lapse in time the explanations changed and these were directed importance of experiential effects and the notion that experiential effects are same for all non-native contrasts. However, research made it clear that the effect of experience does not equally affect ail non-native contrasts as adults can discriminate many non-native contrasts with little difficulty (Moore et al., 1979). Similarly the results that Hindi voicing contrast is easier than the place of articulation contrast, strengthened the possibility that experiential effects might not be permanent.

One of the early study by Strange (1972) has showed that discrimination training was shown to have limited effectiveness on English adults ability to discriminate non-English VOT. Whereas other studies by Pisoni et al. (1982) reported the English adults ability to discriminate lead boundary in VOT by using labelling procedures. Strange et al. (1981) found that only extensive, naturalistic second language learning experience was effective in improving Japanese adults' ability to discriminate the English /ra/-/la/ distinction.

Repp (l984) opined that adults may use both auditory and phonemic processing in their attempts to discriminate sounds. To examine whether adults would show a similar sensitivity to non-native perception even without training, Werker and Tees (1984) tested English adults on the Hindi retroflex/dental and the Nthiakampx-giottalized velar/uvular contrast in a more sensitive procedure. As they were interested in sensitivity they tested adult English speakers on same/different (AX) discrimination task. Using 4X procedure they found that adult subjects can discriminate both contrasts at 2500 msec but not at 1500 msec 151. In the subsequent study, using just the Windi retroflex/dental stimuli they tested subjects for five blocks of trial in one of three ISI conditions, 1500, 500 and 250 msec (Werker and Logan, 1985). Again results revealed sensitivity to the non-native phonetic contrasts in the shorter ISI conditions. Infact, there was even evidence that the subjects can discriminate non-phonetic acoustic cues within either the retroflex or dental category at 500 msec ISI (Werker and Logan, 1985). They proposed that subjects can use one of the three different processing strategies - phonetic, phonemic and acoustic depending upon the interstimulus interval. Findings indicate that the adult listeners can discriminate between tokens on the basis of phonetic and acoustic information if the task requires it but that the most readily available strategy is to perceive speech stimuli in terms of non-native phonemic categories.

Theoretically based explanations specifying which non-native contrasts would be easy or difficult to discriminate have been proposed (Best, Mc.Roberts and Sithole, 1988; Burham, 1986).

Burham (l986) 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 quite similar and it is due to the loss of these clues that difficulties arise in perception of non-native contrasts in adults. Robust refers to contrasts that are widely distributed across the worlds languages and are acoustically less similar. He viewed acoustic sentence as most important dimension of fragile contrasts. Best et al. (l988) have taken the strong stand that phonological status alone should predict whether a contrast is discriminable or not, to a nonnative listener. They propose that there are basically atleast four kinds of non-native contrasts in terms of phonological status, viz., (l) assimilable, (2) non-assimilable, (3) category goodness and (4) two category.

Assimilable contrasts are those in which each member of the contrast can be assimilated to an intermediate phone in the native language. These should be most difficult to discriminate.

Non-assimilable contrast include phones that do not even sound at all like any possible phone from native language. These constrasts are predicted to be most easily discriminable.

Category goodness refers to a non-native contrast whose members 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 other.

Two category refers to a non-native contrast that consists of two non-native phones each of which is assimilable to a constrasting phonemic category in the native language. According to ease of discrimination the four kind of contrasts can be arranged.

Two category>Monassimilable>Category goodness>Assimiiable

In a recent work Polka (1991, 1991) has highlighted at least three independent factors that need to be considered when making predictions concerning the discriminability of nonnative contrasts among adults. These are functional phonetic status (phonemic constrasts), substantiative phonetic status (phonetic variation) and acoustic differences (absolute amount of measurable acoustic differences).

Another area of research that is theoretically motivated is speech perception and production in second language learners. Flege et al. (l987) opines that adult second language learners will avoid even attempting unfamiliar sounding phones in early stages of second language acquisition, but they gradually become better in producing them.

Cross language studies in vowel perception

Languages differ not only according to number of vowels used to contrast meaning (phonemic aspect) but also in terms of phonetic properties that are used to distinguish the vowels they possess. Such differences should have implications in terms of how listeners perceive vowels, especially in the case of identifying phonetic qualities that are not represented in a listener's native language.

A number of studies have examined the perception of vowels by speakers of different languages. Among these studies one of the earliest land mark study was done by Stevens et al. (1969). They asked American and Swedish listeners to identify the tokens of two synthetic vowel continua. One composed of unrounded vowels ranging from unrounded /i/ to rounded /u/. As could be expected, Swedish listeners identified fewer vowels as /i/ than did English listeners (who do not have phonemically distinct /u/) demonstrating that differences in the identification of vowels can be significantly related to vowel inventory of L_1 .

Scholes (1967, 1968) required listeners from many different language groups to identify, using key words, the tokens from a matrix of synthetic vowels formed by F_1 and F_2 values. He found different pattern of identification depending upon the language background of the listener, Again results indicated that the identification of vowel depends at least in part, on the number and nature of the vowei categories in the listener's native language.

Fischer-Jorgenson (l973) compared differences in perception of German and Danish vowels. Subjects, both German and Danish were presented word tokens containing different vowels of both languages. Task given was to identify the vowel and transcribe it. The vowels used were North German vowels (both tense and lax) and Danish vowels (only lax vowels). The results indicated that German listeners had no difficulty in identifying vowels of both languages. Danish listeners made no categorical perception between tense and lax. The authors concluded that duration in addition to spectral characters is important cue for vowel identification being perceived. This report also deals with language bias of subject set to identify time distorted vowels. Although German subjects are told to transcribe vowels with symbols associated with long vowels they respond to short samples of 80 ms length cut out from long vowels as if they were phonologically short. Danish subjects did not show such degree of categorical influence in their response.

Terbeek (1977) suggested that listening vowels in a psychophysical mode might reduce or eliminate such cross language differences. He obtained dissimilarity judgement of 12 monophthongs from speakers of English, German, Thai, Turkish and Swedish (languages that have significantly different vowel inventories). Using multidimensional analysis, he found significant perception differences as function of language group - differences that depended on both vowel inventory and patterns of phonological oppositions.

Terbeek (1977) suggested that access to "psycho-physical" mode of perception might reduce or eliminate the cross language differences in vowel perception, and that auditory representations may provide a "universal" framework of vowel perceptions. However, a great deal of research has shown that adults are language specific perceivers of speech. For example, speakers of different native languages are apt to label vowels in conformity to the numbers and nature of phonemic categories in L_1 (Stevens et al., 1969; Scholes, 1967, 1968; Butcher. 1976; Terbeek, 1977; Terbeek and Harhman, 1972). Previous linguistic experience may also alter listeners weighting of acoustic dimensions relevant to perceived votvei quality, such as duration (Bennett, 1968; Gottfried, 1988; Munro, 1992). Given this, it can be assumed that previous linguistic experience would influence cross language judgement of vowel dissimilarity independently of auditory factors. Miller (1981) opined that durational differences in vowels of English are there and these provide additional cues for providing vowel quality.

Kuhl et. al. C1992) have shown in the vicinity of an L_1 vowel category "prototype" are discriminated readily than are pairs of vowels of equivalent auditory difference that are not located near an L_1 vowel prototype. This "perceptual magnet" effect was an important possible implication for L_2 acquisition. It may mean that an L_2 vowel which is phonetically similar but not identical to an L_1 vowel will be judged more similar phonetically to L_1 vowel, than it would be judged otherwise based solely on its auditory difference from the L_1 vowel. Best et al. (1988) have shown that the discriminability of consonants in an L_2 or foreign language is influenced by how it is categorised, i.e. a pair of unfamiliar L_2 consonants that are assimilated by two distinct L_1 consonant categories will be discriminated better than will a pair of readily discriminable L_2 consonants differ phonetically from the L_1 categories which have assimilated then.

It can be assumed that discriminability of vowels will be related to their perceived phonetic dissimilarity.

Thus categorical status of a pair of vowels will also influence their perceived dissimilarity. A11 else being equal, a pair of vowels that has been identified in terms of two categories may be judged to be more dissimilar than will a pair of vowels identified in terms of single category. Support to this "differential classification" hypothesis was provided by Kewley Port and Atal (l989), who examined synthetic vowels which occupied a small portion of the acoustic vowel space by multi-dimensional scaling (MDS) techniques. These subjects were native monolingual English speakers.

The differential classification hypothesis raises an important guestion related to L_2 acquisition by adults. Does the perceived phonetic dissimilarity of the pairs of vowels in L_2 (and/or L_1) remain constant over the course of L_2 acquisition does it change as a function of experience in the L_2 ? It is certain that L_2 vowels which differ sufficiently from any L vowel are treated falling outside the L_1 inventory (DeLattre, 1964, 1969). Such vowels, if they exist, might evade the perceptual magnet effect described by Kuhl. Flege hypothesized that phonetic category formation for L_2 sounds becomes less likely with increasing age, but that even adult learners may establish categories for L_2 sounds that differ sufficiently from the nearest L_1

sound (Flege, 1987). The results of several studies suggested that vowels which are acoustically distinct from nearest L_1 vowel may ultimately be produced more accurately, but not identical to an L_1 vowel (Major, 1987; Flege, 1991, 1992). Differences in vowel learnabiiity, in turn, might reflect differences in the likelyhood of category formation for vowels encountered in an L_2 .

Cross language vowel perception research (Butcher, 1976; Terbeek, 1977) has suggested that vowels in a "crowded perceptual space" tend to be judged as more dissimilar than vowels in a relatively uncrowded space. Thus if bilinguals establish additional phonetic categories for vowels in an L_2 , and if their psychological vowel space becomes more crowded as a result, the addition of vowel categories should augment perceived vowel dissimilarity, i.e. if a Spanish listener of English were to establish a phonetic category for the English vowel /I/ it might augment the perceived vowel in the high portion of the vowel space. The result of several recent vowel studies suggest that at least some adult Spanish L_2 learners treat English /I/ as distinct from /i/ guaiity vowels fFlege, 1991).

Best et al. (1988) suggested that foreign consonants either map onto an L_1 category or, if very dissimilar, might be treated as a nonspeech sound (i.e. not as 'new' consonant). if this implies to vowels, then it may be possible that categorical status of L_2 voxels will not change.

Flege et al.(l994) in their study tried to determine if perceived dissimilarity of English and Spanish vowels changes as native speakers of Spanish gain experience in English and test the role of auditory difference, categorical status and typicality on vowel dissimilarity rating. The term typicality used here refers to the extent to which phones match listener's phonetic representations in long term memory. Stimulus used was ail the vowels of English and Spanish in minimal pairs and some nonwords 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 these word of each vowel category was paired with that of the words of every other vowel. Three types of pairs were made, i.e. English-English, Spanish-Spanish and Spanish-English. There were nine exemplars of each token and in all 405 tokens were there, 60 subjects were taken for the study and were divided into four groups English (30 subjects) into EnA and EnB randomly and Spanish (30 subjects) into SA and SB on the basis of language experience. SA were non proficient bilinguals and SB were proficient bilinguals with English as second language. The subjects had to rate the in a token on a nine point scaie with (l) as "very similar" and (9) as "very dissimilar". This task was followed by oddity discrimination test. A long ISI of 1.2 sec was used between each word in a pair to encourage use of phonetic cues which are stored in long term memory. Ratings were subjected to correlational analysis. Results showed little effect of L_2 experience on perceived dissimilarity of pairs of English and/or Spanish words.

Typicality hypothesis was proved when English speakers rated English-English pairs as more dissimilar than Spanish speakers and Spanish speakers rated Spanish-Spanish pairs as more dissimilar than English speakers.

Categorical status and auditory difference also played an important part in perceived dissimilarity. Flege et al. (l995) tried to compare vowel perception in monolingual English speaker to bilingual Spanish-English speakers and secondly to study the effect of L_2 experience on dissimilar ratings. They used MDS analysis, with stimuli and other procedures similar to previous study. They came to conclusions that the optimal MDS solution obtained for the native English listeners involved three dimensions (duration, front back and central non-central). Spanish listeners involved two dimensions high-low distinction and others could not be interpreted. Hence the results support the claim that the structure of a listener's vowel space is significantly affected by the vowel inventory of listener's L_1 . The optimal solutions for both Spanish groups proficient and nonproficient bilinguals involved two dimensions and hence learning English apparently did not increase the dimensionality of the Spanish listener's psychological vowel space.

The review reveals that the results depend on several factors like the environment, stimuli, inter-stimulus interval, perceptual paradigm and contextual cues.

1. Environment of testing

There is some recent research showing that nonnative listeners show more difficulty perceiving even relatively easy phones than do native listeners under certain testing conditions. Takata and Nebelek (l990) compared native English speakers to native Japanese speakers on their performance in the modified Rhyme test. Results indicated that though the two groups performed similarly under quiet testing conditions, the native Japanese speakers performed significantly more poorly than the native English speakers in conditions of noise and/or reverberation. Not surprisingly, one of the more common error for native Japanese listeners was r/1 confusion.

2. Stimuli used

Stimuli used in the perceptual studies of vowels has been of two types;

1. natural/synthetic
2. isolated vowels/vowel containing syllables, i.e. as the CV or CVC

Therefore overall stimuli becomes of four types:

1. Natural isolated vowels (Fischer-Jorgenson, 1973)
2. Synthetic isolated vowels (Vinegard, 1970)
3. Natural vowel containing syllable (Flege et al., 1995)
4. Synthetic vowel containing syllables (Port and Atal, 1989)

A11 the four kinds of stimuli are used and it is still a matter of controversy. Whereas argument in favour 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 fVerbrugge and Rakerd, 1985). Advantage of using isolated vowels is that vowel is in it's pure form and doesn't 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 and Tees, 1984). tVerker and Logan (l985) studied using Hindi and retroflex/ dental stimuli in English speakers. They tested subjects for five block of trials on 3 ISI conditions, 1.5 sec, 0.5 sec and 0.25 sec. Results indicated that sensitivity to nonnative phonetic contrast in shorter ISI conditions as subjects could discriminate nonnative phonetic cues within retroflex or dental category at 500 m sec ISI, whereas in ISI above 1500 m sec, subjects used phonemic cues. Flege et al.(1994) suggest use of 1 s to 1.2 s 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., 1994a,b; Werker and Tees, 1984; Fischer-Jorgenson, 1973).

1. Identification tasks
2. AX or similar/different or discrimination tasks

3. AXB method
4. ABX task
5. Oddity task
6. Rating procedures
7. 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 simplest task. 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 most appropriate to test sensitivity to the contrasts.

AXB task has A, X and B, i.e. three sounds are presented successively to the subjects. A and B are standard stimuli, and X is the target stimulus. The subjects are reguired 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 reguired to confirm X to either A category or B category, Used in categorical perception.

In the oddity discrimination, the subject has to identify the odd item out of the three stimulus presented successively (triad) and encircle it. In case of ambiguity he 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 scales, eg. Flege et al. (1994) used a nine point scale with (l) as 'very similar' and (9) as 'very dissimilar'. This dissimilarity is rated on predetermined dimensions. Correlational analysis may be done which are helpful in obtaining weightage given to different dimensions and know which contrast is more readily discriminated. This procedure places high memory demands.

Multi-dimensional Scaling Analysis: The ratings are obtained and thus examined using MDS analysis. This technigue is used to account for the perceived difference between pairs of stimuli by locating the stimuli with in an 'n' dimensional perceptual space. The listeners mean ratings are entered into symmetrical matrices and then analysed using ALSCAL, a program which assumes that dissimilarity judgement for any pair of stimuli reflects underlying perceptual distance between them (Takane et al., 1976). MDS are more sensitive to acoustic differences.

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

5. Contextual clues

Contextuai clues can be of three types and "as said to increase the identification of vowels (Rakerd, 1984). The contexts can be phonetic, phonological and acoustic (Werker and Logan, 1985). There are also some clues known as linguistic sentence context clues. Studies by House and Fairbanks (1953); Lindblom (l963); Stevens (1963) show that vowel perception varies upon depending on the identity of the consonant that precede or follow it. Rakerd (l984) 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 than isolated vowels, i.e. judgements are more stable and secondly three 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 listener 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 that is discrimination becomes more categorical. They also concluded that subject's vowel boundary is not fixed but varies within a certain range. The contextual clues can completely over ride the instantaneous boundary.

The review indicates the importance of cross-language research in the perception of native and nonnative contrasts. India, being a multi-lingual country offers potential for research on cross-language perception. In this context the present study was planned. The aim of the study was to investigate the perception of vowels of Hindi and Bengali as in Hindi-Hindi, Bengali-Bengali and Bengali-Hindi word pairs by monolingual. Hindi and Bengali speakers and bilingual Bengali speakers who have learnt Hindi as second language.

CHAPTER III

METHODOLOGY

I. Subjects

Ninety subjects were taken for the present study. These subjects constituted three groups, i.e. Hindi, Monolinguals, Bengali Monolinguals and Bilinguals with Hindi as their second, iearned language and Bengali as native language.

Group I: It consisted of 30 native Hindi monolingual speakers (l7 females and 13 males) in the age range of 23 to 36 years (mean age = 30 years).

Group II: It consisted of 30 native Bengali monolingual speakers (20 females and 10 males) in the age range of 21 to 39 years (mean age = 33 years).

Group III: It consisted of 30 Bengali bilingual speakers (15 females and 15 males) with Bengali as first language and Hindi as the second learned language. Their age ranged from 25-43 years (mean age 34 years). Their proficiency in spoken Hindi was good (they could communicate in spoken Hindi without any hinderance with normal sentence complexity) All the subjects had reportedly normal hearing and were literatei with a minimum gualification of 10+2 standard.

II. material: The stimuli consisted of 191 tokens consisting of two words (CVC syllables) forming a pair. There were three types of tokens; Bengali-Bengali syllable pair tokens (21 in number), Hindi-Hindi syllable pair tokens (45 in number) and Bengali-Hindi syllable pair tokens (l25 in number).

There were seven Bengali words and ten Hindi words, which were taken to make the tokens. All the words were of CVC kind and had seven Bengali vowels and ten Hindi vowels embedded in them.

The Bengali words examined had seven vowels /a;/, /J/, /ir/, /u.-/, /e/, /ae/ and /o/ and the Hindi words contained ten vowels, /a/, /a.;/, /i/, /i.;/, /e/, /ai/, /o/, /au/ making minimal pairs in the combination /k-i/ (for example [/kal/-/ka.-l/], [/kal/-/kil/], etc.]. For the vowels for which meaningful words were not obtained, nonword syllables or pseudowords were used. For example /e/ in both Hindi and Bengali and /o/ in Hindi.

A total of 21 pairs for Bengali-Bengali, 45 pairs for Hindi-Hindi and 125 pairs for Bengali-Hindi were prepared. Each word (CVC syllable) containing a Bengali/ Hindi vowel was paired with a word containing another Bengali/Hindi vowel. Table I shows the word pairs used for the study. These pairs were visually presented (written on cards) to a Bengali and a Hindi adult normal speaker. The Bengali speaker read the Bengali word pairs and the Hindi

Bengali-Bengali tokens	Hindi-Hindi tokens	Bengali-Hindi tokens	
/ka:l/-/kɔl/	/kal/-/ka:l/	/kɔl/-/kal/*	/kol/-/ku:l/
/ka:l/-/ki:l/	/kal/-/ki:l/	/kɔl/-/ka:l/*	/kol/-/kel/
/ka:l/-/ku:l/	/kal/-/kil/	/kɔl/-/kil/*	/kol/-/kail/*
/ka:l/-/kol/	/kal/-/kul/	/kɔl/-/ki:l/*	/kol/-/kol/
/ka:l/-/kel/	/kal/-/ku:l/	/kɔl/-/kul/*	/kol/-/kaul/*
/ka:l/-/kael/	/kal/-/kel/	/kɔl/-/ku:l/*	/kel/-/kal/*
/kɔl/-/ki:l/	/kal/-/kail/	/kɔl/-/kel/*	/kel/-/ka:l/
/kɔl/-/ku:l/	/kal/-/kol/	/kɔl/-/kail/*	/kel/-/kil/*
/kɔl/-/kol/	/kal/-/kaul/	/kɔl/-/kol/*	/kel/-/ki:l/
/kɔl/-/kael/	/ka:l/-/kil/	/kɔl/-/kaul/*	/kel/-/kul/*
/kɔl/-/kel/	/ka:l/-/ki:l/	/ka:l/-/kal/*	/kel/-/ku:l/
/ki:l/-/ku:l/	/ka:l/-/kul/	/ka:l/-/ka:l/	/kel/-/kel/
/ki:l/-/kol/	/ka:l/-/ku:l/	/ka:l/-/kil/*	/kel/-/kail/*
/ki:l/-/kael/	/ka:l/-/kol/	/ka:l/-/ki:l/	/kel/-/kol/
/ki:l/-/kel/	/ka:l/-/kaul/	/ka:l/-/kul/*	/kel/-/kaul/*
/kael/-/ku:l/	/ka:l/-/kel/	/ka:l/-/ku:l/	/ki:l/-/kal/*
/kael/-/kol/	/ka:l/-/kail/	/ka:l/-/kel/	/ki:l/-/ka:l/
/kael/-/kel/	/kil/-/ki:l/	/ka:l/-/kail/*	/ki:l/-/kil/*
/kol/-/ku:l/	/kil/-/kul/	/ka:l/-/kol/	/ki:l/-/ki:l/
/kol/-/kel/	/kil/-/ku:l/	/ka:l/-/kaul/*	/ki:l/-/kul/*
/ku:l/-/kel/	/kil/-/kel/	/kael/-/kal/*	/ki:l/-/ku:l/
	/kil/-/kail/	/kael/-/ka:l/*	/ki:l/-/kel/
	/kil/-/kol/	/kael/-/kil/*	/ki:l/-/kail/*
	/kil/-/kaul/	/kael/-/ki:l/*	/ki:l/-/kol/
	/ki:l-/kul/	/kael/-/kul/*	/ki:l/-/kaul/*
	/ki:l-/ku:l/	/kael/-/ku:l/*	/ku:l/-/kal/*
	/ki:l-/kel/	/kael/-/kel/*	/ku:l/-/ka:l/
	/ki:l-/kail/	/kael/-/kail/*	/ku:l/-/kil/*
	/ki:l-/kol/	/kael/-/kol/*	/ku:l/-/ki:l/
	/ki:l-/kaul/	/kael/-/kaul/*	/ku:l/-/kul/*
	/kul/-/ku:l/	/kol/-/kal/*	/ku:l/-/ku:l/
	/kul/-/kol/	/kol/-/ka:l/	/ku:l/-/kel/
	/kul/-/kaul/	/kol/-/kil/*	/ku:l/-/kail/*
	/kul/-/kel/	/kol/-/ki:l/	/ku:l/-/kol/
	/kul/-/kail/	/kol/-/kul/*	/ku:l/-/kaul/*
	/kel/-/kol/		
	/kel/-/kaul/		
	/kel/-/kail/		
	/kel/-/ku:l/		
	/ku:l/-/kol/		
	/ku:l/-/kaul/		
	/ku:l/-/kail/		
	/kol/-/kail/		
	/kol/-/kaul/		
	/kaul/-/kail/		

Table I: Tokens used in the study. Tokens with * had two exemplars speaker read the Hindi word pairs into a microphone kept at a distance of 10 cms from the mouth with an interstimulus interval of one second. For the Bengali-Hindi pair both the subjects participated. A11 these were audio recorded on high fidelity cassette which formed the material.

III Method

A11 the listeners were tested in a sound booth Tokens were presented binaurally through headphones at comfortable listening levels. The listener used a binary forced choice (AX task) form to record whether the vowels in the two words in a token were same or different. The order of presentation to each listener was same, i.e. instructions followed by Bengali-Bengali tokens, Hindi-Hindi tokens and Bengali-Hindi tokens. In all each listener had to dichotomize 191 tokens.

IV Acoustic analysis

The seven Bengali vowels and ten Hindi vowels in the words that formed the tokens were spectrographically analyzed. The words were digitized at 16000 Hz sampling frequency with a 12 bit A/D converter. Using the SPGM program developed by the Voice and Speech Systems, Bangalore, the first four formant values of the vowels and the vowel duration for the steady state were measured.

V Analysis

The data thus obtained was tabulated and analysed. For all the three groups per cent same and per cent different responses were calculated and inter group comparisons were made.

CHAPTER IV

RESULTS AND DISCUSSION

I. Acoustic analysis of vowels

The results of acoustic analysis are shown in Table II and III which include the formant values and vowel duration during steady state. It was observed that the high vowels show low F_1 and low vowels show high F_1 . While the back high vowel exhibited low F_2, the front high vowel showed high F_2 and the mid vowels had mid F_2 . F_3 varied in the region of 2400 Hz except for /i/ for which it was higher. While in Hindi the duration of mid vowel was shortest, it was longest for back high vowel. The ratio between the short and the long vowel was 1:2.5. In Bengali all the vowels were found to be long with /i:/ and /u:/ being the shortest. While the average duration of Hindi short vowels was 77 m sec and long vowels was 197 m sec, that of Bengali vowels was 240 m sec. Thus, it appears that Hindi vowels involve four dimensions: duration, high-low, front-back, central-noncentral and Bengali vowels involve three dimensions: high low, front-back and central-noncentral.

II. Cross language perception

Tables IV, V, VI show the analysis for all the groups I, II and III relating to perception of Bengali-Bengali, Hindi-Hindi and Bengali-Hindi tokens respectively.

Vowel	F_1 (in Hz)	F_2 (in Hz)	F_3 (in Hz)	F_4 (in Hz)
/i:/	329 298	2337 2305	2902 3058	3717 3623
/u:/	329	831	2365	3309
/u/	360 329	988 800	 2368	3404 3372
/i/	392	2117	2619	3749
/e/	486 454	2056 2305	2588 2933	3780 3592
/o/	486 455	956 895	2431 2387	3372 3372
/a/	580	1396	2400	3654
/ae/(Bengali)	581	1552	2305	3529
/ai/	643	1741	2431	-
/c/(Bengali)	643	1019	2682	3467
/au/	670	1176	2305	3529
/a:/	706 706	1270 1176	2494 2557	3686 3467

Table II; Formant frequencies for Hindi and Bengali vowels. Values in second line are for Bengali vowels

Phoneme	Hindi	Bengali
/a/	67	-
/J/	-	232
/i/	7S	-
/u/	36	-
/a:/	133	268
/o/	173	266
/e/	191	240
/ae/	-	228
/ai/	225	-
/au/	200	-
/i:/	209	222
/u:/	216	224

Table III: Duration of Hindi and Bengali vowels (in msecs)

Vowels	Group I		Group II		Group III	
	S	D	S	D	S	D
/a:/-/ɔ/	0	100	0	100	0	100
/a:/-/i:/	0	100	0	100	0	100
/a:/-/u:/	0	100	0	100	0	100
/a:/-/o/	0	100	0	100	0	100
/a/-/ae/	0	100	0	100	0	100
/a:/-/e/	0	100	0	100	0	100
/ɔ/-/i:/	0	100	0	100	0	100
/ɔ/-/u:/	0	100	0	100	0	100
/ɔ/-/o/	13.33	86.67	0	100	0	100
/ɔ/-/ae/	0	100	0	100	0	100
/ɔ/-/e/	0	100	0	100	0	100
/i:/-/u:/	0	100	0	100	0	100
/i:/-/ae/	0	100	0	100	0	100
/i:/-/o/	0	100	0	100	0	100
/i:/-/e/	0	100	0	100	0	100
/u:/-/ae/	0	100	0	100	0	100
/u:/-/e/	0	100	0	100	0	100
/u:/-/o/	0	100	0	100	0	100
/ae/-/o/	0	100	0	100	0	100
/ae/-/e/	0	100	0	100	0	100
/e/-/o/	0	100	0	100	0	100

Group I - Hindi Monolingual;Group II - Bengali Monolinguals; Group III - Bengali Bilinguals

Table IV: Per cent similar and per cent dissimilar scores for the three groups for Bengali-Bengali Tokens

Vowels	Group I		Group II		Group III	
	S	D	S	D	S	D
/a/-/a:/	0	100	100	0	96.67	3.33
/a/-/i:/	0	100	0	100	0	100
/a/-/i/	0	100	0	100		100
/a/-/u/	0	100	0	100	0	100
/a/-/u:/	0	100	0	100	0	100
/a/-/e/	0	100	0	100	0	100
/a/-/ai/	0	100	0	100	0	100
/a/-/o/	0	100	0	100	0	100
/a/-/au/	0	100	0	100	0	100
/a:/-/i:/	0	100	0	100	0	100
/a:/-/i/	0	100	0	100	0	100
/a:/-/u/	0	100	0	100	0	100
/a:/-/u:/	0	100	0	100	0	100
/a:/-/e/	0	100	0	100	0	100
/a:/-/ai/	0	100	0	100	0	100
/a:/-/o/	0	100	0	100	0	100
/a:/-/au/	0	100	0	100	0	100
/i/-/i:/	0	100	100	0	96.67	3.33
/i/-/u/	0	100	0	100	0	100
/i/-/u:/	0	100	0	100	0	100
/i/-/e/	0	100	0	100	0	100
/i/-/ai/	0	100	0	100	0	100
/i/-/o/	0	100	0	100	0	100
/i/-/au/	0	100	0	100	0	100
/i:/-/u/	0	100	0	100	0	100
/i:/-/u:/	0	100	0	100	0	100
/i:/-/e/	0	100	0	100	0	100
/i:/-/ai/	0	100	0	100	0	100
/i:/-/o/	0	100	0	100	0	100
/i:/-/au/	0	100	0	100	0	100
/u/-/u:/	0	100	100	0	100	0
/u/-/e/	0	100	0	100	0	100
/u/-/ai/	0	100	0	100	0	100
/u/-/o/	0	100	0	100	0	100
/u/-/au/	0	100	0	100	0	100
/u:/-/e/	0	100	0	100	0	100
/u:/-/ai/	0	100	0	100	0	100
/u:/-/o/	0	100	0	100	0	100
/u:/-/au/	0	100	0	100	0	100
/e/-/ai/	0	100	0	100	0	100
/e/-/o/	0	100	0	100	0	100
/e/-/au/	0	100	0	100	0	100
/ai/-/o/	0	100	0	100	0	100
/ai/-/au/	0	100	0	100	0	100
/o/-/au/	0	100	0	100	0	100

Group I - Hindi Monolingual/Group II - Bengali Monolinguals; Group III - Bengali Bilinguals

Table V: Per cent similar and per cent dissimilar scores for the three groups for Hindi-Hindi vowel pairs

Vowels	Group I		Group II		Group III	
	s	D	5	D	5	
/o/-/a/	0	100	0	100	0	100
/o/-/a:/	0	100	0	100	0	100
/o/-/i/	0	100	0	100	0	100
/o/-/i:/	0	100	0	100	0	100
/o/-/u/	0	100	0	100	0	100
/o/-/u:/	0	100	0	100	0	100
/o/-/e/	0	100	0	100	0	100
/o/-/ai/	0	100	0	100	0	1 00
/i:/-/au/	0	100	0	100	0	100
/a:/-/a/	0	100	100	0	95	5
/a:/-/a:/	100	0	100	0	100	0
/a:/-/i/	0	100	0	100	0	J 00
/a:/-/i:/	0	100	0	100	0	100
/a:/-/u/	0	100	0	100	0	100
/a:/-/u:/	0	100	0	100	0	100
/a:/-/e/	0	100	0	100	0	!00
/a:/-/ai/	0	100	0	100	0	100
/a:/-/o/	0	J00	0	100	0	100
/a:/-/au/	0	100	0	100	0	100

Group I - Hindi Monolingual;Group II - Bengali Monolinguals;
Group III - Bengali Bilinguals

Table VI : Per cent similar and per cent different scores obtained by three groups for Bengali-Hindi tokens

Vowels	Group I		Group II		Group III	
	S	D	S	D	S	D
/o/-/a/	0	100	0	100	0	100
/o/-/a:/	0	100	0	100	0	100
/o/-/i/	0	100	0	100	0	100
/o/-/i:/	0	100	0	100	0	100
/o/-/u/	0	100	0	100	0	100
/o/-/u:/	0	100	0	100	0	100
/o/-/e/	0	100	0	100	0	100
/o/-/ai/	0	100	0	100	0	100
/i:/-/au/	0	100	0	100	0	100
/a:/-/a/	0	100	0	100	0	100
/a:/-/a:/	100	0	100	0	95	5
/a:/-/i/	0	100	100	0	100	0
/a:/-/i:/	0	100	0	100	0	100
/a:/-/u/	0	100	0	100	0	100
/a:/-/u:/	0	100	0	100	0	100
/a:/-/e/	0	100	0	100	0	100
/a:/-/ai/	0	100	0	100	0	100
/a:/-/o/	0	100	0	100	0	100
/a:/-/au/	0	100	0	100	0	100
			0	100	0	100

Group I - Hindi Monolingual: Group II - Bengali Monolingulas:
Group III - Bengali Bilinguals

Table VI : Per cent similar and per cent different scores obtained by three groups for Bengali- Hindi tokens

II.1 Group I

It consisted of thirty Hindi monolingual speakers.

Bengali-Bengali word pair tokens

Hindi speakers gave good perceptual scores on these tokens with 100% dissimilarity scores for all tokens except /ɔ/-/o/ tokens.

Hindi-Hindi word pair tokens

Subjects could identify and differentiate well, all the tokens obtaining 100% scores on all the tokens. This was expected as Hindi is their native language and phonomenon of typicality (Flege, 1994) is proved here.

Bengali-Hindi word pairs tokens

Hindi monolingual speakers obtained 100% dissimilarity scores for ail the tokens except the tokens which had long vowels (tense vowels) for both the languages where they obtain high similarity scores of 96.67% and 93.33% for /0/-/0/ (266 ms and 173 ms), /e/-/e/ (240 ms and 191 ms) and 100% for /u;/-/u.-/ (224 ms to 216 ms); /i.-/-/i.-/ (222 ms and 209 ms) and /a :/-/a.-/ (268 ms and 133 ms). These results show that Hindi speakers use duration as a cue to identify short and long vowels. They could not differentiate between word pairs containing the same vowels of Bengali and Hindi as durational and spectral variations were minimal. Also, as all the Bengali vowels are longer than Hindi vowels, Hindi monolinguals perceive them long only and therefore could not differentiate categorically. A1so, the similarity scores of 97% and 93% for /0/-/0/ and /e/-/e/ could be attributed to the durational differences of both these vowels (266 vs 178 ms and 240 vs 191 ms), while the duration differences between /u.-/-/u:/ (224 vs 216 ms) and /i.-/-/i.-/ (222 vs 209 ms) does not vary much, a similarity score of 100% is obtained.

II.2 Group II

It consisted of thirty Bengali monolingual speakers.

Bengali-Bengali word pair tokens

Group II performed well on this task with 100% different scores for all the tokens which suggest their familiarity with the language and relative experience or phenomenon of typicality explained by Flege (1994).

Hindi-Hindi word pair tokens

The Bengali bilinguals (Group II) could identify all the vowel pairs as different by obtaining 100% dissimilarity scores except that they were unable to identify and differentiate words having long Hindi vowels from words containing short Hindi vowels (/a/-/a.-/, /i/-/i.-/ and /u:/-/u:/).This suggests that monolingual Bengali speakers are unable to make short vs long vowel contrast flax vs tense).

Bengali-Hindi word pair tokens

The subjects showed 100% "different", scores for all the word pair tokens except those containing vowels which differ in duration. This shows inability to discriminate long vs short vowels based on its duration and other cues. 100% similarity scores were also seen in pairs having a Bengali vowel and a corresponding Hindi long vowel as these are comparable in durations.

II. 3 Group III

It consisted of thirty Bengali bilingual listeners.

Bengali-Bengali word pair tokens

Bengali bilinguals could identify and differentiate ail the Bengali vowels containing words from others and obtained 100% dissimilarity scores for all the tokens. This suggests that perception of first language does not change with experience in second language and also explains typicality hypothesis (Flege, 1994).

Hindi-Hindi word pair tokens

Bengali bilingual speakers obtained 100% dissimilarity scores for ail the tokens except that they were unable to discriminate between long and short vowels in Hindi by obtaining 96.67%, 95.67% and 100% similarity scores for /a/-/a:/, /i/-/i.-/ and /u/-/u:/ respectively. This again suggest that Bengali speakers are unable to make significant durational contrast in the second language (Hindi in this case) provided they do not have durational contrast in their native language.

Bengali-Hindi word pair tokens

Group III obtained 100% dissimilarity scores on all the vowel pairs except the vowels which differed only in duration for which they obtained 90%, 96. 67% and 95% similarity scores for /u:/-/u/, /i:/-/i/, and /a:/-/a/ respectively. The listeners also obtained 100% similarity scores for those tokens which had same vowel of both Bengali and Hindi.

II.4 Inter group comparisons

Group I and Group II (monolinguals vs. monolinguals)

Listeners in both groups obtained high dissimilarity scores in Bengali-Bengali word pair tokens. In Hindi word pair tokens, Hindi monolinguals obtained 100% dissimilarity scores on all the tokens. However, some variation is seen in Group II where Bengali monolingual listeners obtained 100% dissimilar scores on most of the vowel pairs, except that they obtained 100% similarity scores on the tokens containing lax and tense vowels.

In Bengali-Hindi word pair tokens, Group I listeners obtained 100% dissimilarity scores on all tokens except containing same vowels from both languages. The Group II listeners showed high similarity scores for lax and tense vowel tokens.

The results show that Bengali monolinguals and Hindi monolinguals differ in vowel perception with Bengali monolinguals not able to differentiate tense and lax vowels. Bengali monolinguals do not appear to use spectral and temporal cues (duration) required to make tense vs lax contrast and they are not able to make categorical perception for tense/lax feature. This is expected as Bengali has only tense vowels. The results also show that both groups use dimensions such as central/noncentral, front/back, high-low and diphthongization as they obtain high scores on vowels separated by these dimensions.

Group I and III: Monolingual (Hindi) and Bilinguals

Listeners in both groups obtained high dissimilarity scores in Bengali-Bengali word pair tokens except that Hindi monolinguals had less scores for />/-/o/ pair. Hindi monolinguals obtained 100% dissimilarity scores on all the Hindi-Hindi tokens where as biiinguals showed high similarity scores for tense and lax vowels. In Bengali-Hindi word pair tokens also, both groups obtained high dissimilarity scores (lOO%) on ail tokens except those consisting of same vowels from both languages. The group III listeners showed high similarity scores for lax and tense vowels.

This shows that bilingual Bengali listeners and monolingual Hindi listeners differ in perceiving vowels. Bengali bilinguals though have learnt Hindi as a second language, do not seem to show the use of durational clue in vowel perception where as Hindi monolinguals do.

Group II to Group III; Monolingual (Bengali) vs Bilinguals

Group II and Group III obtained similar 'different' scores in all three type of tokens, i.e. Bengali-Bengali, Hindi-Hindi and Bengali-Hindi word pair tokens suggesting that they use same perceptual dimensions whether the language in guestion is Bengali or Hindi. This suggests that the vowel perception does not change in Bengali bilinguals as they gain experience in second language (despite learning second language). Table VII summarizes the results.

Vowel pairs	Group I		Group II		Group III	
	D5	SS	DS	SS	DS	SS
Bengali Bengali		/>/-/o/	100%		100%	
Hindi Hindi	100%			Tense vs lax		Tense vs lax
Bengali Hindi		Same vowels from both language		Tense vs lax		Tense vs lax

Table VII; Summary of results

Group I - Hindi Monolinguals;Group II - Bengali Monolinguals; Group III - Bengali Bilinguals

DS - Dissimilarity; SS - Similarity scores

To summarize, the following were evident.

1. Bengali listeners (both monolinguals and bilinguals) seldom use duration as perceptual contrast for vowel perception and thus are unable to identify lax and tense vowels from each other and categorise them. This can be attributed to assimilation fBest et al., 1988) or in other words perceptual magnet effect described by Kuhl et al. (l992). It also verifies Fischer-Jorgenson's (1973) contention that duration can act as a major cue along with spectral cues for vowel contrasting and identification.

2. Learning Hindi or experiential effects of second language (Hindi) has negligible effect on the perception of

vowels of first language and vowels of second language are perceived in accordance with the vowel inventory of first language. This is in confirmation with previous studies of Scholes (l967); Stevens et al. (1969); Fischer-Jorgenson (l973); Flege et al. (l994) and is contrary to Strange et al. (1981) who said listeners iearn contrasts of normal language as they learn language in natural setting.

3. Learning Hindi as a second language did not increase the dimensionality of Bengali bilingual listeners psychological vowel space. Thus, both Bengali monolinguals and Bengali bilinguals perform egually on all tasks. This is in confirmation with the results of study of Flege et al. (l995). That is both Bengali monolinguais and bilinguals and Hindi speakers have front/back, central/noncentral, high-low and diphthongization dimensions. However, Hindi speakers have additional dimension of long vs short.

The results of the study imply following: It has implication in teaching second language to the adults in the aspect that though the bilinguals know the language, their perception may be deficient in second language thus leading to production and perception difficulties. This highlights the need for perceptual training along with language training.

The importance of contextual cues is also high-lighted. During this study the investigator observed that a bilingual subject may be good in second language proficiency and yet may not be able to differentiate the most frequently occurring vowels. It is speculated that the listeners take the heip of the contextual cues to perceive differences in meaning of word in daily life, as change in vowel significantly changes the meaning. For eg. in Hindi /kal/ means tomorrow whereas /Karl/ means time.

Further, it appears that the speech production and speech perception abilities may be related. While Hindi speakers could differentiate both tense and lax vowels fas they appear in speech production), the Bengali speakers could not as Bengali does not have durational differences.

This study has thrown up more guestions than that it has answered and further research in cross language differences in vowel perception is needed to answer the following guestions.

1. How does vowel perception and production change during adult second language acquisition ?

2. How does the perception of vowels in children with bilingual environment develop compared to monolingual ?

3. Vhat are the contextual clues in perception of nonnative contrasts in bilinguals ?

CHAPTER V

SUMMARY AND CONCLUSIONS

Cross language studies have gained importance as they reveal subtle linguistic differences between the languages. Hindi has a larger number of contrastive votveL categories than Bengali. Therefore Hindi uses more phonetic features than Bengali to distinguish vowels (for example duration cues in case of tense and lax vowels). Based on the above fact one might expect that the individual Hindi and Bengali speakers, perceive vowels differently. Specifically, one might expect native Hindi listeners to use more dimensions than native Bengali listeners. One might also spell late that a Bengali listener who has learnt Hindi as a second language may perceive vowels more closely to Hindi listeners than his Bengali monolingual counter part in vowel perception. This experiment was conducted to address the above guestions. The aim of the present study was to investigate the perception of vowels of Hindi and Bengali in Hindi-Hindi, Bengali-Bengali and Bengali-Hindi word pairs by Hindi and Bengali monolinguals and Bengali bilinguals with Hindi as a second language.

Ninety normal hearing adult subjects in the age range of 20-43 years were taken with thirty in each of the three groups, i.e. Hindi monolinguals, Bengali monolinguals and Bengali bilinguals with Hindi as learnt nonnative language. All these subjects were literates. Material consisted of 191 tokens which were pairs of CVC monosyllabic minimally contrastive meaningful words. These formed Bengali-Bengali tokens, Hindi-Hindi tokens and Bengali-Hindi tokens consisting of 10 Hindi and 7 Bengali vowels in CVC position [k-1]. These tokens were uttered by adult Hindi and Bengali male speakers which were audio recorded with Inter-Stimulus Interval of 1 sec and inter-token interval of 5 seconds which formed the material. Vowels in the tokens were acoustically analysed and measurements were made for the formant frequencies and duration. The tokens were given for perceptual evaluation binauraily and the subject was to dichotomize the token words into 'similar' or 'different'. Analysis was done in terms of percentage similarity and percentage dissimilarity score.

The results of the study indicate that

1. While in Hindi, short and long vowels are differentiated, Bengali has only long vowels.

2. Hindi monolingual listener uses more perceptual dimension of vowel perception than a native Bengali monolingual or bilingual with Hindi as nonnative learnt language does.

3. Bengali monolinguals and Bengali bilinguals performed similarly on all tokens. They obtained 100%

dissimilarity score for Bengali-Bengali tokens and could not differentiate tense and lax vowels. It can be inferred that learning the second language (Hindi) did not increase the dimensionality of Bengali bilingual/listener (The psychological vowel space in Bengali monolinguals and bilinguals remain the same) and perception of Hindi vowels by bilinguals reflected the categories of their native language.

The results of the study imply the following: It has implication in teaching second language to the adults in the aspect that though the bilinguals know the language, their perception may be deficient in second language thus leading to production and perception difficulties. This highlights the need for perceptual training along with language training.

The importance of contextual cues is also highlighted. During this study the investigator observed that a bilingual subject may be good in second language proficiency and yet may not be able to differentiate the most frequently occurring vowels. It is speculated that the listeners takes the help of the contextual cues to perceive differences in meaning of word in daily life, as change in vowel significantly changes the meaning. For eg. in Hindi /kal/ means tomorrow whereas /Karl/ means time.

Further, it appears that the speech production and speech perception abilities may be related while Hindi speakers could differentiate both tense and lax vowels fas it appear in speech production), the Bengali speakers could not as Bengali does not have durational differences.

This study has thrown up more questions than that it has answered and further research in cross language differences in vowel perception is needed to answer the following guestions.

1. Wow does vowel perception and production change during adult second language acquisition ?

2. Wow does the perception of vowels in children with bilingual environment develop compared to monolingual ?

3. What are the contextual clues in perception of nonnative contrasts in bilinguals ?

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