ACOUSTIC ANALYSIS OF VOWELS IN KASHMIRI

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DEDICATED To

MY BABUJI - I MISS YOU A LOT

I WISH YOU WERE THERE TO SEE

WHAT YOU WANTED ME TO BE

CERTIFICATE

This is to certify that the dissertation entitled : ACOUSTIC ANALYSIS OF VOWELS IN KASHMIRI is the bonafide work in part "Fulfilment for the degree of Master of Science (Speech and Hearing), of the student with Register No.M922l.

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CERTIFICATE

This is to certify that this dissertation entitled ACOUSTIC ANALYSIS OF VOWELS IN KASHMIRI has been prepared under my supervision and guidance.

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DECLARATION

This dissertation entitled ACOUSTIC ANALYSIS OF VOWELS IN KASHMIRI is the result of my own study under the guidance of Dr. N.P. Nataraja, Professor and Head of the Department of Speech Science, 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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1.1

INTRODUCTION

"Speech generally appears as some kind of unified activity but the successive transformations of spoken message constitutes the essential nature of speech, it is a series of changes. In spite of this humans manage to talk to each other quite easily most of the time. This means that between ail the different forms of message, language units, nerve impulses, movements and sound wave, systematic correspondences or correlations are maintained so that the essential information does not disappear as it is conveyed from speaker to listener. The basis of this essential information is the language system which is known to both listener and speaker; this system dictates what sounds must be kept distinct from each other, what intonation and rhythmic patterns, and the articulatory mechanism is appropriately instructed so that differences appear in the resulting sound waves. These differences are perceived by the listening ear and provide the basis for decoding the message" (Proctor, 1980).

The study of speech involves before everything else the study of correspondences that exist between the various forms of spoken message and because the transformations take place from one medium to another, each level of speech activity calls for its own techniques of investigation. The

linguistic side, with its dependence on memory stores and mental processing, is a psychological study; the action of nerves and muscles are a matter of physiology; the generation and transmission of sound waves fall within the realm of physics. There are many facts to be learned about the physics of speech which have its applications to all language systems.

For the present study five males and four females in the age range of 18-25 years were taken. All the subjects were native speakers of Kashmiri language. Before taking the subjects for the study care was taken that none of the subjects showed any speech and language and hearing abnormalities.

The speech samples of all the subjects contained 29 vowels embedded in the medial position of the word along with the carrier phrase. The recorded samples have been analyzed to obtain the spectral and temporal parameters ie.

a) Formant frequencies

b) Formant intensities

c) Band widths

d) Vowel duration

Kashmiri, though a scheduled language, is neither the official language of Jammu and Kashmir nor is the meclum of

instruction at the higher levels of learning. There is a difference of opinion among scholars as to whether Kashmiri is an indo-aryan language like Bengali and Hindi or is it a language belonging to the Dardic group of languages. There is also equally strong feeling on the question of the use of script for this language. While Sharada and older script, is not currently used, there is the claim of both perso-Arabic and the Nagari scripts for the language. It has been pointed out by scholars that the Perso-Arabic script is inadequate for the language while Nagari, which is relatively better suited is opposed by extra-academic considerations. Under these circumstances, it is absolutely necessary that a balanced view is taken of all the issues involved.

Aim of the study:

This study is an attempt to analyzes the acoustic parameters of different (29) vowels in kashmiri language. Similar studies have been taken up in Indian and foreign languages. However, this is the first study aiming at acoustical analysis of vowels in kashmiri language.

1.4

Hypothesis:

a) There is no significant difference in the formant frequencies of oral and nasal vowels.

b) There is no significant difference in the formant frequencies among males and females subjects.

c) There is a difference in vowel duration between oral and nasal vowels.

d) There is no significant difference between long and short vowels.

e) There is no difference in the bandwidths between oral and nasal vowels.

f) There is difference in formant intensities between oral and nasal vowels.

2.1

REVIEW OF LITERATURE

Sounds are physical events governed by very much the same laws as many other kinds of phenomenon to be found in the physical universe. They exemplify the effects of forces acting upon physical bodies to produce movements of various kinds. The criterion which separates sounds into a category of their own is not, however, a physical one, since it is related to the human receiving apparatus: sounds are those physical events which give rise to the sensation of 'sound' in the human being, in other words the hearing mechanism is sensitive only to certain restricted range of phenomenon in the physical world. Sensations are themselves part of the psychological world so that the study of sounds inevitably links the areas of psychology and physics. It is true that the term 'acoustics' is usually applied to the treatment of physical effects alone, but the word itself in its root meaning signifies relating to the sense of hearing. Speech sounds are a limited class of sounds and in studying the physical side of speech the principal objective is to establish the relations between the physical input to the ear, that is the stimulus, and not only the sensations to which it gives rise but also the further organization of those sensations in accordance with the language system.

2.2

In the world of sound, as elsewhere, some of the things that happen are relatively simple in character and others are extremely complex. We do not need any knowledge of mechanics to realize intuitively that to give an account of the working of a bicycle is a simpler task than to do same for a motor car with an eight cylinder engine. The latter is more complex in the sense that more things are happening at the same time and that to specify the complete working of the mechanism would call for many different kinds of measurements and would involve measuring to much finer limits. The sounds of speech are among the most complex sounds that exist in nature and to specify them is a correspondingly complicate-business. The principles involved are relatively simple anc can be grasped certainly without any previous knowledge of physics or mathematics, but in order to make these principles clear it is necessary to start from the sounds which are very much simpler physically or acoustically speaking, than tr.s sounds which occur in speech, the majority of musical souncs, for example, are less complex than speech sounds.

"Vowel is a conventional vocal sound produced by certain positions of the speech organs which offer little obstruction to the air stream and which forms a series of resonators above the level of larynx in the vocal tract" (Wood, 1971).

2.3

For the production of any sound, a vibrating medium has to be set into motion by some kind of energy. In the case of vowel production vocal folds act as the vibrations and produce the tone' which has a regular pattern. And the vocal tract approximates a tube closed at one end and open at the other.

The quality of vowel depends on the shape of the cavities of the parynx, the mouth and the nose, which in turn depends on the positions of the soft palate, the tongue and the lips. The range of movement, the velocity of movement and the direction of movement of these articulators depend upon synergised neural commands given to them by the nervous system. Enunciation of vowels help in identifying the consonants in speech and to relay prosodic information. Intelligible hearing impaired speakers do enunciate vowels more precisely than unintelligible speakers.

Vowels serve several purposes in a given language. For example -

1. Vowels help in determining the syllable/syllabification.

2. Maximum acoustic energy is transmitted during the production of vowels and makes speech effective.

3. Vowels emphasize the meaningfulness of a sentence by preceding the content words.

4. Distribution of amount of energy for different vowels also plays a very important role in determining the intelligibility of speech.

5. Vowels act as a link between consonants.

6. Vowels play an important role in determining intonation and other suprasegmentals.

Thus vowels play a very important role in any given language. Study of vowels, would become first step in understanding language. Even understanding the language/speech development children must be started with study of vowels, as the child starts speech by producing vowels first. There are very few attempts to study vowels in Indian languages particularly north Indian. Therefore it was considered worth while to make an attempt to understand vowels and Kashmiri language.

Formant: frequency

"The peaks in the spectrum of vowels correspond to the basic frequencies of the vibration of the air in the vocal tract. The region of the spectrum in which the frequency corresponds are relatively large and known as formants. The formants of a sound are those aspects of it which are directly dependent on the shape of the vocal tract and are largely responsible for the characteristic quality. It is the presence of formants that enables us to recognize the different vowels which are associated with the different positions of the vocal organ" (Ladefoged, 1962).

Singh and Singh (1979) define formant frequency as the frequency region that is significantly amplified for the continuous period of time is known as formant frequency.

The formant at the lowest end having a continuous stretch of darkness (On a spectrogram) is called the first formant and is denoted by F_1. The next higher band width with a noticeable stretch of darkness is the second formant, denoted by F_2 and the third higher width is the third formant, denoted by F_3".

2.6

The term formant, a German word was used first by a Physicist Hermann in the second half of the 19th century.

A formant is a range of frequencies but since a formant must give rise to a peak in the spectrum of sound produced the term formant is commonly applied to the frequency at which peak occurs (Fry, 1979). Formants are the most significant enmarks of sound and every vowel is formed by two or more formant ranges (Bunch, 1982).

FORMANT FREQUENCY CHARACTERISTICS OF VOWELS:

The vowel production in an individual is influenced by vocal tract configuration. This modifies the spectrum of vowels in the following ways:

1. Length: The frequency of all formants become low as the length of vocal tract increases.

2. Lip rounding: Increased constriction of the labial pot also lowers all formant frequencies.

3. Anterior oral construction. Elevation of the front of the tongue lowers the first formant and raises the second formant.

4. Posterior oral construction: Raising the posterior part of the tongue tends to lower the second formant.

5. Pharyngeal constriction: Narrowing the pharynx raises the frequency of first formant.

6. Nasalization: The effect of coupling the nasal resonant space to the vocal tract are very complex. Not only are the resonant frequencies altered but antiresonances are introduced. The overall result is highly variable.

"The most significant features of vowel spectrum are the frequencies and amplitudes of the various formants. These correspond to the resonances of the vocal tract, and they produce peaks in the speech spectrum" (Dennes and Penson, 1963, p.117).

Two theories have been proposed regarding the vowel production i.e., cavity tone theory and harmonic theory. According to cavity tone theory proposed by Willis (1830), "The sound identified as vowel was dependent only upon the length of the resonating tube and the vowel tone was completely independent of reed tone" (Fundamental frequency). The vowel heard was the result of an augmentation of

certain of the harmonic components of the reed tone"., according to Wheatstone (1837), the proponent of Harmonic theory of vowel production.

Scripture (1904) cm the basis of a very thorough review and on the basis of his own experiments has concluded that, the vowel production is not a function of the over tones of harmonies but rather a function of natural resonances of a supra glottal resonators. Thus the cavity tone theory is more widely accepted than the harmonic theory.

There are several indications that fundamental voice frequency may be a significant determinant of vowel quality.

In an experiment with a tone generator, Miller (1953) showed that when only a portion of the vowel spectrum is presented, for example, only the first two formants of the (ɔ) of a child's voice correspond approximately to the position of the first two formant for the (a) of a man. If a man raises his fundamental voice frequency to correspond to that of a child (falsetto), the higher formant are removed by filtering of the acoustical result corresponds very closely to the (ɔ) of a child with low pass filtering and may be so interpreted by a listener.

An even more general relation between fundamental voice frequency and vowel perception was observed by Wendahl, (1959). His experiments were conducted with a series resonance synthesizer, which stimulated the first five formants and was excited by a recurrent impulse (Wendaw)1959 employed characteristic resonance positions for various vowels for both male and female speakers and shifted the fundamental frequency over a wide range. His results showed that when the formant positions were held constant, the vowel value judgements varies with different fundamental voice frequencies. Thus the relationship between F_o, and formants have not been made clear.

In the past, studies cm vowel formant frequencies have been reported to clarify some acoustical features of speech sounds. It has been recognized that the vowel formants represent the acoustical resonant properties of vocal tract as shaped in articulation by the tongue (Potter, Kopp and green, 1947; Jobs, 1948; Peterson and Barney, 1952; Peterson 1951, 1959; Potter and Steinberg, 1950; Stevens and House, 1961). Identification of the vowel is chiefly dependent on the first and the second formants.

It has been presumed from past that the first formant corresponds to the back cavity and the second formant

corresponds to the front cavity of the mouth (Joos, 1948). Studies of synthesized speech and measurements of the size of vocal tract on x-ray pictures reveals that the first and second formants are not simply acoustic features of front cavity and back cavity in the vocal tract (Fant, 1960).

"The first formant" the frequency of the first formant is generally dependent more on the back cavity volume than on the volume of other cavities. An exception is the vowel [a], where F_1 is affected equally on a percentage basis by a change in the front cavity volume.

Since the back cavity of [a] is much shorter than the front cavity, the percentage increases of F_1 due to the removal of a small unit length section of the back cavities larger than the shift caused by a removal of a section of the same length in the middle of the front cavity.

F_1 of the vowels [e], [i] and [t] is almost completely determined by the back cavity volume and the narrowest section of the mouth cavity. In the vowels [u], [o] and [a] is somewhat more dependent on the front cavity constriction section. The contribution of F_1 of [u] from the back cavity volume is somewhat larger than that from the front cavity.

"The second formant only in the case of the vowel [t] was the mouth cavity with associated orifice found to be the essential determinant of F_2. F_2 of [i] is clearly a half wavelength resonance of the back cavity. There is a similar but not so appearent tendency of F_2 of [e] to be influenced more by the back than by the front cavity.

The second formant of the back vowels [u] , [o] and [a] is some what more dependent on the front cavity than on the back cavity. Providing the cavity volume changes are introduced on a constant percentage basis. This tendency is apparent, but if the volume changes are performed by means of a constant length reduction, there is an equal dependency of F_2 on the two cavities for [u] and also for Call. In the case of [u], F_2 is dependent much more on the relative dimensions of the tongue position than on the lip section. These two parts of the compound resonator system have about the same effect on F_2 of both /a/ and Co]. The lip section is of [i] and does not have a very marked influence of [e] either" (Fant, 1960, p.162).

"Needless to say, the vocal tract of a child is smaller in size than that of an adult. But we cannot easily assume that the formants have higher frequencies in proportion to

the size of the vocal tract with age as a whole, because different parts of the vocal tract with age as a whole, because different parts of the vocal tract presumably change at different rates" (Eguchi and Hirsh, 1969).

The psychophysiological development is also considered to be one of the factors in determining the variation informant frequency with age, along with the anatomical changes. Further, the perception of vowels is not dependent solely on the formant frequencies but also influenced by many other factors (Peterson, 1952).

Kent (1976) reports that "the formant frequencies of children's vowels are higher than the values obtained for adult females and higher yet than the values obtained for adult males. On the one hand, this result is to be expected given the differences in the length of the vocal tract between children and women and between children and men. On the other hand, mathematical prediction of the observed differences has been the subject of several papers, right up to the present. If growth of the vocal tract were uniform, their prediction would be simple enough. However, Fant (1960) argued that there are differences other than size between the vocal tract anatomies of men and women, and that children apparently are more like women in the configuration

of their vocal tracts. hence, as a boy grows into manhood, the changes that occur in the formant structure of his vowels cannot be likened exactly to the changes in resonant frequencies that are observed as a uniform acoustic tube is lengthened. The problem of the scaling of formant patterns is important for speech perception, because of its implication it holds for the recognition of phonemes and speakers. This issue has been discussed in several papers (Broadbent, Ladefoged and Lawrence, 1956; Gerstman, 1968; Fijisaki and kawashima, 1968).

Mol (1963) reported that the data of Peterson and Barney (1952) reveals an apparently linear change in formant structure among children, women, and men. He ascribed this linear change to the principle of uniform axial growth.

The principle of uniform growth of this vocal tract is not without proponents (Kent, 1976).

But study by Eguchi and Hirsh (1969) gives little support to Mol's principle of uniform axial growth.

Nordstrom and Lindblom (1975) report that the linear relationships in the formant data of men, women and children. They suggest that departures from linearity in the Peterson

and Barney (1952) data may be explained by articulatory differences among the speakers, especially because not all of the speakers in the investigation were native Americans.

Formant frequencies of adult male and adult female vowels were compared by means of scale factors based on ratio as follows by Fant (1966).

1. First formant scale factor

$$K_1 = \frac{F_1 \text{ of female}}{F_1 \text{ of male}} - 1 \times 100$$

2. Second formant scale factor

$$K_2 = \frac{F_2 \text{ of female}}{F_2 \text{ of male}} - 1 \times 100$$

Fant (1966) concluded from his calculation that the scale factors relating male and female data vary with the class of the vowels, with the average scale factor about 18%. In addition, he determined that the scale factors for both F_1 and F_2 were low for rounded each vowels, that the scale factor for F_1 was low for any close or highly rounded, and

that the scale factor for F_1 was high for very open front or back vowels. Fant (1966) pointed out that these differences are consistent with differences in vocal tract anatomy between males and fameles, males having a greater relative length of the pharynx than females.

The scale factor defined above can be used to characterise developmental changes in the formant structures of vowels. Scale factors calculated from the data of Eguchi and Hirsh (1969) indicate that the children often had average F_1 value approaching those for the adult female subjects. In view of this unusual results, the formant frequency values reported by Eguchi and Hirsch (1969) should be treated continuously. Considering the data for F_2, which are more systematic than those for F_1, during the developmental period of 3-13 years, second formant scale factor changes at the annual rate of 3.4% for an adult male referent and about 2% for an adult female referent.

Kent (1976) has drawn the following tentative conclusions about child adult scale factors.

1. The scale factor for F_1 is large for the high vowels but small for the low vowels.

£. The scale factor for F_2 is large for the front vowels but small for the close back vowels.

Bunch (1982) states that the various factors affecting formant frequencies *are* related to the frequency of the vocal fold vibration the resonating frequency of the pharynx and further the amount of damping. Winckle (1967) while discussing the transfer function of vocal tract states that "when there is a severe damping of resonances in the vocal tract there are wider resonance curves for the formants, and therefore a wider excitation zone for the formation of non-harmonic partials".

Sundberg (1977) is of the opinion that the alterations in the configuration of the vocal tract gives rise to variations in ranges of formant frequencies. Combinations of variations in the shape and extent of opening of lips, the position of the tongue, mandible and soft palate have been considered to be contributing for the changes in the responses of the cavities in the vocal tract to different frequencies. At least four formants can be identified in any vowels irrespective of the pitch according to Sundberg (1977).

Variability in children's formant patterns for vowels. Study by Eguchi and Hirsh (1969) are the only substantial source of data in this area that the intrasubject standard deviations of both F_1 and F_2 for five vowels in five recitations each of the sentences -"He has a blue pen and I am tall" have been calculated. The variability of standard deviations of both F_1 and F_2 have been found to decrease with age, uniform ie. the variability of SDs decreased from 3-11 years.

The relative values of F_0, F_1 and F_2 reach an asymptotic level at about 11 or 12 years of age at which age the variability of the children's data is about the same as the variability of the adult data. This has been considered by Eguchi and Hirsh (1969) as the evidence to show that the young children were more inaccurate in articulatory positioning than the older subjects.

Lindblom (1972) questioned Eguchi and Hirsh's (1969) assumption that the variability of F_1 and F_2 is descriptive of instability in articulatory positioning. Lindblom (1972) showed that a hypothetical curve reflecting the error of formant frequency estimation to the fundamental frequency is similar in form to the age dependent standard deviation curve

presented by Eguchi and Hirsh (1969). And therefore Lindblom (1972) suggests that the "measurement error might be a significant factor in the variability data derived from the spectrographic measurements. The problem would be easier to evaluate if estimates of the measurement error has been obtained separately for each group used in the study". However, Eguchi and Hirsh (1969) reported measurement errors based only on size different vowels spoken by a 6 year old child and by an adult male.

Therefore, the conclusion by Eguchi and Hirsh (1969) have to be considered with some reservation.

Kent (1976) states that "beyond the question of postural stability; formant patterns, either relative or absolute, might have some value in the identification and diagnosis of deviant development. However, many conditions that are sufficiently severe so as to affect the formant structure are readily signaled by gross changes in physical appearance, such as congenital malformations of the head and neck. Perhaps, though, formant patterns can be used as one index of normal anatomical development, especially during the first two years of life, when the distance between the larynx and the oral cavity gradually increases to form a pharyngeal tube (Negus, 1962; Liberman, et al. 1972; Liberman, 1973).

Abnormalities that effect the development of the pharyngeal cavity conceivably could be detected by appropriate measurement of formant structures.

Maria Gabriella (1989) concluded from her study time and/or frequency variations of first formant must be taken into account if an invariant property is to be associated with vowel.

Stimulus with higher F_1 onset frequencies and F_1 maximum at the beginning of vocalic portion characterize long vowels (Maria Gabriella, 1989).

Vowel duration:

Raphael (1972) studied the effect of varying preceding vowel duration upon the perception of word-final stops, fricatives and clusters in synthetic speech. It was found that, regardless of the cues for voicing or voicelessness used in the synthesis of the final consonant or cluster, listeners perceived the final'segments as voiceless when they were preceded by vowels short duration and as voiced when they were preceded by vowels of long duration.

Wadrip-Frum (982) suggested that in natural speech, vowel duration differences re probably neither necessary nor adequate cue to this distinction and that voicing during closure may be required to disambiguate voiced stops.

In American English the finding of shorter vowel duration before vowels as opposed to voiced stops is consistent over a large number of adult speakers, in several studies and phonetic environments studies (House, 1961; House and Fairbanks, 1953; Klatt, 1973). For pre-pausal syllables, the vowels before the voiceless cognate averages about 60V. (range 52'/. to 69'/.) of the vowel before the voiced cognate. The data on children's productions show the same tendency, although the difference is not early significant for the youngest (2 to 3 year old) speakers (Dismoni, 1974: Gseenles, 1978; Naeser, 1977 a).

Krause (1982) reporting the data on boundary in children aged 3-6 years, suggested that as the age of the listener increased, progressively shorter vowel durations were required to shift a listener's judgements of a post vocalic stop from voiceless to voiced.

Refinement of vowel duration with an increase in age is demonstrated for both speech perception and production (Krause, 198S).

Klatt (1973) reported baaed on his study that vowels become strongly in compressible beyond a certain amount of shortening and that vowel duration modification rules should have the form $D_o = K (D_1 - D_{m2n}) + D_{m1n}$, where D_1 is the input duration to the rule. D_D is the output duration of the rule. D_{m1n}, is the minimum duration for the vowel and scale factor K is greater than zero and depends on a particular rule.

Nasal duration appears to be a stronger cue than vowel duration for the word final voice voiceless consonant distinction in CVNC utterances (Raphael, Dorman, Freeman, and Tobin, 1975).

Spectrographic analysis of vowels in English indicates that vowel lengthening is triggered by phonological rather than physiological 'voicing'. The acquisition of the lengthening rule is in turn motivated by perceptual factors, speakers perceive vowels before phono1ogica1ly "voiced" consonants as longer than those before phonologically "voiceless" consonants (Thomas Walsh and Parker, 1981).

Disimoni (1974) in a preliminary study of certain turning relationship in the speech of stutterers indicated that differences exist in the duration and in certain aspects of timing of fluent sequences of phonemes in stutterer. Stutterers also showed greater variability than nan stutterers in durational control.

Christnerser and Wenberg (1976) observed that the overall vowel durations of esophageal speakers, indicating that esophageal speakers do not compensate for their striking domination in an supply for speech by decreasing the vowel duration.

Study conducted by Whitehead and Jones (1976) revealed that in a normal hearing and hearing-impaired population, vowels were significantly longer in duration in a voiced consonant environment, when compared with the voiceless environment. Vowels were also significantly longer in duration in a fricative environment when compared to a plosive environment. For the deaf population, the same trends were evident although the differences were not significant.

Collins, Rosenbek and Wertz (1983) pointed out that normal speakers of English reduced the duration of the

vowels, as the words increased in length. However, in a spectrographic analysis of vowel duration in apraxic speech, they found the vowel duration to be significantly longer than those of normal speakers. The result suggested that vowel reduction is a robust phenomenon which resists impairment even in apraxic speech, despite often significant disturbances in motor programming.

Acoustic studies along this line in children, were recently reported by Disimoni (1974) who made oscillographic measurements of vowels and consonant duration in CVC and VCV utterances of children aged 3, 6 and 9 years. It was concluded from these studies that the variability of the durations tended to decrease with age and this parallels the age related variance (Hurish, 1969). In addition the vowel duration in the voilen consonant environments remained relatively constant for all ages tested, while the duration of vowels invoiced consonant environments were found to increase with age.

Mean duration of vowels / i / and /a/ pooled in voiced */R/* and voiceless /o/ consonant environment (Data in adult column taken from Peterson and Lehiste, 1960 (Dismoni, 1974).

Rashmi (1985) determined the vowel duration of /i/ in idu in children and found hat the males and females showed a consistent decrease in the vowel duration as a function of age. Savithri (1984) found that a low vowel had longer duration than a high vowel in Kannada.

Vowel durational values compared for both voiceless and voiced consonant inverts were found to be significantly different in six and nine year old subjects but not in three year old subjects. Durational differences begin to appear by age of three although the differences do not reach statistical significance until age six. Disimoni interpreted his data as evidence of a developmental pattern in which the control of duration changes rapidly in the period between 3 and 6 years.

Raphael, Dorman and Geffner (1980) studied the vowel duration in minimal pairs differing only in the voicing characteristics of the final consonant, in 3 and 4 years old children. Spectrographic analysis revealed that children produced vowel duration differences of the same nature and same magnitude as those found in adult speaker's utterances. However, they reported that the duration of preceding vowel, as well as the duration of voicing during the final consonant

closure, are reliable production of the voicing characteristic of the final consonant.

Smith (1978) reported that durations of non-sense utterances were 15% longer for four year old than for adults and 31% longer for two year olds than for adults. Reduction of segment duration with age may be a consequence of neuromuscular maturation, therefore durational measurements may be one way of characterizing a child's developmental progress in attaining adult like speech motor control.

Another reason may be that the developmental patterns in the control of duration are a necessary substrate for research on the acquisition of phonological process (Kent, 1980).

Another developmental pattern emerging from studies of children's variability of performance (Eguchi and Hirsh, 1969; Dismoni, 1974; Tingley and Allen, 1975; Kent, 1980). If variability is taken as an index of maturation of motor control, then it appears that a child's speech production continues to improve procession until at least, 11 to 12 years of age. This gradual decline in performance variability as a function of age, accords with part of Bruner's (1973) definition of development of skilled acts.

Comprehensive data on the development of tuning control in children's. Speech also are needed for the quantitative study of speech disorders. Many disorders particulatory those of neurologic origin involve disturbance of timing control. For both diagnostic and rehabilitative purpose, it is useful to know similarities and differences between these abnormalities or timing normal development and the children's timing control of that of normal adults (Kent, 1980).

Speculations on the role of the cerebellum in motor control after emphasizes the need for the cerebellum to gain experience to predict and modify as required the motor consequences of efferent outflow. By this reasoning the cerebellum must be an active participant in the motor learning of speech production. There is at least a superficial resemblance in so far as both young children and individuals with dysarthria of cerebellum origin tend to have speech segments that are longer and more variable in duration than those of normal adults (Kent, Netsell, and Abbs, 1979). However, Kent (1980) has pointed out that although four year olds and cerebellar dysarthrias share a tendency of prolong speech segments, the timing control for sulbnere were determined duration does not seem to be fundamentally similar

for these two groups. Systematic studies of temporal regulation in developing and disordered speech should be helping in testing hypothesis abut the structures of motor programs in speech productions and the ways in which these programms are acquired and maintained.

There are guidances to show that slow speakers are more variable in timing control than fast speakers.

Vowel duration has been measured in various languages English (Klait, 1980; Raphael, et al. 1975; Walsh and Parker, 1981); Kannada (Rajapurohit, 1982); Malayalam (Velaudan); Tamil (Balasubramanyam, 1982); Japenese (Homma, 1981); Frech (O'Shaughnessy, 1981; Mack, 1982); Swedish (Lyberg, 1981); Hungarian (Fonagy, Fonagy and Dupuy, 1980) and in Dutch (Nooteboon, 1972).

The average durations of the English vowels have been named by Peterson and Lehiste (1960).

Factors that influence the durational structure of sentence are as follows (Klatt, 1976):

Extra linguistic:

Psychological and physical state
(Williams and Stevens, 1972).

Speaking rate (Huggeins, 1964)
(Goldman-Eisler, 1968).

Discourse level:

Position within a paragraph
(Lehiste, 1975).

Semantic:

Emphasis and semantic novelty
(Cokes et al. 1973)

Syntactic:

Phrase structure lengthening
(Martin, 1970; Klatt, 1975)

Word level

Word final lengthening
(Lehiste, 1972; Otter, 1973).

Phonological/phonetic

-> Inherent phonological duration for a segment (Peterson and Lehiste, 1960)

-> Effect of linguistic stress (Parameter and Trevino, 1936)

-> Effect of post vocalic consonant (House and Fairbanks, 1953).

Physiological:

Incompressibility (Klatt, 1973). In addition to these factors, Lyberg (1981) reported a strong relationship between duration and the fundamental frequency change. However, he further goes on to say that the fundamental frequency contours can never be a secondary effect of the segment durations and that it seems quite impossible to generate the fundamental frequency contour only from duration values.

Lee (1978) has reported that the difference in duration between tone classes is primarily determined by the shape of the fundamental frequency contour. The intrinsic duration of a vowel in a tone language is conditioned by the tone that the vowel carries.

On the other hand Notebborn (1972), Cooper (1976), Lindblom et al. (976) and Lehiste (1976) have observed duration to be independent of fundamental frequency contours.

Nataraja and Jagadeesh (1984) have shown a relationship between fundamental frequency of voice and vowel duration.

Rashmi (1985) has reported that both the males and females show a decrease in the vowel duration with increase in age. After 12 years the decrease in vowel duration is not significant. Dismoni (1973) reports similar findings.

Vowel Amplitude:

The problem as noted by several investigators (Carhart, 1970; Martony, 1968; Miller, 1968) may take several forms. Voicing may be too soft or too loud or the volume may vary erratically. Miller (1968) points out that the way in which the volume of a speakers voice is affected by hearing loss may depend on the nature of the impairment. An incividual with sensori-neural loss may tend to speak in an abnormally loud voice because he does not receive feedback whereas the patient with conductive loss may tend to speak softly.

Carhart to talk to each advocates (1970) that deaf people be trained of four or five levels of loudness and to shift from one to the other depending upon kinesthetic cues and reactions from listeners to judge the appropriateness of the level at which they are talking at any given time.

Peternon (1946) considers voice quality to be relatively important determinant of intelligibility. Adams (1914) on the other hand points out that while it may have little effect on intelligibility in a technical sense, it can play a very important role in determining whether what deaf speaker is saying will in fact be understood by an unfamiliar listener. She states that people who are unfamiliar with deaf persons may find their speech so disagreeable when they first encounter it that they may not make the effort necessary to understand it, even if it is adequate for communication.

The amplitude of sustained vowels were measured at dominant amplitude peak of each fundamental period of an acoustic signal in order to investigate the periodicity in the modulation of the amplitude. Laryngeal neoplans and unilateral laryngeal paralysis and the normals as controls were studied. High correlation was often found between the concecutive dominant amplitude peaks. The results seem to

indicate that amplitude information may be useful for the development of an objective measure to evaluate laryngeal dysfunction and to detect some pathologies in larynx (Yasuokoike, 1969).

Band width:

Research indicates that when the first and second formants of vowel are separated by less than about 3.5 Bark perception of its height and some other aspects of it quality are determined by some weighted average of the low frequency spectrum, rather then by particular harmonic or hypothetical formant frequencies. This spectral averaging has been called central of gravity effect (COG). Although the existence of the effect is generally accepted, the factors that govern it are poorly understood. One possibility is that the influance of spectral envelope on perceived vowel quality increases as low frequency spectra prominence become less well defined. A series of three experiments examined this possibility in (1) nasal vowels, where the Icwest spectral prominence is broader and flatter than the oral vowels; (2.) first versus second formant vowels with band width appropriate for oral vowels; and (3) two formant vowels with very narrow or very wide bandwidths.

The results of these experiments show that, when 2 or more spectral peaks lie within 3.5 Bark of one another, F_1 and the centroid roughly determine the boundaries within which the perceptual COG lies; the frequencies of spectral peaks dominate responses when formant bandwidths are narrow, where as overall spectral shape exerts more influence when spectral prominences are wide. Assuming that all vowels undergo the same processing, it is suggested that vowel quality, particularly height, is determined both by the frequency of the most prominent harmonics in LF region and by the slopes of skirts i the vicinity of these harmonics. These two effects are most clearly separable in vowels with poorly defined spectral prominence whose shape cannot be adequately described by specifying the frequencies and degree of prominence of just or two harmonics, or hypothetical formant peaks.

3.1

METHODOLOGY

Introduction:

The study was aimed to analyze the vowels in Kashmiri language and to provide information about formant frequencies, energy level, bandwidth and vowel duration cf 29 vowels seen in Kashmiri language.

The study consisted of the following steps:

Step-1 : Selection of subjects.
Step-2 : Selection of test material.
Step-3 : Recording of the test sample.
Step-4 : Analysis of speech samples for the measurement of
a) Formant frequencies
b) Energy levels
c) Bandwidths
d) Vowel duration

Subjects:

Five adult male and four adult female speakers in the age range of 18-25 years were selected as subjects. These subjects satisfied the following conditions ie. the subjects:

a) speaking Kashmiri as the mother tongue, and

b) had no speech and hearing disorder.

Speech material:

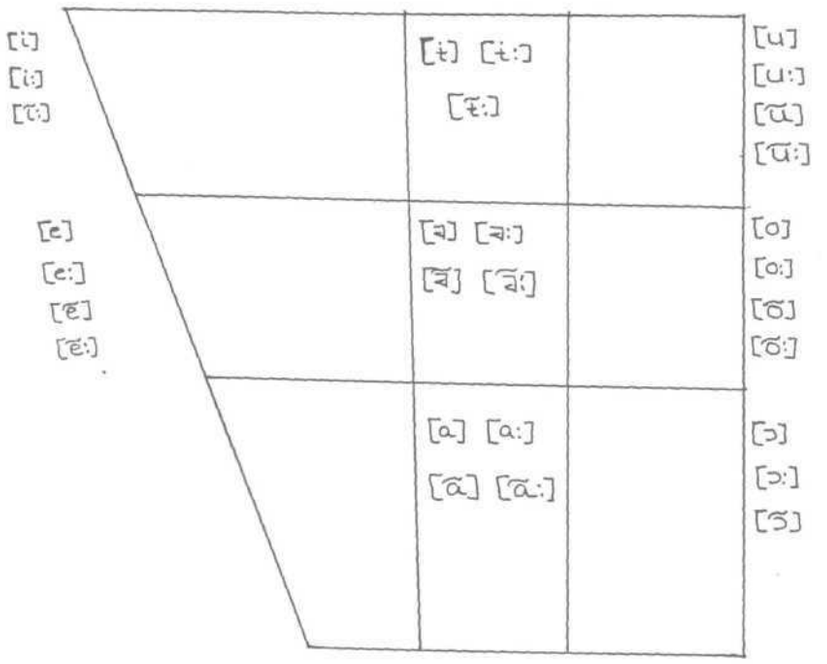
Speech material comprised of twenty-nine meaningful words - CVC combination. C1 and C2 were not constant. They were varied to form the meaningful word. Vowels studied were:

1.	[i]	11.	[ɨ]	21.	[õ:]
2.	[i:]	12	[ɨ:]	22.	[ū]
3.	[a]	13.	[ɔ]	23.	[ū:]
4.	[a:]	14.	[ɔ:]	24.	[a]
5.	[e]	15.	[ə]	25.	[ā:]
6.	[e:]	16.	[ə:]	26.	[ē]
7.	[u]	17.	[ɵ:]	27.	[ē:]
8.	[u:]	18.	[ɵ:]	28.	[ə̃]
9.	[o]	19.	[ɔ̃]	29.	[ə̃:]
10.	[o:]	20.	[õ]		

Description of vowels:

Zid	[i]	High front unrounded short vowel
bi:th	[i]	High front unrounded long vowel
ktr	[t]	High central unrounded short vowel
krt:l	[t:]	High central unrounded long vowel
kath	[a]	Low central short vowel

va:n	[a:]	Low central long vowel
beh	[e]	Mid front unrounded short vowel
saphe:d	[e:]	Mid front unrounded long vowel
kuth	[u]	High back rounded short vowel
ku:n	[u:]	High back rounded long vowel
dod	[o]	Mid back rounded short vowel
ko:th	[o:]	Mid back rounded long vowel
dɔd	[ɔ]	Low back rounded short vowel
sɔ:d	[ɔ:]	Low back rounded long vowel
thadZ	[a]	Mid central unrounded short vowel
ka:phi	[a:]	Mid central unrounded long vowel
p͡i:t͡ʃ	[i͡:]	High front unrounded long nasalized vowel
k͡t:t͡ʃʰ	[t͡:]	High central unrounded long nasalized vowel
tr͡ʃmb	[ɔ͡]	Low back rounded short nasalized vowel.
kõd	[õ]	Mid back rounded short nasalized
sõ:th	[õ:]	Mid back rounded long nasalized vowel
kūz	[ū]	High back rounded short nasalized vowel
tsū:th	[ū:]	High back rounded long nasalized vowel
kāh	[ā]	Low central short nasalized vowel
hā:gul	[ā:]	Low centrl long nasalized vowel
kēh	[ē]	Mid front unrounded short nasalized vowel
šē:kh	[ē:]	Mid front unrounded long nasalized vowel
pāz	[ā]	Mid central unrounded short nasalized vowel
hā:z	[ā:]	Mid central unrounded long nasalized vowel.



VOWELS IN KASHMIRI.

The speech material and the phonetic description of each vowel has ben taken from Kashmiri Phonetic Reader' (Jawahar Lal Handoo, 1983) - CIIL Phonetic Reader Series-8, Central Institute of Indian Languages, Mysore-6.

Attempts were made to select a voiceless stop for C2. When such a combination did not result in a meaningful word, then a voiced stop was selected.

The words were studied with a carrier phrase. The target word was embedded in a carrier phrase in the following format:

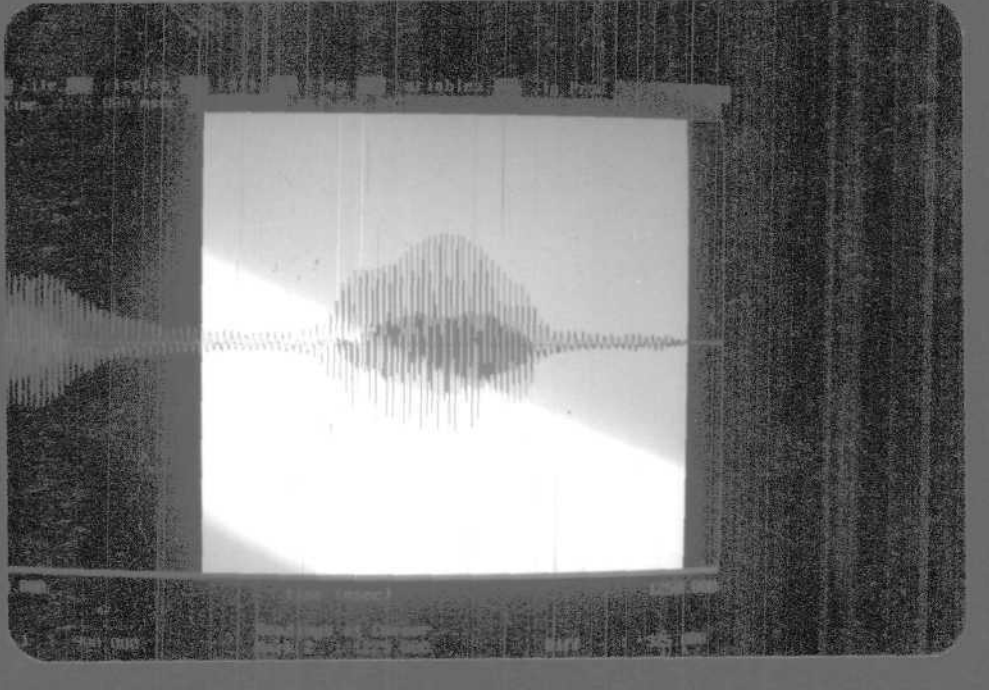
* Now I will say - target word.
* WΛnj ᴡΛNΛ bΛ - target word.

Recording procedure:

Each subject was seated comfortably in a sound treated room and was asked to read the stimulus material presented on 3' x 5" cards in front of microphone (AKG - unidirectional) placed approximately at a distance of 10 cms from his/her mouth. Each card was presented with a gap of 3—5 seconds. They were asked to read as normally as possible subjects were asked to repeat whenever they made a mistake.

These stimulus materials were digital1y recorded on magnetic diskettes using PC/AT computer with a 12 bit A/D and D/A converter at a sampling frequency of 16 KHz using record

Pic. 1: RECORDING SET UP



Pic. 2: MONITOR SHOWING WAVEFORM OF VOWEL (i:)

Acoustical analysis:

The target word was segmented from the carrier phrase and subjected to the acoustic analysis to derive the above four defined parameters.

Measurement of vowel duration:

The vowel duration of the target word was measured from the spectrogrm as follows:

The time duration between the initial regular vibration to the final regular vibration associated with the vowel that followed the initial stop consonant.

Measurement of formant frequency, level and bandwidth:

The formant frequencies (F_1, F_2, F_3, F_4), level (L_1, L_2, L_3, L_4.) and bandwidth (BW_1, BW_2, BW_3, BW_4) were extract using "VSS - Analysis" program. This program is based on LPC - Auto correlation method. The window size of 30 mili seconds and at 10 mill seconds resolution incase of male speech samples. In case of female speech samples the window size was 15 miliseconds and the resolution was 5 m.sec.

The middle pitch period of the test vowel was identified using speech wave form editor program DWSSDSP'. This pitch period was blocked and subjected to LPC (14 and 12 coefficients). The formant data, level and the bandwidths were obtained.

4.1

RESULTS AND DISCUSSION

The study aimed at acoustic analysis of 29 vowels which included long oral vowels, short oral vowels, long nasal vowels and short nasal vowels position as uttered by five males and five female subjects of the word along with a carrier phrase.

The vowels were analyzed to obtain:

1. Formant frequencies (Fl, F2, F3 and F4)
2. Formant intensities (LI, L2, L3 and L4)
3. Bandwidths (BW1, BW2, BW3, and BW4)
4. Vowel duration (VD)

The mean, standard deviation and the range (minimum to maximum) of all the above parameters for males and females are presented.

Table-1 : Shows reulst of male subjects.:

Vowel	F1	F2	F3	F4	L1	L2	L3	L4	BW1	BW2	BW3	BW4	VD
[i]	458.8 (18.12)	2270.8 (4.08)	3369.2 (18.75)	5102.2 (47.51)	42.2 (4.32)	58.8 (3.19)	76.4 (3.57)	69.6 (3.20	103 (18.80)	86.2 (18.97)	96.4 (8.41)	300.8 (41.33)	102.4 (18.25)
[i:]	366.8 (21.89)	1856 (12.21)	2534 (43.41)	3300.6 (11.88)	61.6 (2.96)	62.8 (2.38)	66 (2.73)	70.8 (4.14)	102.6 (21.57)	120.2 (11.90)	169.6 (5.02)	296 (18.68)	246 (30.36)
[ɪ:]	357.6 (27.85)	1763.4 (66.89)	2352.76 (36.82)	3747.12 (47.12)	69.6 (2.07)	43.2 (3.19)	54.2 (3.96)	41.6 (4.50)	120.2 (6.34)	198.8 (38.71)	74.4 (7.53)	377.4 (10.0)	261 (40.54)
[ʊ]	429.6 (24.99)	935 (20.48)	2089.8 (34.44)	3185.4 (23.09)	71 (1.58)	63 (2.54)	58.6 (2.96)	62.6 (6.02)	104.6 (10.85)	127 (14.83)	123.6 (5.98)	161.6 (36.75)	100.8 (18.49)
[ʊ:]	462 (21.18)	837.8 (17.48)	2452.4 (36.26)	3178.6 (30.75)	69.4 (2.70)	61.8 (3.03)	55.6 (4.03)	66.2 (5.67)	114.2 (13.21)	259.2 (43.83)	106.2 (6.72)	340 (28.01)	252.2 (64.46)
[ɑ]	410 (17.62)	820. (28.94)	2380.4 (34.41)	3170.6 (22.73)	55.4 (2.70)	67.6 (3.20)	63.6 (4.21)	64.8 (4.65)	58.2 (10.13)	222.8 (29.34)	134.8 118.56)	98.4 (44.46)	160.8 (20.74)
[ɑ:]	380.4 (9.28)	868.2 (39.97)	2440.8 (40.99)	3337 (34.63)	59.4 (3.20)	64.8 (2.77)	61.4 (61.18)	65.6 (4.56)	118.2 (5.16)	534.2 (23.74)	189.2 (10.61)	321.6 (42.29)	262.4 (26.34)
[e]	458.8 (52.56)	1664.8 (23.05	2436.2 (45.86)	3258.8 (21.18)	63.8 (2.58)	71.4 (2.30)	70.4 (3.36)	70.2 (3.89)	92.2 (16.97)	137.2 (25.47)	312.4 (25.14)	260.4 (38.8)	154.6 (46.40)
[e:]	459 (28.39)	1730.2 (17.66)	2441.2 (88.6)	3460.6 (36.97)	70.4 (2.07)	60.2 (1.48)	56 (3.53)	66.6 (3.71)	66 (8.15)	73.4 (13.4)	208.2 (5.80)	181 (15.04)	191 (29.09)
[ɛ:]	368.2 (14.30)	1600 (21.93)	2312.2 (13.12)	3313 (22.27)	40.8 (5.76)	44.8 (1.48)	55.8 (3.19)	49.6 (2.19)	128 (34.24)	243 (33.1)	286 (41.24)	429.6 (76.65;	234.6 (17.86)
[ɛ]	359.8 (32.01)	135b (45.72)	2392 (17.67)	3279.4 (26.62)	40 (4.18)	76.6 (2.07)	61 (2.44)	60 (2.23)	129.2 (5.35)	235.6 (2.84)	186.6 (19.93)	305.4 (34.70)	149.2 (38.53;
[o]	469.8 (23.64)	950.4 (26.66)	2514.8 (20.4)	3399.4 (27.12)	66.4 (3.04)	44.2 (4.08)	71.6 (2.88)	73.2 (4.43)	79.8 (26.1)	118.8 (7.29)	128.2 (15.12)	176.8 (68.12)	142 (15.74)

Vowel	F1	F2	F3	F4	LI	L2	L3	L4	BW1	BW2	BW3	BW4	VD
[ɑ:]	410.4 (19.08)	835.2 (34.6)	2419 (34.l5)	3257.8 (29.55)	71.6 (2.40)	56.2 (3.34)	58.2 (3.56)	70.4 (7.70)	110.6 (24.09)	146.6 (26.11)	139.8 (21.52)	79.8 (18.96)	246.6 (36.08)
[ʘ:]	386.4 (16.13)	895.6 (45.67)	2471.8 (46.75)	3334.4 (31.76)	69.4 (1.61)	68.1 (3.53)	55.6 (4.44)	68 (3.93)	113.2 (28.72)	29.4 (26.02)	115.6 (11.21)	326.2 (46.17)	254 (40.64)
[ɓ]	425.6 (22.64)	2215.5 (18.89)	3056.6 (36.05)	3813 (39.76)	68.6 (3.04)	39.8 (3.49)	65.8 (3.49)	78 (2.91)	116.4 (10.13)	234.6 (56.73)	111.4 (35.59)	265.6 (40.83)	157.2 (26.12)
[ɑ̃]	341.6 (15.77)	878.2 (20.58)	2279.4 (21.89)	3114 (55.55)	69.4 (2.40)	69 (2.64)	65.2 (3.70)	65.2 (3.27)	117 (19.89)	181.8 (83.85)	192.4 (33.36)	321.6 (40.24)	171 (29.67
[ɔ]	633.6 (20.00)	1064.4 (31.65)	2614.6 (14.72)	3349.2 (29.81)	64.4 (4.93)	74.6 (2.70)	78.6 (3.04)	77.2 (5.21)	107.6 (23.77)	904 (14.97)	161.2 (28.7)	253.6 (21.8)	175.6 (19.11)
[ɔ:]	645 (12.20)	960.4 (23.25)	2655.4 (37.38)	3580 (33.99)	56.8 (2.77)	73.4 (2.30)	68.6 (3.57)	65.6 (4.61)	112.6 (23.71)	140 (8.57)	157.8 (31.21)	443.6 (29.44)	258.4 (55.35)
[t]	561.4 (56.6)	1117.4 110.73)	2389.2 (37.9)	3204.8 (56.93)	70 (3.39)	48.2 (2.58)	61.8 (.92)	64.2 (5.44)	102.4 (24.7)	149 (32.2)	238.6 (18.54)	102 (16.80)	150.2 (20.47)
[t:]	409.2 (25.561	1105.6 (15.89)	2209 (45.62)	3540.8 (43.17)	71.2 (1.92)	56.2 (1.92)	59.8 (2.16)	80 (4.06)	95.2 (36.38)	135 (15.95)	254.8 (25.72)	115.2 (42.07)	234.4 (56.61)
[ɾ:]	384.4 (29.05)	924.6 (47.65)	2106.6 (24.40)	3233.2 (33.70)	65.4 (2.07)	66.2 (3.11)	60.4 (4.5)	62.6 (7.23)	109.2 (7.91)	189.6 (98.41)	219.2 (14.23)	438.8 (9.33)	261.2 (28.88)
[ɑ]	726.2 (19.24)	1072 (26.16)	2416.6 (20.41)	3365.6 (12.50)	56.2 (2.38)	78.8 (3.34)	71.8 (3.70)	55.8 (3.56)	63.8 (13.77)	139.8 (22.68)	147 (25.33)	216 (40.63)	143.4 (29.25)
[ɑ:]	441 (31.59)	979.2 (35.13)	2474.4 (39.27)	3359.6 (25.32)	58.2 (2.38)	68.4 (5.22)	53.8 (3.27)	56 (4.18)	121.4 (1.51)	246.8 (98.32)	199 (29.24)	238.2 (46.60)	184.2 (41.98)
[ɑ]	739.6 (11.7)	1155.2 (26.88)	2391 (31.73)	3917.6 (71.89)	72.8 (3.19)	76 (3.16)	71 (6.67)	66.6 (3.28)	95.8 (19.7)	77.6 (21.98)	158.4 (11.56)	401.2 (15.75)	127.4 (23.26)

Vowel	Fl	F2	F3	F4	L1	L2	L3	L4	BW1	BW2	BW3	BW4	VD
[a:]	799.6 (40.77)	1049.8 (35.3)	2491.2 (69.72)	3341.8 (38.86)	56.4 (5.45)	72.8 (2.88)	60.6 (3.57)	66.6 (4.44)	58.6 (8.20)	130.8 (20.38)	394.2 (13.95)	310.6 (8.44)	285.6 (41.97)
[ə]	475.2 (10.66)	1123 (13.92)	2469.8 (36.16)	3102.4 (55.55)	161.8 (2.38)	65.6 (2.07)	71.2 (4.20)	64.2 (3.27)	87.4 (8.79)	80.4 (13.53)	132.6 (3.91)	167.6 (59.62)	125.4 (17.78)
[ɜ:]	565.4 (36.10)	1247.8 (23.3)	2205.2 (35.08)	3107.4 (59.45)	68.8 (2.86)	70.2 (2.86)	72.6 (3.04)	73 (3.31)	82.8 (19.04)	119.6 (23.23)	233.8 (26.62)	126 (63.03)	148.4 (24.49)
[ɐ̃:]	370.2 (15.15)	942.6 (40.02)	2595 (49.74)	3083.2 (28.49)	65.4 (3.04)	67.8 (4.43)	74 (3.16)	82.1 (6.61)	88 (17.60)	316.8 (26.83)	233.4 (14.63)	232.4 (69.73)	202.6 (87.15)
[ɐ̃]	334.4 (23.21)	1052.6 (41.65)	2407.4 (26.85)	3579 (22.96)	45.2 (3.34;	32.6 (3.36)	63.2 (3.70)	45.2 (4.20	132.2 (12.51)	251.2 (32.62)	261.2 (45.02)	465.2 (28.72)	171 (6.63)

FORMANT FREQUENCIES OF VOWELS

The mean average value and the standard deviation of the first four formants of all the vowels have been presented in Table-1.

The analysis of the vowel [i] the formants showed Fl of 458 Hz in the range of 37.4 Hz - 547 Hz and the Standard Deviation was 18.2 whereas the F2 was 2270 in the range of the 226 Hz to 2276 Hz and the Standard Deviation was 36.08. 3369 Hz was the mean F3 in the range of 3247 to 35.62 Hz and the Standard Deviation was 18.75. The mean F4 was 5102 Hz in the range of 4938 to 5287 Hz and the Standard Deviation was 47.5.

Vowel [i:] long showed 366.8 Hz as Fl it ranged from 337 to 395 Hz, the Standard Deviation 21.89 Hz, was seen as F2 with range varying from 1845 Hz - 875 Hz and the Standard Deviation was 12.2. F3 was 2643 Hz and the range of 2494 to 2601 Hz and Standard Deviation was 43.41 whereas Ft was 3300.6 Hz and it ranged from 3291 Hz to 3319 Hz and Standard Deviation being 11.80.

For [t] Fl was 561 Hz with the range varying from 473 Hz to 624 Hz, and Standard Deviation 56.61. The F2 calculated

was 1174.4 Hz with a range of 1105 Hz to 1134 Hz and Standard Deviation being 10.73. The F3 was 238 Hz with range of 2290 Hz to 2506 Hz and Standard Deviation being 37.9. The mean F4 was 3204 Hz with a range of 3129 to 3263 and Standard Deviation being 56.93.

For [t:] Fl was 409.2 Hz with the range of 382 to 435 Hz and the Standard Deviation was 25.56, F2 - 1105.6 Hz with range of 1087 to 1125 and Standard Deviation of 15.89, F3 was Standard Deviation 45.62, F4 obtained was 3540 Hz with range of 3501 Hz -3606 Hz and the Standard Deviation of 43.17.

Vowel [a] revealed Fl as 475 with the range of 460 Hz to 489 Hz and Standard Deviation 10.66, F2 1123 Hz with the range of 1105 to 1138 Hz and the Standard Deviation 13.92, F3 was 2489 Hz with the range of 2449 Hz to 2548 Hz and Standard Deviation 36.16, F4 was 3102.4 Hz with range of 3017 to 3168 Hz and Standard Deviation 55.55.

The mean of first formant frequencies for vowel [a:] was 565.4 Hz and it ranged from 522 Hz - 612 Hz and Standard Deviation was 36.10, F2 mean was 1247.8 Hz and Standard Deviation was 23.3 with the range of 1223 Hz to 128 Hz, For F3 the mean value was 2205.2 Hz with the lower and upper limit of the range being 2155 Hz and 2256 Hz respectively and

Standard Deviation being 35.08. The mean value of F4 was 3107.4 Hz and it ranged from 3040 Hz to 3199 Hz and the Standard Deviation was 59.4.

For vowel [e] the mean of the first formant was 458.8 and the range was 415 Hz to 535 Hz and the Standard Deviation being 53.56. For F2 the mean value was 1664.8 with range of 1628 Hz and 1689 Hz and Standard Deviation was 23.05. The mean for F3 was 2436.2 and it ranged from 2395 Hz to 2511 Hz and the Standard Deviation was 45.86. F4 had a mean value of 3258 Hz. with the range of 3255 to 3307 Hz and the Standard Deviation was 21.18.

The study of Table-1 [e:] revealed Fl, mean value, as 459 Hz with range of 417 Hz 483 Hz and the Standard Deviation was 28.39. The F2 mean value was 1730.2 Hz with range of 1706 Hz 1750 Hz and the Standard Deviation of 7.66 was observed. The mean F3 value was 2441.2 Hz with the range of 2374 to 2586 Hz and the Standard Deviation was 88.6 whereas the mean. F4 was 3460.6 Hz the range being 1675 to 2007 Hz and the Standard Deviation was 36.97.

For Vowel (a) the mean Fl was 739.6 Hz and the range was 627 to 754 Hz and the Standard Deviation being 11.7. The mean F2 was 1155 Hz with the range of 1124 to 1187 Hz and the

Standard Deviation being 35.08, The mean value of F4 was 3107.4 Hz and it ranged from 3040 Hz to 3199 Hz and the Standard Deviation was 59.4.

For vowel [e] the mean of the first formant was 458.8 and the range was 415 Hz to 535 Hz and the Standard Deviation being 53.56. For F2 the mean value was 1664.8 with range of 1628 Hz and 1689 Hz and Standard Deviation was 23.05. The mean for F3 was 2436.2 and it ranged from 2395 Hz to 2511 Hz and the Standard Deviation was 45.86. F4 had a mean value of 3258 Hz. with the range of 3255 to 3307 Hz and the Standard Deviation was 21.18.

The study of Table-1 [e:] revealed Fl, mean value, was 459 Hz with range of 417 Hz 483 Hz and the Standard Deviation was 28.39. The F2 mean value was 1730.2 Hz with range of 1706 Hz 1750 Hz and the Standard Deviation of 7.66 was observed. The mean F3 value was 2441.2 Hz with the range of 2374 to 2586 Hz and the Standard Deviation was 88.6 whereas the mean. F4 was 3460.6 Hz the range being 1675 to 2007 Hz and the Standard Deviation was 36.97.

For Vowel (a) the mean Fl was 739.6 Hz and the range was 627 to 754 Hz and the Standard Deviation being 11.7. The mean F2 was 1155 Hz with the range of 1124 to 1187 Hz and the

Standard Deviation being 26.88. The mean F3 value was 2391 Hz and it ranged from 2364 Hz to 2444 Hz and the Standard Deviation was 31.73. 3914 Hz was the mean F4 and it ranged 3801 Hz to 3997 Hz with Standard Deviation being 71.89.

The analysis of [a:] has shown mean Fl was 799.6 Hz with the range of 624-710 and the Standard Deviation as 40.77. F2 1049.8 Hz with the range of 1005-1087 Hz found the mean and the Standard Deviation was 35.3. F3 had a mean value of 2491.2 Hz and it ranged between 2414 Hz to 2552 Hz and the Standard Deviation was 69.42. F4 mean value was 3341.8 Hz with the range of 3307 to 3400 Hz and the Standard Deviation was 38.86.

For vowel [u] the mean value, range and the Standard Deviation of the formant frequencies were for Fl the mean was 129 Hz and range was 397 Hz to 459 Hz ana the Standard Deviation was 24.99. The mean F2 was 935 Hz and the range being 900 Hz to 952 and the Standard Deviation 20.48. The mean F3 was 2089 Hz with the range of 2047 Hz to 2139 Hz and the Standard Deviation was 34.44. For F4 the mean value was 3185.4 Hz, the range was 3155 Hz to 3216 Hz and the Standard Deviation was 23.09.

For vowel [u:] the Fl mean value was 462 Hz with the range of 438 to 489 Hz of the Standard Deviation being 21.18. Mean F2 value was 837.8 Hz with the range of 824 to 867 Hz and the Standard Deviation 17.4. The F3 mean value was 2452.4 Hz with the range of 2398 Hz to 2496 Hz with a Standard Deviation of 36.36. The mean value of F4 was 3178 Hz the range was 3132 to 3223 Hz with a Standard Deviation of 30.75.

Analysis of [o] gave mean Fl value of 4696 Hz with the range of 456 Hz to 490 Hz and Standard Deviation was 23.62. F2 had a mean value of 950 Hz, with range varying from 906 Hz to 973 Hz and the Standard Deviation was 26.68. F3 ranged from 2331 Hz to 2668 Hz and the mean was 2514 Hz with Standard Deviation 20.4. The 3399 Hz was the mean value of F4 and it ranged from 3157 Hz to 3230 Hz with the Standard Deviation of 27.72.

Similarly, for [o:] mean Fl was 410.4 Hz and it ranged from 389 Hz to 430 Hz and the Standard Deviation was 19.08. F2 the mean was 835 Hz with a range of 807 to 895 Hz and Standard Deviation was 34.6. F3 varied from 2371 Hz to 2466 Hz with the mean of 2419 and the Standard Deviation was 34.15. F4 had a mean of 3257.8 Hz, the range was from 3321 to 3297 Hz and the Standard Deviation was 29.55

Analysis of vowel [ɔ] revealed the mean Fl as 633.6 Hz with the range of 610 to 655 Hz and the Standard Deviation was 20.00. Mean F2 was 1064 Hz with a range of 1024 to 1103 Hz and Standard Deviation was 31.65. For F3 the mean value was 2614 Hz, the range being 2598 to 2632 Hz and the Standard Deviation was 14.72. F4 had a mean of 3349.2 Hz with the range of 3397 to 3461 Hz and Standard Deviation 29.81.

For vowel [ɔ:] the mean value of Fl was 645 Hz with the range of 636 to 665 Hz and the Standard Deviation was 12.20. The mean F2 960.4 Hz with the range of 932 to 996 Hz of the Standard Deviation was 23.25. The mean value of F3 was 2655 Hz with a range of 2598 to 2701 Hz and the Standard Deviation was 37.38. F4 had a mean 3580 Hz and the range of 3532 Hz to 3628 Hz, the Standard Deviation 33.99.

NASALIZED VOWELS:

Analysis of nasalized vowel [ɔ̃:] showed mean Fl as 357.6 Hz with the range of 321 to 391 Hz and the Standard Deviation was 27.85. F2 had a mean of 1763.4 Hz with the range of 2378 to 2560 Hz and Standard Deviation was 66.89. Mean F3 was 2352.76 Hz, the range was 3498 to 3591 Hz and the Standard Deviation was 36.82. F4 had a mean value of 3747.12

with the range of 4708 to 4827 Hz and Standard Deviation being 47.12 [ĩ:] had mean Fl of 384.4 Hz with range of 406 Hz to 478 Hz Standard Deviation 29.05. 924 Hz was the mean of F2 with the range of 877 Hz and the Standard Deviation as 47.65. F3 had a mean value of 2106.6 Hz with range of 2510 to 2636 Hz and Standard Deviation was 24.40. F4 had a mean value of 3258 Hz with the range of 3198 Hz to 32.77 and Hz and the Standard Deviation being 33.70.

Analysis of [ā :] showed mean Fl was 370.2 Hz, it ranged from 347 to 389 with a Standard Deviation of 15.15. F2 mean value was 942.6 and the range was 867 to 981 Hz and the Standard Deviation was 40.02. F3 had a mean of 2595 Hz and the range was 2537 to 2654 Hz and the Standard Deviation was 49.54. F4 revealed a mean of 3083.2 Hz and range of 3055 Hz to 3215 Hz with the Standard Deviation of 28.49.

For [ū:] the formant mean values were Fl 380.4 Hz with the range of 372 Hz to 396 Hz and the Standard Deviation 9.28, F2 868.2 Hz with the range of 600 Hz to 700 Hz and the Standard Deviation of 39.97. The mean of F3 was 2440.8 Hz. The range was 2392 to 2482 Hz of the Standard Deviation was 40.99. Mean F4 was 3397 Hz with the range of 3290 Hz to 3378 Hz and the Standard Deviation of 34.63.

[õ:] had mean of Fl as 386.4 Hz the range as 36 Hz to 402 Hz the Standard Deviation 16.13. The mean F2 was 895.6 Hz and ranged 639 Hz to 764 Hz and the Standard Deviation was 15.67. The mean F3 was 2471 Hz and the range was 2427 to 2541 Hz and the Standard Deviation was 46.75. F4 had a mean value of 3334.4 Hz, the range was 3290 to 3376 Hz and Standard Deviation of 31.76.

[ā:] revealed mean Fl as 441 Hz with the range of 394 Hz to 468 Hz and the Standard Deviation was 31.59. Mean value of F2 was 979.2 Hz, the range was 953 to 1035 Hz and had the Standard Deviation of 35.13. F3 mean value was 2474.4 Hz, the range was 2419 Hz to 2512 Hz and Standard Deviation was 39.27. F4 mean value was 3359.6 Hz, the range was 3325 to 3395 Hz and the Standard Deviation was 25.32.

Mean Fl for [ē], was 359.8 Hz with the range of 515 Hz to 591 Hz and the Standard Deviation was 32.01. F2 mean value was 1356 Hz, the range was 1698 Hz to 1823 Hz and the Standard Deviation was 45.72 mean F3 was 2392 with the range of 2373 Hz to 2414 Hz and the Standard Deviation was 17.67. The mean value of F4 was 3279.4 Hz the range was 3239 Hz to 3311 Hz and the Standard Deviation was 26.62.

Vowel [ū] showed Fl mean of 410 Hz, the range of 390 Hz to 435 Hz and the Standard Deviation of 17.62 Hz. F2 mean was 820 Hz, the range was 887 to 960 Hz and Standard Deviation was 28.94. Mean F3 was 2380 Hz, the range was 2424 to 2514 Hz and the Standard Deviation was 14.41. F4 mean value 3170.6 Hz with the range of 3698 Hz to 3754 Hz and the Standard Deviation was 22.73.

For [ā] the mean Fl was 726 Hz and range was 702 Hz to 752 Hz and the Standard Deviation was 9.24. Mean value of 1072 Hz was for F2 and the range was 1035 to 1100 Hz and the Standard Deviation was 26.16. Mean F3 was 2416.6 Hz, the range was 2393 -2441 Hz and the Standard Deviation was 20.41. Mean F4 value was 3365.6 Hz with a range of 3341 Hz to 3392 Hz and Standard Deviation of 12.50.

Vowel [ɔ̃], the mean Fl was 425.6 Hz with the range of 827 Hz to 883 Hz and the Standard Deviation was 22.6. The Standard Deviation was 18.89. F3 had a mean of 3056.6 Hz and the range of 3015 to 3100 Hz and the Standard Deviation was 36.05. The mean F4 value was 3813 Hz, the range was 3762 to 3856 Hz and Standard Deviation was 39.76.

On analysis of [õ] the mean Fl was found to be 341.6 Hz, the range being 598 Hz to 641 Hz of the Standard Deviation

was 15.77. Mean value of F2 was 878.2 Hz, the range was 855 to 900 Hz and the Standard Deviation was 20.58. F3 mean value was 2279.4 the range was 2258 Hz to 2312 and the Standard Deviation was 289. Mean F4 was 3114 Hz and range was 3047 Hz to 3164 Hz and the Standard Deviation was 55.55.

[ã] vowel had mean Fl as 334.4 Hz with the range of 302 Hz to 328 Hz and the Standard Deviation was 23.21 Hz. Mean F2 was 1052.6 Hz, the range was 1012 Hz to 1118 Hz and the Standard Deviation was 14.65. The mean F3 value was 2407.4, the range was 2382 Hz to 2447 Hz and the Standard Deviation as 26.85. Mean value of F4 was ^579 Hz with the range of 3556 to 3607 and the Standard Deviation was 22.96.

Analysis of [ẽ:] revealed the mean Fl as 368 Hz with the range of 352 Hz to 389 Hz and the Standard Deviation was 14.30. Mean F2 was 1600 Hz, the range was 1760 Hz to 1826 Hz and Standard Deviation was 2.93. F3 mean value was 2312 Hz and the range was 2137 to 3376.5 and the Standard Deviation was 13.12. Mean F4 was 3313 Hz with the range of 3279 Hz to 3334 Hz and the Standard Deviation was 22.27.

BANDWIDTH:

The bandwidths (BW1, BW2, 8W3 and BW4) of the first four formants obtained using LPC co-variance and the results were:

For vowel [i] the mean BW1 was 103 Hz with the range of 74-123 Hz and Standard Deviation 18.80. BW2 mean value was 86.2 Hz with the range of 68-115 Hz and 18.97 being the Standard Deviation. For BW3 the mean was 96.4 Hz with the range of 88-107 Hz and Standard Deviation 8.41. BW4 was 300.8 Hz with the range 231-335 Hz and Standard Deviation being 102.4.

On analysis of vowel [i:] the mean BW1 as 102.6 Hz with the range of 80-126 and Standard Deviation 2.57. Mean of BW2 was 120.2 Hz with the range of 112 to 141 Hz and with a Standard Deviation of 11.90. BW3 mean value was 169.6 Hz, the range was 162-176 Hz and Standard Deviation was 5.02. For BW4 mean was 296 Hz with the range of 275-325 Hz and Standard Deviation was 18.68.

Vowel [t] showed mean BW1 as 105.4 Hz with the range of 72-128 Hz and the Standard Deviation 24.7. Mean BW2 was 149 Hz with the range 102-193 Hz and Standard Deviation 32.2. BW3 as 238.6 Hz, the range being 214-260 Hz and the Standard Deviation 18.54. BW4 mean value was 102 Hz, the range was 80-125 Hz and the Standard Deviation was 16.80.

For [t:], BW1 mean value was 95.2 Hz with the range of 45-139 Hz and Standard Deviation 36.38. BW2 mean was 135 Hz

with the range 121-158 Hz and the Standard Deviation being 15.95. BW3 mean value was 254.8 Hz, the range was 231-298 Hz and the Standard Deviation 25.72. Mean BW4 was 115.2 Hz with the range of 84-189 Hz and the Standard Deviation of 42.07.

Vowel [a] revealed BW1 mean value as 87.4 Hz, the range was 79 to 100 Hz and Standard Deviation was 8.79. Mean BW2 was 80.4 Hz with the range of 62 to 98 Hz and Standard Deviation being 13.53. BW3 had a mean of 132.6 Hz, the range was 128 to 137 Hz and Standard Deviation 3.91. Mean BW4 was 167 Hz with the range of 128-273 Hz and the Standard Deviation was 59.62.

For vowel [a:] the mean BW1 was 82.8 Hz the range was 60-112 Hz and the Standard Deviation was 19.04. Mean BW2 119.6 Hz with the range of 85-149 Hz and the Standard Deviation being 23.23. BW3 mean value was 233.8 Hz with the range of 198 to 263 Hz and had the Standard Deviation of 26.62. For BW4 the mean was 126 Hz with the range of 53 to 207 Hz and the Standard Deviation was 63.03.

Analysis of vowel [e] revealed mean BW1 of 92.2, the range being between 74-112 Hz and the Standard Deviation 16.97. For BW2 the mean value was 137.2 Hz, with the range of 102 to 168 Hz and the Standard Deviation of 25.47. BW3

was 312.4 Hz and the range was 274 to 334 Hz and the range was 274 to 334 Hz and the Standard Deviation was 25.74. For BW4 the mean was 260.4 Hz with the range of 197 to 301 Hz and the Standard Deviation was 38.8.

For [e:] the mean value of BW1 was 66 Hz, the range was 54 to 75 Hz and the Standard Deviation being 8.15. Mean BW2 was 73.4 Hz, the range being 53 to 89 Hz and the Standard Deviation of 13.4. BW3 mean was 208.2 Hz with the range of 199-215 Hz Standard Deviation being 5.80. BW4 mean value was 181 Hz with the range of 167 to 200 Hz and the Standard Deviation was 15.04.

BW1 mean value for [a] was 95.8 Hz with the range of 75 to 128 Hz and the Standard Deviation 19.7 the mean of BW2 was 77.6, the range was 51 to 110 Hz and the Standard Deviation of 2.98. For BW3 mean was 158.4 Hz with the range of 144 to 173 Hz and the Standard Deviation was 11.56. BW4 mean value was 401.2 Hz and the range was 375 to 415 Hz and Standard Deviation was 15.75.

The mean BW1 for [a:] was 58.6 Hz the range was 46 to 68 Hz and Standard Deviation being 8.20. Mean BW2 was 130.8 Hz with the range of 115 to 165 Hz and Standard Deviation being 20.38. Mean BW3 was 394.2 Hz, the range was 376 to 411 Hz

and the Standard Deviation was 13.95. BW4 mean was 310.6 Hz with the range of 299 to 320 and with the Standard Deviation of 8.44.

For [u] mean BW1 was 104.6 Hz, the range was 88-118 Hz and the Standard Deviation being 10.85. Mean BW2 was 127 Hz, the range was 113-150 Hz and the Standard Deviation was 14.83. Mean BW3 was 123.6 Hz and the ranged from 115.to 131 Hz, the Standard Deviation was 5.98. Mean BW4 mean value was 161.6 Hz, with the range of 120 to 214 Hz and the Standard Deviation was 36.75.

Vowel [u:] revealed mean BW1 as 114.2, with the range of 92 to 123 Hz, and the Standard Deviation of 13.21. Mean BW2 was 259.2 Hz and the range was 217 to 332 Hz, and the Standard Deviation was 43.83. Mean BW3 was 106.2 Hz, the range was 97 to 114 Hz and the Standard Deviation of 6.72. The mean BW4 was 30 Hz with the range of 295 to 367 Hz and the Standard Deviation being 28.01.

For [o] the mean BW1 was 79.8 Hz with the range of 58 to 12 Hz and the Standard Deviation was 26.1. Mean BW2 was 118.8 Hz with the range 106-124 Hz and the Standard Deviation was 7.29. Mean BW3 was 128.2 Hz with the range of 105-141 Hz, and the Standard Deviation being 15.13. Mean of BW3 was

176.8 Hz, the range was 115 to 262 Hz and the Standard Deviation was 63.13.

Similarly for vowel [o:] mean BW1 was 110.6 Hz with the range of 79 to 146 Hz and the Standard Deviation of 24.09. Mean BW2 value was 146.6 Hz, the range was 112 to 174 Hz and the Standard Deviation was 26.11. BW3 mean was 139.8 Hz and the range was 114 to 169 Hz, and the Standard Deviation was 21.52. Mean BW4 was 79.8 Hz with the range of 59 to 105 Hz and the Standard Deviation is being 18.96.

Analysis of [ɔ] revealed mean BW1 as 107.6 Hz with the range of 84 to 133 Hz and the Standard Deviation was 23.77. Mean BW2 was 904 Hz with the range of 78 to 110 Hz, and the Standard Deviation was 23.77. Mean BW2 was 904 Hz with the range of 78 to 110 Hz, and the Standard Deviation was 28.7. Mean BW4 was 253.6 Hz with the range of 231 to 277 Hz and the Standard Deviation of 2.80.

For [ɔ:] mean BW1 was 112.8 Hz with the range of 71 to 128 Hz and the Standard Deviation 23.71. Mean BW2 was 140 Hz with the range of 128 to 151 Hz, and the Standard Deviation of 8.57. Mean BW3 was 157.8 Hz with the range 114-196 Hz and the Standard Deviation was 31.21. BW4 mean value was 43.6 Hz, the range was 399-470 Hz and the Standard Deviation was 29.44.

NASALIZED VOWELS:

Analysis of [ĩ:] showed mean BW1 was 120.2 ranging from 122 to 544 Hz and the Standard Deviation was 6.34. Mean BW2 was 198.8 Hz with the range of 137 to 476 Hz, and the Standard Deviation of 38.71. Mean BW3 was 74.4 Hz with the range of 85 to 100 and the Standard Deviation was 7.53. Mean value of BW4 was 377.4 Hz with the range of 129 to 764 Hz and the Standard Deviation of 10.

Vowel [ẽ:] showed mean BW1 as 109.2 Hz the range was 332 to 857 Hz and the Standard Deviation was 7.91. Mean BW2 was 189.6 Hz with the range of 150 to 201 Hz and the Standard Deviation was 98.41. BW3 mean value was 219.2 Hz with the range of 84 to 1487 Hz and the Standard Deviation being 14.23. Mean BW4 438.8 Hz, the range was 200 to 495 Hz, and the Standard Deviation was 9.33.

For [ã:] mean BW1 was 88 Hz and the range was 311 to 423 Hz and the Standard Deviation was 17.o0. Mean BW2 was 316.25 Hz with the range of 320 to 371 Hz and the Standard Deviation of 26.83. BW3 mean value was 233.4 Hz with the range of 200 to 405 Hz and the Standard Deviation being 14.63. Mean BW4 was 232.4 with the range was 246-254 Hz and the Standard Deviation was 69.73.

Mean BW1 of [ū:] was 118.2 Hz, the range of 113 to 419 Hz and the Standard Deviation 5.16. Mean BW2 was 534.2 Hz with the range of 111 to 189.2 Hz and the Standard Deviation 23.74. Mean BW3 was 189.2 Hz the range was 88 to 272 Hz and the Standard Deviation was 10.61. Mean BW4 was 321.6 Hz, the range was 251 to 327 Hz and the Standard Deviation being 42.29.

For [õ:] mean BW1 was 113.2 Hz, with the range of 66 to 144 Hz and the Standard Deviation 28.72. Mean BW2 was 29.4 Hz, with the range of 194 to 257 Hz and the Standard Deviation was 26.02. Mean BW3 was 115.6 Hz, the range was 103 to 129 Hz, and the Standard Deviation 11.21. Mean BW4 was 26.2 Hz with the range of 278-397 Hz and the Standard Deviation being 46.17.

For [ā:] revealed mean BW1 of 121.4 Hz the range was 120 to 123 Hz and the Standard Deviation was 1.51. Mean BW2 was 246.8 Hz, the range was 114 to 376 Hz and the Standard Deviation was 98.32. Mean BW3 as 199 Hz, with the range of 179-249 Hz, and the Standard Deviation of 29.24, mean BW4 was 238.2 Hz the range was 182-296 Hz and the Standard Deviation was 46.60.

For [ē] the mean BW1 was 129.2 Hz, the range was 124 to 138 Hz and the Standard Deviation 5.35. Mean BW2 was 235.6 Hz, the range was 201 to 256 Hz and the Standard Deviation of 2.84. For BW3 the mean was 186.6 Hz the range was 160 to 206 Hz and the Standard Deviation was 19.93. Mean BW4 as 305.4 Hz the range was 263 to 352 Hz and the Standard Deviation was 34.70.

Vowel [ū] revealed that the mean BW1 was 158.2 Hz, the range was 143 to 171 Hz and the Standard Deviation was 10.13. Mean BW2 222.8 Hz, the range was 172 to 248 Hz and the Standard Deviation was 29.34. For BW3 mean was 13.8 Hz, with the range was 108 to 151 Hz and the Standard Deviation being 18.56. Mean BW4 was 98.4 Hz, the range was 44 to 156 Hz and the Standard Deviation was 44.46.

For [ā] mean BW1 was 63.8 Hz, the range was 42 to 79 Hz and Standard Deviation 13.77. Mean BW2 was 139.8 Hz, the range was 111 to 173 Hz and the Standard Deviation being 22.68. For BW3 the mean was 147 Hz, the range was 114 to 17c, Hz and the Standard Deviation was 25.33. For BW4 the mean value was 21b Hz, the range was 179 to 272 Hz and the Standard Deviation was 40.63.

Mean BW1 of [ɔ̃] was 116.4 Hz, the range was 98 to 12 Hz and the Standard Deviation 10.13. For BW2 was 234.6 Hz, the range was 150 to 287 Hz and the Standard Deviation was 56.73. Mean BW3 was 111.4 Hz, with the range of 75 to 164 Hz, and the Standard Deviation being 35.59. For BW4 the mean value was 265.5, the range was 22 to 301 Hz, and the Standard Deviation being 40.83.

Analysis of [õ] revealed mean BW1 as 117 Hz, the range was 90 to 140 Hz and the Standard Deviation was 19.89. Mean BW2 was 181.8 Hz, the range was 89 to 257 Hz and the Standard Deviation of 83.85. For BW3 the mean was 92.4 Hz, with the range was 168 to 250 Hz and the Standard Deviation of 33.36. Mean BW4 was 32.6 Hz, the range was 270-372 Hz and the Standard Deviation was 40.24.

For [ā] mean BW1 was 132.2, the range was 123 to 154 Hz and the Standard Deviation was 12.51. Mean BW2 was 251.2 Hz, the range was 312 to 289 Hz and the Standard Deviation being 32.62. For BW3 mean value 261.2 Hz, the range was 26.337 Hz. and the Standard Deviation being 45.02. Mean BW4 was 465.2 Hz with the range of 433 to 501 Hz and the Standard Deviation of 28.72.

Vowel [ē:] showed mean BW1 was 128 Hz with the range was 103 to 167 Hz and the Standard Deviation was 34.24. Mean BW2 33.1 was 243 Hz, with the range of 205 to 285 Hz and the Standard Deviation of 33.1. For BW3, the mean value was 286 Hz, the range was 232 to 338 Hz and the Standard Deviation being 41.24. Mean BW4 was 429.6 Hz, the range was 364 to 546 Hz, and the Standard Deviation 76.65.

FORMANT INTENSITIES

The energy level (L1 - L4) of the first four formants were calculated for each vowel in RdB.

On analysis [i], mean L1 was 42.2 RdB the range was 37 to 47 dB and the Standard Deviation was 4.32. The mean L2 was 58.8 RdB with the range of 55 to 63 dB and the Standard Deviation was 3.19. Mean L3 was 76.4 RdB with the range of 73 to 81 dB and Standard Deviation of 3.57 mean L4 value was 69.6 dB and the range was 65 to 73 dB with Standard Deviation of 3.20.

Vowel [i:] had L1 mean as 61.6 dB, the range of 57.67 dB and Standard Deviation was 2.96. Mean L2 was 62 dB, the range was 60 to 66 dB and the Standard Deviation being 2.38 L3 mean value was 66 dB with the range of 63 to 70 dB and

Standard Deviation was 2.73. Mean L4 was 70.8 dB, the range was 66 dB and the Standard Deviation was 4.14.

For [t], L1 mean value was 70 dB the range was 65 to 74 dB and the Standard Deviation was 3.39. Mean L2 was 48.2 dB, the range was 45 to 52 dB and the Standard Deviation was 2.58. L3 mean value was 61.8 dB, the range was 59 to 64 and Standard Deviation was 0.92. L4 mean value was 64.2 dB. The range was 57 to 70 dB and the SD was 5.44.

Vowel [t:] showed mean L1 as 71.2 dB, the range 69 to 74 and the Standard Deviation was 1.92. Mean L2 was 56.2 dB, the range was 56 to 61 dB and Standard Deviation was 1.02. L3 mean value was 59.8 dB, the range was 57 to 63 dB and Standard Deviation 2.16 mean. L4 was 80 dB with the range 74 to 85 dB and the Standard Deviation was 4.06.

Vowel [a] revealed mean L1 as 61.8 dB the range was 59 to 65 dB and the Standard Deviation was 2.38. For L2 the mean value was 65.6 dB with the range of 63 to 68 dB and the Standard Deviation of 2.07. L3 mean value was 71.2 dB, the range was 67 to 77 and the Standard Deviation 4.20. L4 mean was 64.2 dB, the range was 60 to 69 dB and the Standard Deviation was 3.27.

Formant intensity levels of vowel [a:] were mean L1 as 68.8 dB, the range was 65 to 72 dB and the Standard Deviation was as 2.36. L2 was 70.2 dB with the range of 67 to 74 dB and the Standard Deviation of 2.86. Mean L3 was 72.6 dB, the range was 69 to 77 dB and the Standard Deviation of 3.04. L4 mean value was 73 dB with the range of 68 to 77 dB and the Standard Deviation was 3.31.

Vowel [e] showed mean L1 as 63.8 dB with the range 60 to 67 dB and the Standard Deviation 2.53. Mean L2 as 71.4 dB, the range as 69 to 76 dB and the Standard Deviation of 2.30. L3 mean value was 70.4 dB, the range was 66 to 74 dB, and the Standard Deviation being 3.36. L4 was 70.2 dB with the range of 66 to 76 dB and the Standard Deviation was 3.89.

For [e:] mean L1 was 70.4 dB, the range was 68 to 73 dB and the Standard Deviation of 2.07. Mean L2 was 60.2 dB, the range was 58 to 62 dB and the Standard Deviation was 1.48. L3 mean value was 56 dB with the range being 52 to 61 and Standard Deviation of 3.53. L4 mean value was 06.6 dB with the range of 62 to 72 dB and had 3.71 as Standard Deviation.

Mean L1 for [a] was 72.8 dB with the range 69 to 77 dB and Standard Deviation of 3.19. L2 mean value was 76 dB with the range 1 to 38 dB and Standard Deviation was 3.16 L3 mean

value was 71 dB, the range was 60 to 77 dB and the Standard Deviation was 6.67. L4 mean value was 66.6 dB with the range of 63 to 71 dB and Standard Deviation of 3.28.

The mean L1 for [a:] was 56.4 dB, the range was 50-63 dB and the Standard Deviation was 5.45. L2 mean value was 72.8 dB with the range of 69-76 dB and the Standard Deviation of 2.8. Mean L3 was 60.6 dB, the range was 57-66 dB and the Standard Deviation was 3.57. Mean L4 value was 66.6 dB the range was 60.72 dB and Standard Deviation being 4.44.

For vowel [u] L1 mean value was 71 dB, the range was 69-73 dB and the Standard Deviation was 1.58. L2 mean value was 63 dB with the range of 60-66 dB and Standard Deviation was 2.54. Mean L3 was 56.6 dB with the range of 54-62 and had the 2.96 as the Standard Deviation. Mean L4 was 62.6 dB, the range was 55-70 dB and the Standard Deviation was 6.02.

Mean L1 for [u:] was 69.4 dB, the range was 65-70 dB and Standard Deviation being 2.70. L2 mean was 61.8 dB with the range of 58-66 dB and Standard Deviation of 3.03. L3 mean value was 55.6, the range was 51-60 dB and the Standard Deviation was 4.03, Mean L4 was 66.6 dB, the range was 58-72 dB and the Standard Deviation was 5.67.

For [o] mean L1 was 66.4 dB, the range was 60 to 7066 dB and the Standard Deviation was 3.04. L2 mean value was 44.2 dB, the range 38-49 dB and the Standard Deviation being 4.08. Mean L3 was 71.6 dB, the range was 69-76 dB and Standard Deviation was 2.83. Mean L4 value was 73.2 dB, the range being 269-80 31 dB and the Standard Deviation was 4.43.

L1 mean value for [o:] was 71.6 dB with the range of 69-75 dB and Standard Deviation being 2.40. Mean L2 was 56.2 dB the range was 52-60 dB and had 3.34 as the Standard Deviation. L3 mean value was 58.2 dB the range was 54-62 dB and the Standard Deviation was 3.56, mean L4 was 70.4 dB, the range was 59-77 and Standard Deviation was 7.70.

Analysis of vowel [ ] revealed mean L1 as 64.4 dB with the range of 60-70 dB and the Standard Deviation 4.03. Mean L2 was 74.6 dB, the range was 71-78 dB and the Standard Deviation was 2.70. Mean L3 78.6 and the Standard Deviation was 3.04 range was 75 to 82. Mean L4 value was 77.2 dB, the range was 72-85 dB and the Standard Deviation was 5.21.

Mean L1, for [:] was 56.8 dB with the range of 54-60 dB and Standard Deviation being 2.77. L2 mean value was 73.4 d5 with the range 71-77 dB and the Standard Deviation was 2.30. Mean L3 was 68.6 dB the range was 55-73 dB bad 3.57 as

Standard Deviation. L4 mean value was 65.6 dB, the range was 60-71 dB and the Standard Deviation was 4.61.

NASALIZED VOWELS

Vowel [T:] showed mean L1 as 64.6 dB with the range of 67-72 dB and the Standard Deviation was 2.07. Mean L2 was 43.2 dB the range was 34-47 dB and the Standard Deviation being 3.19. Mean L3 was 54.2 dB, in the range was 49-58 dB and the Standard Deviation was 3.96. Mean L4 was 41.6 dB, with the range was 35-47 dB and the Standard Deviation was 4.50.

Analysis of [ī:] revealed mean L1 was 65.4 dB, with the range of 63-68 dB and the Standard Deviation of 2.07. Mean L2 was 66.2 dB the range was 63.70 dB and Standard Deviation was 3.12. Mean L3 was 60.4 dB the range was 56-66 dB and the Standard Deviation was 4.15 mean L4 value was 62.6 dB, the range was 54 to 71 dB and the Standard Deviation was 7.73.

For [ī:] mean L1 value was 65.4 dB the range was 62-69 dB and the Standard Deviation was 3.04. L2 mean value was 67.8 dB with the range of 62-73 dB and the Standard Deviation was 4.43. Mean L3 was 74 dB, the range was 70-78 dB and the

Standard Deviation being 3.16. Mean L4 was 81.2 dB the range was 74 -89 dB and the Standard Deviation was 6.61.

[ū:] had mean L1 as 59.4 dB, the range was 55-62 dB, and the Standard Deviation was 3.20. Mean L2 was 64.8 dB, the range was 61.4 dB and the Standard Deviation being 2.77. Mean L3 was 61.4 dB, the range was 54-59 dB and had 6.18 the Standard Deviation. L4 mean value was 60.6 dB, tne range was 61-73 dB and the Standard Deviation was 4.56.

For [õ:] mean L1 was 69.4 dB with the range of 67-72 dB and the Standard Deviation was 1.81. Mean L2 was 68 dB with the range of 63-72 dB and the Standard Deviation was 3.53. Mean L3 was 55.6 dB, the range was 50-61 dB and the Standard Deviation was 4.44. L4 mean value was 68 dB, tne range was 64-73 dB and the Standard Deviation was 3.93.

Mean L1 for [ā:] was 38.2 dB, the range was 55-61 dB and the Standard Deviation was 2.38. L2 mean value was 68.4 dB the range was 62-75 dB and the Standard Deviation of 5.22. Mean L3 was 53.8 dB with the range of 49-58 and Standard Deviation 3.27. Mean L4 was 56 dB, the range being 51-62 dB and the Standard Deviation was 4.18.

For [ē] mean L1 was 40 dB with the range of 35-46 dB and the Standard Deviation 4.18. Mean L2 value was 76.6 dB, the range was 74-79 dB and the Standard Deviation was 2.07. L3 mean value was 61 dB the range was 58-64 dB and the Standard Deviation was 2.74. Mean L4 was 60 dB with the range of 57-63 dB and the Standard Deviation being 2-33.

Vowel [ū] revealed mean L1 as 67.6 dB with the range of 52-59 dB and Standard Deviation was 3.20. Mean L2 was 63.6 dB with the range of 63-71 dB and Standard Deviation being 4.21. Mean L3 was 64.8 dB with the range of 58-69 dB and the Standard Deviation of 4.65. L4 mean value was 58.2 dB with the range of 60-71 dB and Standard Deviation was 10-13.

For [ā] mean L1 was 56.2 dB, the range was 54-60 dB and the Standard Deviation was 2.38. Mean L2 was 78.8 with the range of 75-83 dB and the Standard Deviation of 3.34. mean L3 was 71.8 dB, the range was 68.77 dB and the Standard Deviation was 3.70. L4 mean value was 55.8 dB, the range being 52-60 dB and Standard Deviation being 3.56.

Mean of L1 for [ ] was 68.6 dB with the range of 69-73 dB and had 3.04 as the Standard Deviation. L2 mean was 39.8 dB with the range of 35-45 dB and the Standard Deviation was

3.76. Mean L3 value was 65.8 dB, the range was 62 - 70 dB and the Standard Deviation was 63.49. L4 mean value was 78 dB the range was 75-82 dB and Standard Deviation being 2.91.

For [õ] mean L1 was 69.4 dB, the range was 66-72 dB the Standard Deviation was 2.40. Mean L2 was 69 dB, the range was 65.7 dB, with the range of 60-69 and Standard Deviation 3.27.

On analysis of [ā] the mean L1 was 45.2 dB with the range of 40-44 dB and the Standard Deviation of 3.34. Mean L2 was 32.6 dB with the range of 39-47 dB and Standard Deviation was 3.36. L3 mean value was 63.2 dB, the range was 54.68 dB and the Standard Deviation of 3.70. Mean L4 was 45.2 dB with the range of 40-50 dB and Standard Deviation was 4.20.

Vowel [ē:] showed mean L1 as 40.8 dB with tr.e range of 33-47 dB and the Standard Deviation was 5.76. Mean L2 was 44.8 dB, the range was 43-47 dB and had 1.48 as tre Standard Deviation. L3 mean value was 55.8 dB with the range of 52-60 dB and Standard Deviation was 3.19. Mean of L4 was 49.6 dB with the range of 47-53 dB and Standard Deviation of 2.14.

VOWEL DURATION:

Results of the analysis gave the following mean vowel durations along with the range and the range and the Standard Deviation.

For [i] the mean vowel duration (VD) was 102 msec, with the range of 75 to 126 msec, and the Standard Deviation of 18.25.

[i:] had a mean duration of 246 msec. The range was 208 to 277 msec, and the Standard Deviation was 30.36.

Duration of [t] was 150 msec. The range was 115 to 167 msec, and the Standard Deviation was 20.47.

VD of [t:] was 234 msec, with the range of duration between 189 to 317 msec, and the Standard Deviation was 56.61

For [a] the duration was 125 msec. The range was between 96 to 140 msec, and the Standard Deviation was 17.78.

Vowel [a:] had a duration of 148 msec, the range being 119 to 178 msec, and the Standard Deviation being 24.49.

[e] had a duration of 154 msec. with the range of and the Standard Deviation.

For [e:] the duration was 191 msec. The range was 102 to 224 msec, and the Standard Deviation was 46.40.

Vowel [a] had a mean duration of 127 msec. The range was 90 to 154 msec, and the Standard Deviation was 23.28.

Mean VD of [a:] was 285 msec, the range was 225 to 337 msec, and the Standard Deviation of 41.92.

For [u] the mean VD was 140 msec, the range was 81 to 285 msec, and the Standard Deviation of 82.23.

[u:] had a mean VD of 252 msec, the range was 188 to 356 msec, and the Standard Deviation was 64.46.

Vowel Co] had a mean VD of 142 msec, the range was 122 to 156 msec, and the Standard Deviation was 15.74.

Similarly, for [o:] mean VD was 246 msec. The range was 198 to 285 msec, and the Standard Deviation was 36.08.

For [ ] the mean VD was 175 msec. The range was 148 to 200 msec, and the Standard Deviation was 19.11.

Vowel [:] had mean VD of 258 msec, the range was 204 to 317 msec, and the Standard Deviation was 55.35.

NASALIZED VOWELS:

For [ī:] the mean VD was 261 msec, the range was 204 to 304 msec, and the Standard Deviation was 40-54.

Mean Standard Deviation for [t:] was 236 msec. The range was 215 to 293 msec, and the Standard Deviation was 28.88

Vowel [ā:] had mean VD of 202 msec. The range was 114 to 316 and the Standard Deviation was 87.15.

For [ū:] mean VD was 262 msec, the range was 232 to 300 msec, and the Standard Deviation was 26.34.

Mean VD of [õ:] was 254 msec, the range was 189 to 292 msec, and the Standard Deviation was 40.65.

Vowel [ā:] had a mean duration of 184 msec. The range was 125 to 243 and the Standard Deviation was 41.98.

For [ē] mean VD was 149 msec, the range was 106 to 202 msec, and the Standard Deviation was 38.53.

[ū] had mean VD of 160 msec, the range was 133 to 180 msec, and the Standard Deviation 20.74.

[ā] had mean VD of 143 msec, with the range of 109 to 184 msec, and Standard Deviation being 29.25.

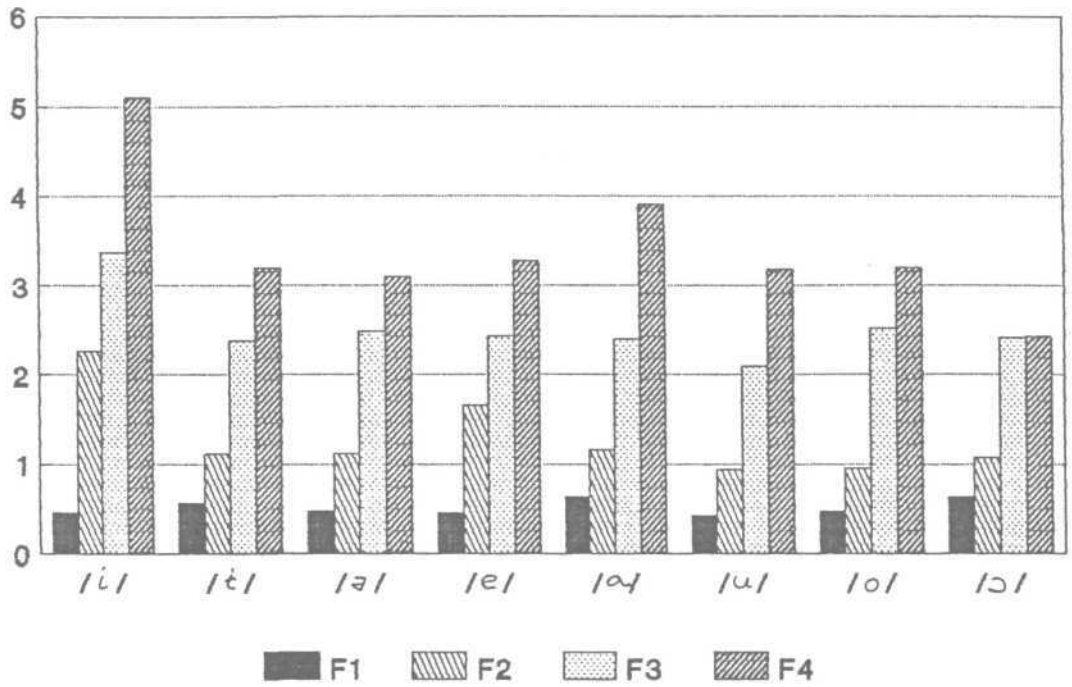
For [ ] the mean VD was 157 msec, the range was 138 to 203 msec, and the Standard Deviation was 26.12.

Vowel [õ] had mean VD of 171 msec the range was 123 to 201 msec, and Standard Deviation was 29.87.

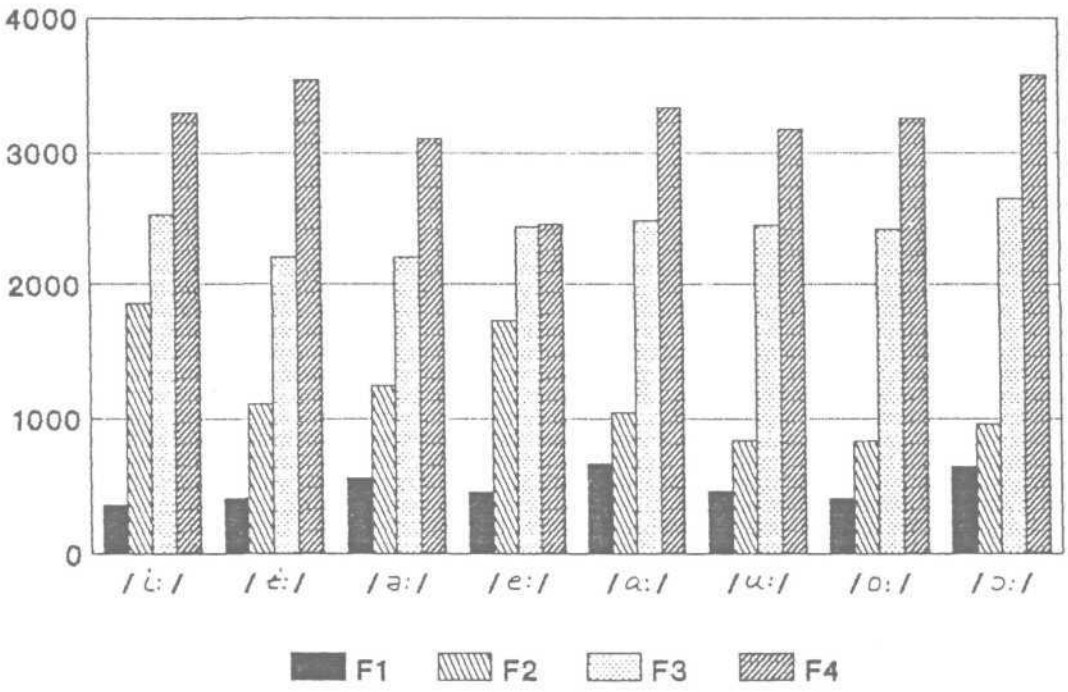
VD for [ā] was 182 msec, the range was 164 to 182 msec, and the Standard Deviation was 6.63.

Analyse of [ē:] revealed the mean VD of 234 msec, the range was 218 to 255 msec, and the Standard Deviation was 17.86

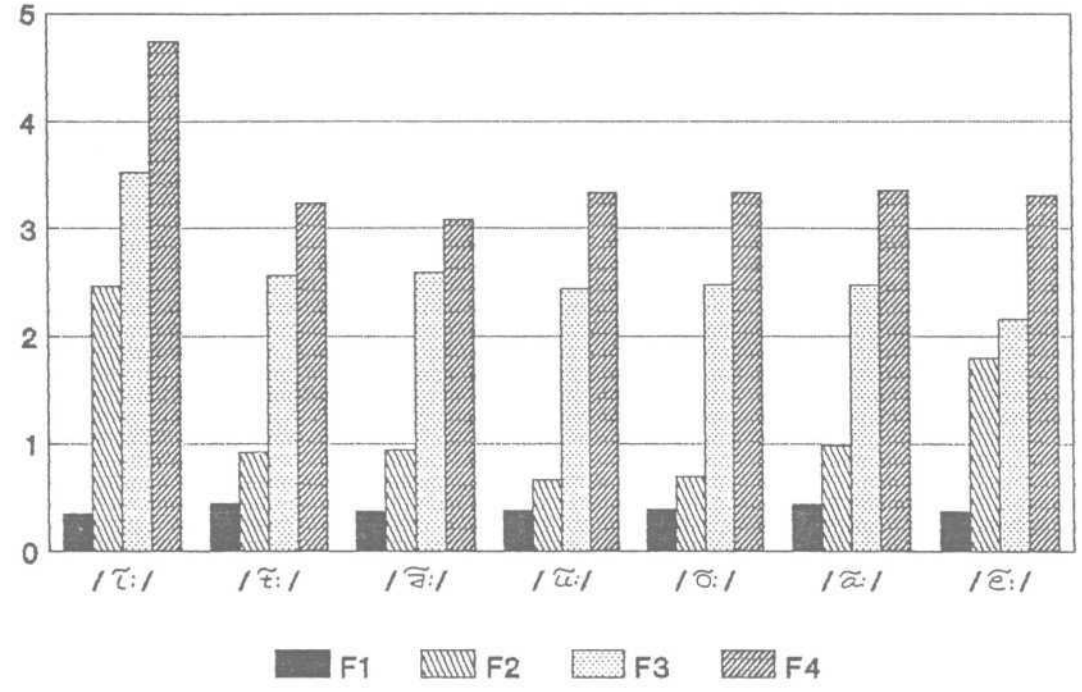
Formant frequencies of short oral vowels
(in males)



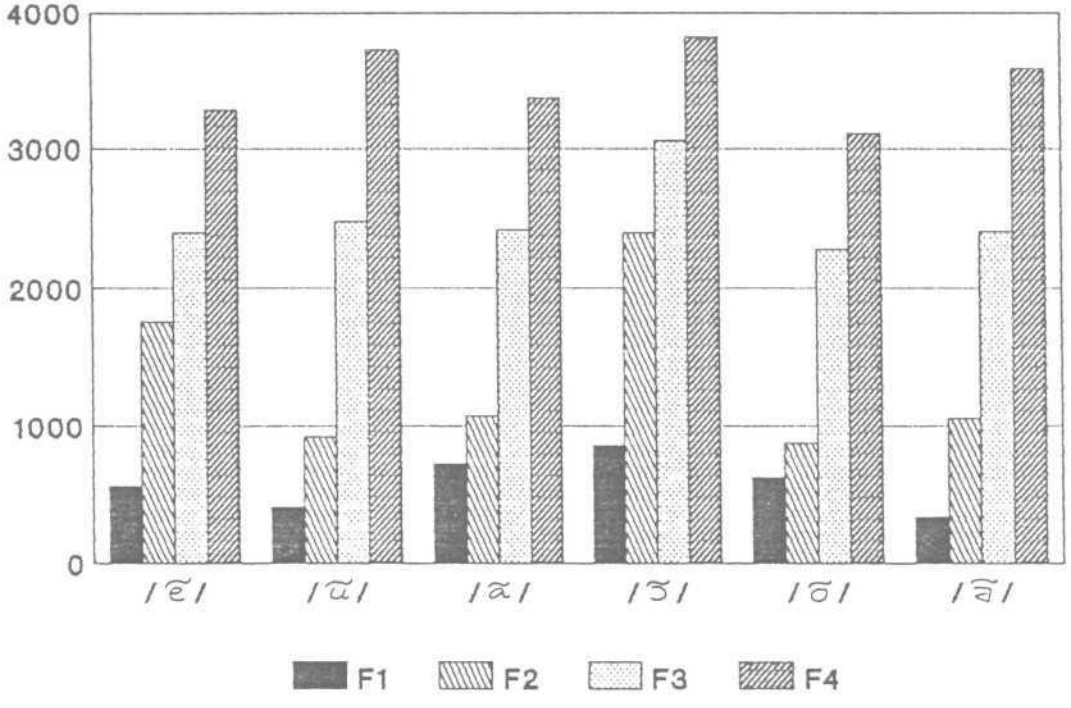
Formant frequencies of long oral vowels
(in males)



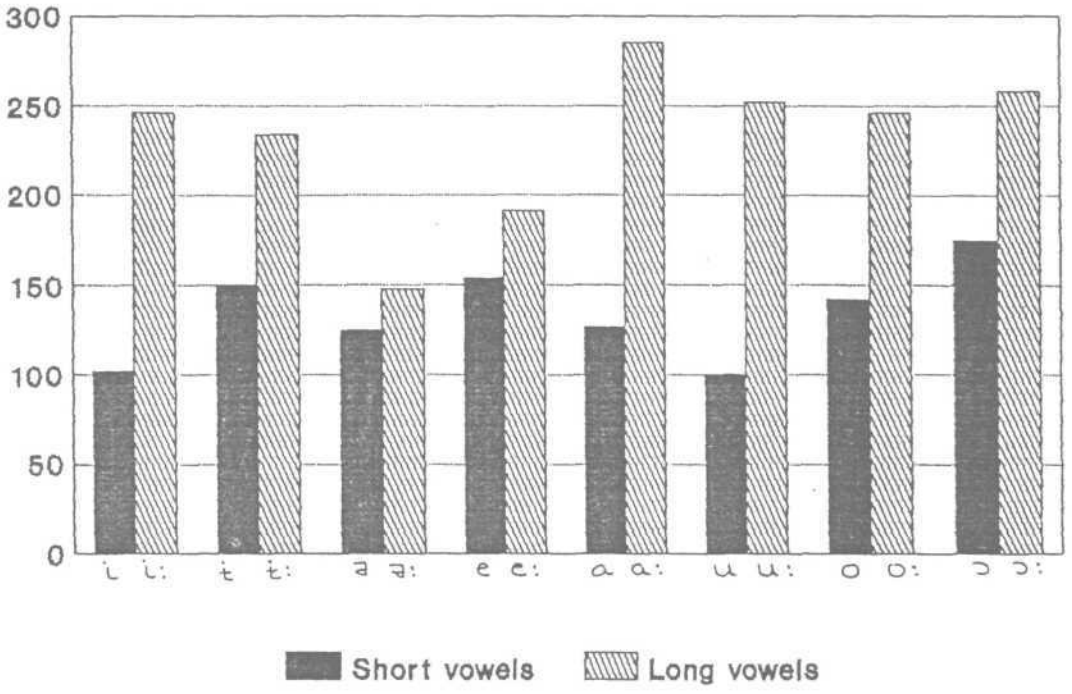
Formant frequencies of long nasal vowels
(in males)



Formant frequencies of short nasal vowel
(in males)



Vowel duration of oral vowels
(in males)



Vowel duration of nasal vowels
(in males)

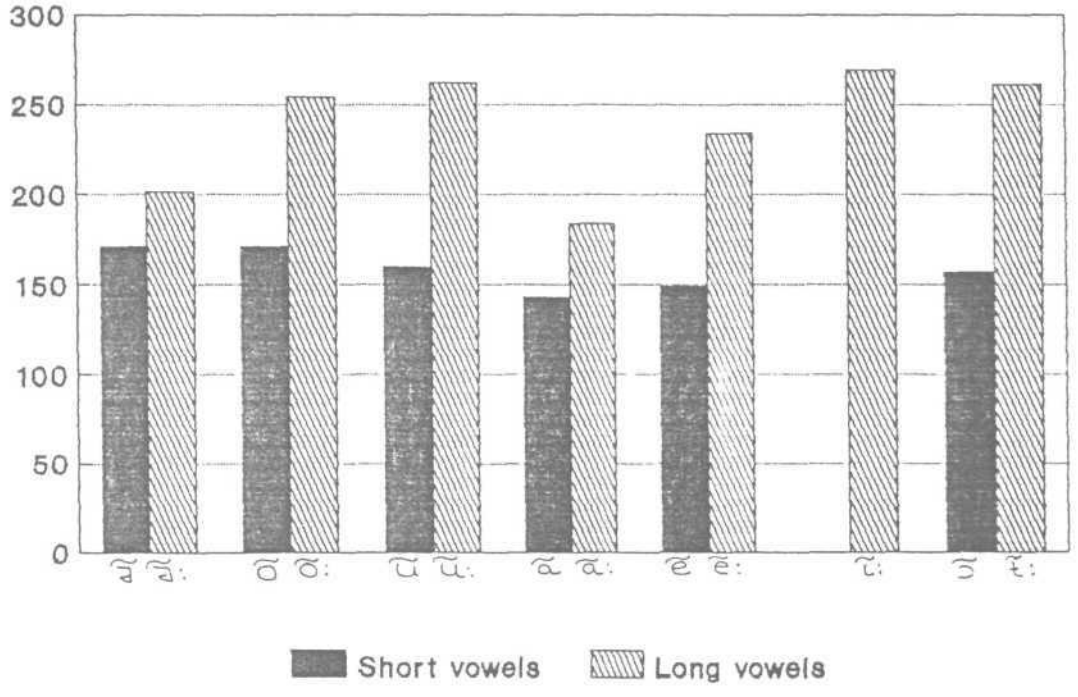


Table-II: Shows reulst of female subjects.

Vowel	Fl	F2	F3	F4	L1	L2	L3	L4	Bw1	Bw2	BW3	Bw4	VD
[i]	528.25 (20.78)	1753.15 (36.74)	2950.5 (28.97)	3651.25 (37.48)	27.75 (5.16)	38.75 (3.95)	14.75 (2.06)	24.75 (3.27)	145.25 (10.10)	141.5 (25.03)	183.25 (17.69)	175.10 (12.79)	89.25 (2.21)
[i:]	330.5 (43.27)	1945 (69.02)	2970.2 (48.53)	3707.25 (41.20)	24.75 (3.09)	17.75 (5.56)	56.5 (12.20)	38 (9.09)	126.5 (9.2)	107.5 (15.75)	175.75 (19.9)	202.15 (25.69)	165.5 (14.4)
[ɪ:]	342.7 (17.63)	2363 (33.13)	3245 (20.58)	4315 (37.19)	22.5 (3.5)	22.25 (2.62)	13.75 (.5)	11.75 (.5)	134.5 (8.66)	273 (8.90)	339 (20.26)	257.5 (5.44)	274.5 (19.89)
[u]	476.25 (29.84)	1621 (48.40)	2721 (27.78)	3522 (32.6)	24 (7.7)	21 (5.57)	28.5 (1.66)	14 (.90)	84 (12.75)	178 (17.33)	211 (17.61)	198.75 (37.75)	87.75 (12.60)
[ʊ:]	464.25 (22.38)	1431 (23.26)	2050 (22.27)	3670 (20.15)	37.5 (4.5)	50 (1.63)	28 (3.09)	35.75 (4.03)	152 (45.00	198 (24.17)	191 (14.89)	201.76 (17.99)	252 (21.50)
[ɑ]	325.5 (23.62)	936.2 (25.73)	2186 (35.5)	3324 (27.29)	35.75 (5.15)	20.25 (6.84)	23.25 (6.44)	15.25 (9.53)	153 (33.33)	266 (8.29)	323.75 (14.71)	332.25 (12.66)	261.5 (14.50)
[ɑ:]	442.45 (46.41)	1025.45 (40.63)	2119.25 (47.67)	3344 (54.26)	15.75 (7.27)	23.25 (1.25)	38.75 (9.93)	53.5 (1.91)	139 (12.56)	268.25 (18.24)	164.5 (10.52)	253 (127.4)	180.25 (13.57)
[e]	518 (24.06)	2008 (43.3)	2749 (42.2)	3516.75 (31.05)	49.25 (2.36)	35.75 (3.05)	45.25 (11.17)	42.25 (10.23)	104.75 (20.98)	183.5 (15.5)	168.75 (14.39)	222.25 (18.89)	143.5 (2.81)
[e:]	496 (43.19)	1751 (20.42)	2729.75 (32.07)	3466.25 (22.28)	61.5 (5.06)	(18.5) (7.7)	44 (9.20)	37.5 (7.07)	134.25 (22.83)	169.25 (12.78)	214.25 (13.49)	202.25 (16.30)	204 (7.34)
[ɛ:]	443.75 (54.73)	1235 (38.48)	2476 (27.08)	3376.5 (52.44)	27.75 (10.90)	38 (10.49)	49.75 (12.54)	32.5 (5.89)	205 (15.72)	223 (26.70)	203.75 (13.43)	248.5 (11.44)	152 (7.77)
[æ]	438 (32.69)	1618 (37.92)	2206 (30.08)	3305.5 (25.80)	32 (6.6)	57 (7.07)	69 (14.9;	51 (10.45)	140.5 (17.42)	293.75 (15.52)	301.75 (13.00)	299.75 (15.52)	119.75 (11.88)

Vowel	1:1				LI	L2	L3	L4 1	BW1	BW2	BW3	BW4	1 VD
[o]	493 t2o.25;	1637.5 (19.52;	2394 (32.35;	3624 (2b.13)	46.75 (18.13)	37.75 (6.18)	20 (10.63)	17 (.564)	139 (10.55)	154 (41.16)	243.25 (27.06)	232.11 (37.76)	172.53 (23.18)
[o:]	479 (5.03,	1536 (2U.39)	2u39 (39.64)	371b (19.32,	53.25 (14.24;	30 (7.34)	29 (6.22)	14.75 (1.72)	151 (7.43)	144 (33)	239 (3.69)	199.12 (27.76)	215 (11.09)
[õ:]	451 (17.25;	1072.5 (3b.62)	2345.5 (29.98,	3567.1 (24.77)	30.5 (6.6;	18 (5.6)	29.5 (10.01)	19.5 (8.34)	160 (14.71)	233 (19.92)	278 (1.04)	303 (11.06)	304.25 12.84)
[õ]	437.5 (16.06)	1057.25 (17.90;	2949 (31.26)	3766 (27.66,	22.5 (10.20)	26.75 (7.27)	19.75 (9.53)	15.5 (4.20)	163.5 (22.11)	165.5 (14.79)	264.25 (72.47)	255 (35.54)	140.7 (14.6)
[ɔ]	ovy.75 (15.29)	1296.25 (25.95)	2756.25 (2s.71;	3686.25 (36.16;	30.75 (8.52)	25 (12.08)	27 (8.7)	31 (4.19)	72.5 (3.27)	89.5 (8.19)	107 (16.08)	112 (10.32)	157.25 (10.87)
[ɔ:]	a/7.75 (cO.51)	1324.5 (16.2U,	2627.25 (34.12;	3731.75 (40.7)	43 (10.08)	3s (12.44)	22 (7.43)	27.5 (12.60)	96.7 (12.97)	101.75 (9.46)	123.5 (12.68)	97.2 (11.21,	231.75 (8.42)
[ɔ̃]	516.75 (14.51)	1101.75 (25.71,'	2161 (39.11;	2415 (25.29)	27.75 (2.98;	18 (6.37)	2b (4.32)	32.75 (4.19)	147.75 (34.4)	225.5 (14.77)	309 (15.57)	351 (14.06)	137.25 (16.02)
[t]	470 (22.30,	14/9 (12.7)	2519 (19.17,	3575 (32.12;	53.75 (11.43.1	26.75 (2.20,	16.75 (1.11)	52 (2.44)	94.25 (5.02)	143.25 (14.08)	192.35 (14.88)	172 (2.31)	124.5 (11.3)
[t:]	4UJ.5 (9.46)	1413 (31.62)	266c.65 (339.17)	3795.75 (31.76;	56.25 (12.41)	29 (8.84)	34 (13.4)	23.75 (7.00)	87 (11.82)	98.7 (8.35)	102 (11.0)	120 (7.08)	182 (16.99)
[t̃:]	JcH.55 (23.58)	613.25 (20.23,	2332.5 (24.13)	3542 (25.28)	27.5 (12.15)	17.5 (.58)	10.25 (.85)	8.5 (.51)	167.75 (30.70)	337.75 (43.15)	217.75 (32.57)	389.75 (28.07)	250.5 (25.26)
[a]	529.25 (23.691	1300 (45.35)	2677 (17.32)	3429.5 (27.23)	23 (4.08)	46.25 (10.12)	22.25 (3.7)	27 (6.22)	96.5 (7.7)	192.5 (12.47)	251.5 (8.58)	303.25 (12.59)	145.25 (6.44)
[a:]	69a (20.1)	1252 (.45.73)	2696 (22.2)	3433 (21.99)	12.25 (2.98)	36 (12.27)	19.5 (7.32,	33.25 (17.44)	192.5 (85.36)	268.5 (136.47)	228 (24.72)	179.25 (107.24)	213.75 (37.90)

Vowel	Fl	F2	F3	F4	L1	L2	L3	L4 1	BW1	BW2	BW3	BW4 1	VD
[ɑ]	763.7 (19.2)	1513 (36.12)	2954 (29.17)	3929.7 (32.1)	41.5 (6.68)	50.5 (10.59)	20 (6.9)	23.25 (4.08)	167.2 (58.54)	208.2 (24.57)	287.25 (27.56)	218.3 (20.29)	124.25 (16.04)
[ɑ:]	834.7 (20.92)	1239.6 (27.4)	2506 (60.33)	3513 (43.40)	32.75 (3.4)	43 (4.05)	30.75 (4.9)	23.75 (6.82)	106.25 (17.44)	201.5 (23.30)	210 (18.69)	309 (24.41)	252 (14.41)
[a]	544 (46.52)	1701 (36.64)	2691.2 (63.09)	4103.5 (25.99)	40.5 (4.4)	19.75 (9.03)	29 (4.83)	25 (2.24)	104.25 (17.30)	24.25 (18.87)	231.25 (19.74)	324.75 (16.57)	195 (19.08)
[a:]	536 (46.31;	15=0 (32.4)	2681 (23.4)	3572 (45.67)	47.75 (15.28)	25.75 (3.20)	23.00 (10.88)	23 (16.02)	162 (42.49)	160 (13.30)	230 (24.17)	173 (26.36)	177 (19.96)
[ɐ:]	475 (64.56)	1387 (38.8)	2832 (33.7)	3491 (32.7)	15.5 (0.50)	7.25 (.95)	(20.75 (9.60)	12.5 (7.32)	233.75 (33.13)	274.25 (16.54)	30.75 (42.40)	354 (26.23)	309 (18.49)
[ɐ]	472 (30.42)	1445 (24.69)	2667 (29.70)	3603 (48.39)	23 (6.05)	14.75 (1.5)	13.25 (4.92)	21.25 (8.99)	158.25 (8.26)	149.75 (18.20)	185 (26.17)	343 (35.43)	211 (15.12)

FORMANT FREQUENCIES OF VOWELS

The mean average value and the standard deviation of the first four formants of all the vowels have been presented in Table-11

The analysis of the vowel CiH the formants showed Fl of 528 Hz in the range of 37. A- Hz - 547 Hz and the Standard Deviation was SO. 78 whereas the FE was 1753 in the range of the 226 Hz to 2276 Hz and the Standard Deviation was 36.74. 2950 Hz was the mean F3 in the range of 3247 to 35.62 Hz and the Standard Deviation was 28.91. The mean F4 was 3651.25 Hz in the range of 4938 to 5287 Hz and the Standard Deviation was 37.48.

Vowel Ci:] long showed 330.5 Hz as Fl it ranged from 447 to 648 Hz, the Standard Deviation 43.27 Hz, was seen as F2 with range varying from 154*4- Hz - 1974 Hz and the Standard Deviation was 69.02. F3 was 2970.2 Hz and the range of 2789 to 3206 Hz and Standard Deviation was 48.53 whereas F4 was 3707.25 Hz and it ranged from 3247 Hz to 4383 Hz and Standard Deviation being 41.20.

For Ct3 Fl was 470 Hz with the range varying from 394 Hz to 544 Hz, and Standard Deviation 22.30. The F2 calculated

was 1479.4 Hz with a range of 13S5 Hz to 162U Hz and Standard Deviation being IE.7. The F3 was 2519 Hz with range of 2658 Hz to 3055 Hz and Standard Deviation being 19.17. The mean F4 was 3575 Hz with a range of 3339 to 4544 and Standard Deviation being 32.19.

For :t:] Fl was 483.5 Hz with the range of 470 to 442 Hz and the Standard Deviation was 9.46, F2 - 1413 Hz with range of 1365 to 1516 and Standard Deviation of 31.82, F3 mean was Standard Deviation 24.17, F4 obtained was 3795.75 with range of 3215 Hz - 4776 Hz and the Standard Deviation of 3i.76.

Vowel C 3] revealed Fl as 544 with the range of 513 Hz to 613 Hz and Standard Deviation 46.52, F2 1701 Hz with the range of 1625 to 1779 Hz and the Standard Deviation 36.64, F3 was 2881 Hz with the range of 3120 Hz to 3247 Hz and Standard Deviation 23.4, F4 was 3572.4 Hz with range *of* 4246 to 4411 Hz and Standard Deviation <45.67.

The mean of first formant frequencies for vowel ["3 :] was 536.H Hz and it ranged from 476 Hz - 579 Hz and Standard Deviation was 46.31, F2 mean was 1387.8 Hz and Standard Deviation was 38.8 with the range of 1456 Hz to 1754 Hz, For F3 the mean value was 2832 Hz with the lower and upper limit of the range being 2658 Hz and 3213 Hz respectively and

Standard Deviation being 33.7. The mean value of F4 was 3491 Hz and it ranged from 3598 Hz to 4494 Hz and the Standard Deviation was 32.7.

For vowel [e] the mean of the first formant was 518.8 and the range was 396 Hz to 586 Hz and the Standard Deviation being 24.06. For F2 the mean value was 2008 with range of 1658 Hz and 2768 Hz and Standard Deviation was 43.3. The mean for F3 was 2749 and it ranged from 2368 Hz to 3354 Hz and the Standard Deviation was 42.26. F4 had a mean value of 3516.75 Hz. with the range of 3098 to 4577 Hz and the Standard Deviation was 31.05.

The study of Table-2 [e:] revealed F1, mean value, was 496 Hz with range of 435 Hz 533 Hz and the Standard Deviation was 43.19. The F2 mean value was 1751 Hz with range of 1066 Hz 1235 Hz and the Standard Deviation of 20.42 was observed. The mean F3 value was 2729.75 Hz with the range of 2431 to 3205 Hz and the Standard Deviation was 32.07 whereas the mean. F4 was 3466.25 Hz the range being 3038 to 4547 Hz and the Standard Deviation was 22.28.

For Vowel (a) the mean Fl was 763.7 Hz ana the range was 520 to 770 Hz and the Standard Deviation being 20.1. The mean F2 was 1513 Hz with the range of 1265 to 1875 Hz and the

Standard Deviation being 38.28. The mean F3 value was 2954 Hz and it ranged from 2874 Hz to 3081 Hz and the Standard Deviation was 29.17. 3929 Hz was the mean F4 and it ranged 3692 Hz to 4348 Hz with Standard Deviation being 32.1.

The analysis of [a:] has shown mean F1 was 834.7 Hz with the range of 385-788 and the Standard Deviation as 20.92. F2 1239.6 Hz with the range of 1114-1621 Hz found the mean and the Standard Deviation was 27.4. F3 had a mean value of 2506 Hz and it ranged between 1732 Hz to 3100 Hz and the Standard Deviation was 60.33. F4 mean value was 3513 Hz with the range of 3334 to 4594 Hz and the Standard Deviation was 43.40.

For vowel [u] the mean value, range and the Standard Deviation of tne formant frequencies ware for Fl the mean was 476.25 Hz and range was 344 Hz to 405 Hz and the Standard Deviation was 29.84. The mean F2 was 1621 Hz and the range being 1350 Hz to 1897 and the Standard Deviation 48.40. The mean F3 was 2548 Hz with the range of 3213 Hz to 3213 Hz and the Standard Deviation was 27.78. For F4 the mean value was 3522 Hz, the range was 3154 Hz to 4273 Hz and the Standard Deviation was 32.6.

For vowel [u:] the F1 mean value was 464.25 Hz with the range of 236 to 481 Hz of the Standard Deviation being 22.38. Mean F2 value was 1431 Hz with the range of 1325 to 1569 Hz and the Standard Deviation 23.26. The F3 mean value was 2050 Hz with the range of 2748 Hz to 3674 Hz with a Standard Deviation of 22.27. The mean value of F4 was 3670 Hz the range was 3129 to 4361 Hz with a Standard Deviation of 20.15.

Analysis of [o] gave mean Fl value of 493 Hz with the range of 474 Hz to 486 Hz and Standard Deviation was 26.25. F2 had a mean value of 1837.5 Hz, with range varying from 1257 Hz to 1876 Hz and the Standard Deviation was 19.52. F3 ranged from 2314 Hz to 3154 Hz and the mean was 2394 Hz with Standard Deviation 32.35. The 3624 Hz was the mean value of F4 and it ranged from 3228 Hz to 4447 Hz with the Standard Deviation of 26.13.

Similarly, for [o:] mean Fl was 479 Hz and it ranged from 444 Hz to 586 Hz and the Standard Deviation was 5.03. F2 the mean was 1536 Hz with a range of 1104 to 1492 Hz and Standard Deviation was 20.39. F3 varied from 2091 Hz to 3099 Hz with the mean of 2639 and the Standard Deviation was 39.64. F4 had a mean of 3716 Hz, the range was from 3200 to 4485 Hz and the Standard Deviation was 19.32.

Analysis of vowel [ ] revealed the mean Fl as 608.75 Hz with the range of 537 to 781 Hz and the Standard Deviation was 15.29. Mean F2 was 1298.25 Hz with a range of 1235 to 1387 Hz and Standard Deviation was 25.95. For F3 the mean value was 2756.25 Hz, the range being 2598 to 3156 Hz and the Standard Deviation was 25.95. F4 had a mean of 3686.25 Hz with the range of 3261 to 4223 Hz and Standard Deviation 3616.

For vowel [:] the mean value of Fl was 688.75Hz with the range of 389 to 834 Hz and the Standard Deviation was 20.51. The mean F2 1324.5 Hz with the range of 111 to 1790 Hz of the Standard Deviation was 16.2. The mean value of F3 was 2161 Hz with a range of 2236 to 2991 Hz and the Standard Deviation was 39.11. F4 had a mean 3731.75 Hz and the range of 3124 Hz to 4203 Hz, the Standard Deviation 40.7.

NASALIZED VOWELS:

Analysis of nasalized vowel [ĩ :] showed mean Fl was 342.7 Hz with the range of 325 to 365 Hz and the Standard Deviation was 17.63. F2 had a mean of 2363 Hz with the range of 2333 to 2410 Hz and Standard Deviation was 33.13. Mean F3 was 3245 Hz, the range was 3125 to 3344 Hz and the Standard Deviation was 20.58. F4 had a mean value of 4315 with the range of 4141 to 4821 Hz and Standard Deviation being 37.19.

[t:] had mean Fl of 384.5 Hz with range of 406 Hz to 478 Hz Standard Deviation 23.58. 813.25 Hz was the mean of F2 with the range of 877 Hz and the Standard Deviation as 20.13. F3 had a mean value of 2732.5 Hz with range of 2510 to 2636 Hz and Standard Deviation was 24.13. F4 had a mean value of 3542 Hz with the range of 3198 Hz to 32.77 and Hz and the Standard Deviation being 25.28.

Analysis of [ā:] showed mean Fl was 375 Hz, it ranged from 342 to 386 with a Standard Deviation of 64.56. F2 mean value was 1387 and the range was 860 to 981 Hz and the Standard Deviation was 38.8. F3 had a mean of 2832 Hz and the range was 2365 to 4087 Hz and the Standard Deviation was 33.7. F4 revealed a mean of 3491 Hz and range of 3254 Hz to 5016 Hz with the Standard Deviation of 32.7.

For [ū:] the formant mean values were Fl 325.5 Hz with the range of 453 Hz to 564 Hz and the Standard Deviation 23.62, F2 868.2 Hz with the range of 1585 Hz to 2722 Hz and the Standard Deviation of 25.73. The mean of F3 was 2186 Hz. The range was 2548 to 4536 Hz of the Standard Deviation was 35.5. Mean F4 was 3324 Hz with the range of 3035 Hz to 3481 Hz and the Standard Deviation of 27.9.

[õ:] had mean of F1 as 451 Hz the range as 485 Hz to 520 Hz the Standard Deviation 17.25. The mean F2 was 1072.5 Hz and ranged 891 Hz to 1694 Hz and the Standard Deviation was 36.12. The mean F3 was 2345.5 Hz and the range was 2461 to 3468 Hz and the Standard Deviation was 29.98. F4 had a mean value of 3567.1 Hz, the range was 3548 to 4427 Hz and Standard Deviation of 24.77.

[ā:] revealed mean Fl as 696 Hz with the range of 525 Hz to 405 Hz and the Standard Deviation was 20.1. Mean value of F2 was 1252 Hz, the range was 1011 to 1315 Hz and had the Standard Deviation of 45.75. F3 mean value was 2698 Hz, the range was 2522 Hz to 2700 Hz and Standard Deviation was 22.2. F4 mean value was 3433 Hz, the range was 3420 to 3495 Hz and the Standard Deviation was 21.98.

Mean Fl for [ē], was 438 Hz with the range of 515 Hz to 586 Hz and the Standard Deviation was 32.69. F2 mean value was 1618 Hz, the range was 2575 Hz to 2896 Hz and the Standard Deviation was 37.92 mean F3 was 2206 with the range of 3158 Hz to 3311 Hz and the Standard Deviation was 30.08. The mean value of F4 was 3305.5 Hz the range was 3698 Hz to 4522 Hz and the Standard Deviation was 25.80.

Vowel: [ū] showed F1 mean of 325.5 Hz, the range of 554 Hz to 789 Hz and the Standard Deviation of 23.63 Hz. F2 mean was 936.2 Hz, the range was 1145 to 1293 Hz and Standard Deviation was 25.73. Mean F3 was 2186 Hz, the range was 2293 to 3462 Hz and the Standard Deviation was 35.5. F4 mean value 3324 Hz with the range of 2379 Hz to 4156 Hz and the Standard Deviation was 27.9.

For [ā] the mean Fl was 529.25 Hz and range was 481 Hz to 697 Hz and the Standard Deviation was 23.69. Mean value of 1300 Hz was for F2 and the range was 1406 to 1974 Hz and the Standard Deviation was 45.25. Mean F3 was 2677 Hz, the range was 2470 - 3066 Hz and the Standard Deviation was 17.32. Mean F4 value was 3429.5 Hz with a range of 3215 Hz to 4511 Hz and Standard Deviation of 27.3.

Vowel [ɔ̃], the mean Fl was 518.75 Hz with the range of 507 Hz to 658 Hz and the Standard Deviation was 14.51. The mean F2 was 1187.5 Hz and range was 955 Hz to 1478 Hz and the Standard Deviation was 25.71. F3 had a mean of 2161 Hz and the range of 1345 to 2621 Hz and the Standard Deviation was 39.11. The mean F4 value was 2415 Hz, the range was 3215 to 3561 Hz and Standard Deviation was 25.29.

OH analysis of [õ] the mean F1 was found to be 451 Hz, the range being 315 Hz to 550 Hz of the Standard Deviation was 17.25. Mean value of F2 was 1072.5 Hz, the range was 784 to 1318 Hz and the Standard Deviation was 36.62. F3 mean value was 2369.4 the range was 2658 Hz to 3719 and the Standard Deviation was 39.64. Mean F4 was 3716 Hz and range was 3254 Hz to 4563 Hz and the Standard Deviation was 19.32.

[ā] vowel had mean Fl as 472.4 Hz with the range of 481 Hz to 697 Hz and the Standard Deviation was 30.42 Hz. Mean F2 was 1445 Hz, the range was 1406 Hz to 1974 Hz and the Standard Deviation was 24.69. The mean F3 value was 2667, the range was 2470 Hz to 3066 Hz and the Standard Deviation as 29.70. Mean value of F4 was 3603 Hz with the range of 3215 to 4511 and the Standard Deviation was 48.39.

Analysis of [ē:] revealed the mean Fl as 443.75 Hz with the range of 366 Hz to 491 Hz and the Standard Deviation was 54.73. Mean F2 was 1235 Hz, the range was 2730 Hz to 2856 Hz and Standard Deviation was 38.48. F3 mean value was 2476 Hz and the range was 2731 to 3213 and the Standard Deviation was 27.08. Mean F4 was 3376.5 Hz with the range of 3158 Hz to 4406 Hz and the Standard Deviation was 52.44.

BANDWIDTH:

The bandwidths (BW1, BW2, BW3 and BW4) of the first four formants obtained using LPC co-variance and the results were:

For vowel [i] the mean BW1 was 141.25 Hz with the range of 97-181 Hz and Standard Deviation 10.10. BW2 mean value was 141.5 Hz with the range of 206-263 Hz and 25.03 being the Standard Deviation. For BW3 the mean was 183.25 Hz with the range of 128-287 Hz and Standard Deviation 17.69. BW4 was 175.10 Hz with the range 200 - 335 Hz and Standard Deviation being 12.79.

On analysis of vowel [i:] the mean BW1 as 126.5 Hz with the range of 114-134 and Standard Deviation 9.2. Mean of BW2 was 107.5 Hz with the range of 151 to 332 Hz and with a Standard Deviation of 15.75. BW3 mean value was 175.75 Hz, the range was 122 - 333 Hz and Standard Deviation was 19.9. For BW4 mean was 202.15 Hz with the range of 175-325 Hz and Standard Deviation was 25.69.

Vowel [t] showed mean BW1 as 94.25 Hz with the range of 67-121 Hz and the Standard Deviation 5.02. Mean BW2 was 143.25 Hz with the range 1062-313 Hz and Standard Deviation 14.08. BW3 as 192.35 Hz, the range being 145-221 Hz and the

Standard Deviation 14.88. BW4 mean value was 172 Hz, the range was 110-195 Hz and the Standard Deviation was 2.31

For [t:], BW1 mean value was 87 Hz with the range of 112 - 189 Hz and Standard Deviation 11.82. BW2 mean was 98.7 Hz with the range 206 - 588 Hz and the Standard Deviation being 8.35. BW3 mean value was 102 Hz, the range was 252 - 501 Hz and the Standard Deviation 11.0. Mean BW4 was 120 Hz with the range of 115-155 Hz and the Standard Deviation of 7.08.

Vowel [ ] revealed BW1 mean value as 104.25 Hz, the range was 80 to 121 Hz and Standard Deviation was 17.30. Mean BW2 was 24.25 Hz with the range of 196 to 232 Hz and Standard Deviation being 18.87. BW3 had a mean of 231.25 Hz, the range was 157 to 262 Hz and Standard Deviation 19.74. Mean BW4 was 324.75 Hz with the range of 300-359 Hz and the Standard Deviation was 16.57.

For vowel [:] the mean BW1 was 233.75 Hz the range was 65-109 Hz and the Standard Deviation was 33.13. Mean BW2 274.25 Hz with the range of 241-339 Hz and the Standard Deviation being 16.54. BW3 mean value was 30.75 Hz with the range of 208 to 245 Hz and had the Standard Deviation of 42.40. For BW4 the mean was 354 Hz with the range of 168 to 341 Hz and the Standard Deviation was 26.23.

Analysis of vowel: [e] revealed mean BW1 of 104.75 the range being between 56-145 Hz and the Standard Deviation 20.98. For BW2 the mean value was 183.5 Hz, with the range of 116 to 211 Hz and the Standard Deviation of 15.5. BW3 was 168.75 Hz and the range was 135 to 192 Hz and the range was 274 to 334 Hz and the Standard Deviation was 14.39. For BW4 the mean was 222.25 Hz with the range of 175 to 270 Hz and the Standard Deviation was 18.89.

For [e:] the mean value of BW1 was 134.25 Hz, the range was 100 to 146 Hz and the Standard Deviation being 22.83. Mean BW2 was 169.25 Hz, the range being 115 to 246 Hz and the Standard Deviation of 12.78. BW3 mean was 214.25 Hz with the range of 191-246 Hz Standard Deviation being 5.80. BW4 mean value was 202.25 Hz with the range of 122 to 317 Hz and the Standard Deviation was 16.30.

BW1 mean value for [a] was 167.2 Hz with the range of 124 to 251 Hz and the Standard Deviation 58.74 the mean of BW2 was 208.2, the range was 136 to 320 Hz and the Standard Deviation of 24.57. For BW3 mean was 287.25 Hz with the range of 231 to 402 Hz and the Standard Deviation was 27.56. BW4 mean value was 218.3 Hz and the range was 142 to 357 Hz and Standard Deviation was 20.29.

The mean BW1 for [a:] was 106.25 Hz the range was 168 to 275 Hz and Standard Deviation being 17.44. Mean BW2 was 201.5 Hz with the range of 164 to 279 Hz and Standard Deviation being 13.30. Mean BW3 was 210 Hz, the range was 148 to 270 Hz and the Standard Deviation was 18.69. BW4 mean was 309 Hz with the range of 158 to 489 and with the Standard Deviation of 24.41.

For [u] mean BW1 was 84 Hz, the range was 21-149 Hz and the Standard Deviation being 1275. Mean BW2 was 178 Hz, the range was 117-269 Hz and the Standard Deviation was 17.33. Mean BW3 was 211 Hz and the ranged from 139 to 398 Hz, the Standard Deviation was 17.61. Mean BW4 mean value was 198.5 Hz, with the range of 175 to 220 Hz and the Standard Deviation was 37.75.

Vowel [u:] revealed mean BW1 as 152, with the range of 96 to 206 Hz, and the Standard Deviation of 45.0. Mean BW2 was 198 Hz and the range was 120 to 316 Hz, and the Standard Deviation was 24.17. Mean BW3 was 191 Hz, the range was 124 to 219 Hz and the Standard Deviation of 14.89. The mean BW4 was 201.76 Hz with the range of 198 to 295 Hz and the Standard Deviation being 17.99.

For: [o] the mean BW1 was 139 Hz with the range of 123 to 153 Hz and the Standard Deviation was 10.55. Mean BW2 was 154 Hz with the range 94 to 187 Hz and the Standard Deviation was 41.16. Mean BW3 was 243.25 Hz with the range of 143-281 Hz, and the Standard Deviation being 27.06. Mean of BW3 was 232.11 Hz, the range was 201 to 320 Hz and the Standard Deviation was 87.76.

Similarly for vowel [o:] mean BW1 was 151 Hz witn the range of 140 to 156 Hz and the Standard Deviation of 7.43. Mean BW2 value was 244 Hz, the range was 124 to 194 Hz and the Standard Deviation was 33.0. BW3 mean was 239 Hz ard the range was 235 to 243 Hz, and the Standard Deviation was 3.69. Mean BW4 was 199.12 Hz with the range of 117 to 236 Hz and the Standard Deviation is being 27.76.

Analysis of [ ] revealed mean BW1 as 72.5 Hz with the range of 127 to 192 Hz and the Standard Deviation was 3.27. Mean BW2 was 89.5 Hz with the range of 214 to 298 Hz, and the Standard Deviation was 8.19. Mean BW2 was 107 Hz with the range of 117 to 152 Hz, and the Standard Deviation was 16.06. Mean BW4 was 112 Hz with the range cf 120 to 131 Hz and the Standard Deviation of 10.32.

For [:] mean BW1 was 96.7 Hz with the range of 69 to 255 Hz and the Standard Deviation 12.97. Mean BW2 was 101.75 Hz with the range of 116 to 188 Hz, and the Standard Deviation of 9.46. Mean BW3 was 123.5 Hz with the range 189 to 237 Hz and the Standard Deviation was 12.68. BW4 mean value was 97.2 Hz, the range was 100-125 Hz and the Standard Deviation was 11.21.

NASALIZED VOWELS:

Analysis of [ĩ:] showed mean BW1 was 134.5 ranging from 123 to 144 Hz and the Standard Deviation was 8.66. Mean BW2 was 273 Hz with the range of 165 to 183 Hz, and the Standard Deviation of 8.9. Mean BW3 was 339 Hz with the range of 325 to 309 and the Standard Deviation was 20.26. Mean value of BW4 was 257.5 Hz with the range of 153 to 165 Hz and the Standard Deviation of 5.44.

Vowel [t:] showed mean BW1 as 167.75 Hz the range was 125 to 198 Hz and the Standard Deviation was 30.70. Mean BW2 was 337.75 Hz with the range of 274 to 369 Hz and the Standard Deviation was 93.15. BW3 mean value was 217.75 Hz with the range of 188 to 255 Hz and the Standard Deviation being 32.57. Mean BW4 389.75 Hz, the range was 207 to 476 Hz, and the Standard Deviation was 28.07.

For [ঈ:] mean BW1 was 233.75 Hz and the range was 185 to 256 Hz and the Standard Deviation was 33.13. Mean BW2 was 274.25 Hz with the range of 258 to 297 Hz and the Standard Deviation of 16.52. BW3 mean value was 30.75 Hz with the range of 299 to 384 Hz and the Standard Deviation beng 42.40. Mean BW4 was 354 with the range was 321-385 Hz and the Standard Deviation was 26.23.

Mean BW1 of [ū:] was 139 Hz, the range of 122 to 199 Hz and the Standard Deviation 12.56. Mean BW2 was 268.25 Hz with the range of 230 to 299 Hz and the Standard Deviation 18.24. Mean BW3 was 164.5 Hz the range was 262 to 369 Hz and the Standard Deviation was 10.52. Mean BW4 was 253 Hz, the range was 154 to 329 Hz and the Standard Deviation being 127.4.

For [õ:] mean BW1 was 160 Hz, with the range of 142 to 226 Hz and the Standard Deviation 14.71. Mean BW2 was 233 Hz, with the range of 181 to 318 Hz and the Standard Deviation was 19.92. Mean BW3 was 278 Hz, the range was 209 to 268 Hz, and the Standard Deviation 1.04. Mean BW4 was 30.3 Hz with the range of 223 to 310 Hz and the Standard Deviation being 11.06.

For [ā:] revealed mean BW1 of 192.5 Hz the range was 205 to 298 Hz and the Standard Deviation was 85.36. Mean BW2 was 268.5 Hz, the range was 125 to 324 Hz and the Standard Deviation was 136.47. Mean BW3 as 228 Hz, with the range of 195 to 279 Hz, and the Standard Deviation of 24.72, mean BW4 was 179.25 the range was 195 to 273 Hz and the Standard Deviation was 103.24.

For [ē] the mean BW1 was 140.5 Hz, the range was 103 to 266 Hz and the Standard Deviation 17.42. Mean BW2 was 293.75 Hz, the range was 115 to 399 Hz and the Standard Deviation of 15.52. For BW3 the mean was 301.75 Hz the range was 196 to 248 Hz and the Standard Deviation was 13.0. Mean BW4 as 299.75 Hz the range was 121 to 340 Hz and the Standard Deviation was 15.52.

Vowel [ū] revealed that the mean BW1 was 153 Hz, the range was 123 to 150 Hz and the Standard Deviation was 33.33. Mean BW2 266 Hz, the range was 215 to 324 Hz and the Standard Deviation was 8.29. For BW3 mean was 323.75 Hz, with the range was 132 to 164 Hz and the Standard Deviation being 14.71. Mean BW4 was 332.25 Hz, the range was 135 to 369 Hz and the Standard Deviation was 12.66.

For [ā] mean BW1 was 96.5 Hz, the range was 239 to 255 Hz and Standard Deviation 7.7. Mean BW2 was 192.5 Hz, the range was 127 to 296 Hz and the Standard Deviation being 12.47. For BW3 the mean was 251.5 Hz, the range was 244 to 262 Hz and the Standard Deviation was 8.53. For BW4 tne mean value was 303.25 Hz, the range was 197 to 305 Hz and the Standard Deviation was 12.59.

Mean BW1 of [ɔ̃] was 147.75 Hz, the range was 125 to 199 Hz and the Standard Deviation 34.4. For BW2 was 255.5 Hz, the range was 201 to 260 Hz and the Standard Deviation was 14.77. Mean BW3 was 309 Hz, with the range of 273 to 398 Hz, and the Standard Deviation being 15.57. For BW4 me mean value was 351, the range was 328 to 385 Hz, and the Standard Deviation being 14.06.

Analysis of [õ] revealed mean BW1 as 163.5 Hz, the range was 135 to 189 Hz and the Standard Deviation was 22.11. Mean BW2 was 165.5 Hz, the range was 154 to 185 Hz and the Standard Deviation of 14.79. For BW3 the mean was 284.25 Hz, with the range was 198 to 367 Hz and the Standard Deviation of 72.47. Mean BW4 was 255 Hz, the range was 211 to 298 Hz and the Standard Deviation was 35.54.

For [ৰ] mean BW1 was 132.2, the range was 123 to 154 Hz and the Standard Deviation was 8.26. Mean BW2 was 149.75 Hz, the range was 127 to 171 Hz and the Standard Deviation being 18.20. For BW3 mean value 185 Hz, the range was 159 to 217 Hz. and the Standard Deviation being 26.17. Mean BW4 was 343 Hz with the range of 303 to 389 Hz and the Standard Deviation of 35.43.

Vowel [ē:] showed mean BW1 was 205 Hz with the range was 153 to 284 Hz and the Standard Deviation was 15.72. Mean BW2 was 223 Hz, with the range of 168 to 335 Hz and the Standard Deviation of 26.70. For BW3, the mean value was 203.75 Hz, the range was 119 to 321 Hz and the Standard Deviation being 13.43. Mean BW4 was 248.5 Hz, the range was 192 to 334 Hz, and the Standard Deviation 11.44.

FORMANT INTENSITIES

The energy level (L1 - L4) of the first four formants were calculated for each vowel in RdB.

On analysis [i], mean L1 was 27.75 RdB the range was 4 to 37 dB and the Standard Deviation was 5.16. The mean L2 was 38.75 RdB with the range of 2 to 66 dB and the Standard Deviation was 3.95. Mean L3 was 14.75 RdB with the range of

12 to 16 dB and Standard Deviation of 2.06 mean L4 value was 24.75 dB and the range was 5 to 73 dB with Standard Deviation of 3.27.

Vowel [i:] had L1 mean as 24.75 dB, the range of 22 to 29 dB and Standard Deviation was 3.00. Mean L2 was 17.65 dD, the range was 14 to 26 dB and the Standard Deviation being 5.56. L3 mean value was 56.5 dB with the range of 34 to 77 dB and Standard Deviation was 12.70. Mean L4 was 38.0 dB, the range was 26 to 48 dB and the Standard Deviation was 9.09.

For [ẗ], L1 mean value was 59.75 dB the range was 27 to 73 dB and the Standard Deviation was 11.13. Mean L2 was 2b.75 dB, the range was 3 to 45 dB and the Standard Deviation was 2.20. L3 mean value was 16.75 dB, the range was 3 to 26 and Standard Deviation was 1.11. L4 mean value was 52 dB. The range was 2 to 8 dB and the SD was 2.44.

Vowel [ẗ:] showed mean L1 as 56.25 dB, the range 29 to 77 and the Standard Deviation was 12.41. Mean L2 was 29 dB, the range was 8 to 53 dB and Standard Deviation was 8.24. L3 mean value was 34 dB, the range was 24 to 53 dB and Standard Deviation 13.4 mean. L4 was 23.75 dB with tne range 15 to 40 dB and the Standard Deviation was 7.0.

Vowel [] revealed mean L1 as 40.5 dB the range was 36 to 46 dB and the Standard Deviation was 4. 4. For L2 the mean value was 19.75 dB with the range of 1 to 35 dB and the Standard Deviation of 9.03. L3 mean value was 29 dB, the range was 12 to 38 and the Standard Deviation 4.83. L4 mean was 25 dB, the range was 2 to 45 dB and the Standard Deviation was 2.24.

Formant intensity levels of vowel [:] were mean L1 as 47.75 dB, the range was 25 to 58 dB and the Standard Deviation was as 15.28. L2 was 25.75 dB with the range of 23 to 29 dB and the Standard Deviation of 3.20. Mean L3 was 23 dB, the range was B to 31 dB and the Standard Deviation of 10.88. L4 mean value was 23 dB with the range of 5 to 37 dB and the Standard Deviation was 16.02.

Vowel [e] showed mean L1 as 49.25 dB with the range 23 to 69 dB and the Standard Deviation 2.36. Mean L2 as 35.75 dB, the range as 6 to 48 dB and the Standard Deviation of 3.05. L3 mean value was 45.25 dB, the range was 31 to 58 dB, and the Standard Deviation being 11.17. L4 was 45.25 dB with the range of 12 to 58 dB and the Standard Deviation was 10.23.

For [e:] mean L1 was 61.5 dB, the range was 47 to 75 dB and the Standard Deviation of 5.06. Mean L2 was 18.5 dB, the range was 13 to 30 dB and the Standard Deviation was 7.7. L3 mean value was 44 dB with the range being 31 to 51 and Standard Deviation of 9.20. L4 mean value was 37.5 dB with the range of 12 to 48 dB and had 7.07 as Standard Deviation.

Mean L1 for [a] was 41.45 dB with the range 18 to 56 dB and Standard Deviation of 6.68. L2 mean value was 50.5 dB with the range 32 to 67 dB and Standard Deviation was 10.59 L3 mean value was 20 dB, the range was 11 to 26 dB and the Standard Deviation was 6.09. L4 mean value was 23.25 dB with the range of 8 to 38 dB and Standard Deviation of 4.08.

The mean L1 for [a:] was 32.75 dB, the range was 5 to 55 dB and the Standard Deviation was 3.4. L2 mean value was 43 dB with the range of 2 to 66 dB and the Standard Deviation of 4.05. Mean L3 was 30.75 dB, the range was 26 to 36 dB and the Standard Deviation was 4.9. Mean L4 value was 23.75 dB the range was 2 to 38 dB and Standard Deviation being 6.82.

For vowel [u] L1 mean value was 24 dB, the range was 13 to 30 dB and the Standard Deviation was 7.7. L2 mean value was 21 dB with the range of 3 to 35 dB and Standard Deviation was 5.57. Mean L3 was 28.5 dB with the range of 13 to 35 and

had the 1.66 as the Standard Deviation. Mean L4 was 14 dB, the range was 4-22 dB and the Standard Deviation was .90.

Mean L1 for [u:] was 37.5 dB, the range was 17 to 50 dB and Standard Deviation being 4.5. L2 mean was 50 dB with the range of 3 to 7 dB and Standard Deviation of 1.63. L3 mean value was 28, the range was 26 to 33 dB and the Standard Deviation was 3.09, Mean L4 was 35.75 dB, the range was 30 to 39 dB and the Standard Deviation was 4.03.

For [o] mean L1 was 46.75 dB, the range was 28 to 66 dB and the Standard Deviation was 18.13. L2 mean value was 37.75 dB, the range 29 to 43 dB and the Standard Deviation being 6.18. Mean L3 was 20 dB, the range was 11 to 38 dB and Standard Deviation was 10.63. Mean L4 value was 25 dB, the range being 2 to 31 dB and the Standard Deviation was .564.

L1 mean value for [o:] was 53.25 dB with the range of 35 to 66 dB and Standard Deviation being 16.24. Mean L2 was 30 dB the range was 21 to 36 dB and had 7.34 as the Standard Deviation. L3 mean value was 29 dB the range was 7 to 46 dB and the Standard Deviation was 6.22 mean L4 was 14.75 dB, the range was 2 to 36 and Standard Deviation was 1.72.

Analysis of vowel [ɔ] revealed mean L1 as 30.75 dB with the range of 24-48 dB and the Standard Deviation 8.52. Mean L2 was 25 dB, the range was 12 to 28 dB and the Standard Deviation was 12.08. Mean L3 27 and the Standard Deviation was 8.75 range was 14 to 23 to 82. Mean L4 value was 31 dB, the range was 14 to 39 dB and the Standard Deviation was 4.19.

Mean L1, for [ɔ:] was 43 dB with the range of 15 to 59 dB and Standard Deviation being 10.08. L2 mean value was 36 dB with the range 7 to 48 dB and the Standard Deviation was 12.44. Mean L3 was 22 dB tne range was 11.27 dB had 7.43 as Standard Deviation. L4 mean value was 27.5 dB, the range was 5-35 dB and the Standard Deviation was 12.60.

NASALIZED VOWELS

Vowel [ĩ:] showed mean L1 as 22.5 dB with the range of 19 to 26 dB and the Standard Deviation was 3.5. Mean L2 was 22.25 dB the range was 20 to 263 dB and the Standard Deviation being 3.19. Mean L3 was 13.75 dB, in the range was 13 to 15 dB and the Standard Deviation was .5. Mean L4 was 11.75 dB, with the range was 7-12.5 dB and the Standard Deviation was .5.

Analysis of [ī:] revealed mean L1 was 37.5 dB, with the range of 24 to 42 dB and the Standard Deviation of 2.15. Mean L2 was 17.5 dB the range was 10 to 18.5 dB and Standard Deviation was 0.51. Mean L3 was 10.25 dB the range was 2-19 dB and the Standard Deviation was .85 mean L4 value was 8.25 dB, the range was 3 to 12 dB and the Standard Deviation was .51.

For [ɛ̃:] mean L1 value was 15.5 dB the range was 62-69 dB and the Standard Deviation was 0.50. L2 mean value was 7.25 dB with the range of 62-73 dB and the Standard Deviation was 1.95. Mean L3 was 120.75 dB, the range was 70-78 dB and the Standard Deviation being 9.60. Mean L4 was 12.5 dB the range was 74 to 89 dB and the Standard Deviation was 7.32

[ū:] had mean L1 as 15.75 dB, the range was 15 to 48 dB, and the Standard Deviation was 7.27. Mean L2 was 23.25 dB, the range was 4 to 18 dB and the Standard Deviation being 11.25. Mean L3 was 38.75 dB, the range was 4 to 19 dB and had 9.93 the Standard Deviation. L4 mean value was 53.5 dB, the range was 1 to 21 dB and the Standard Deviation was 1.91

For [õ:] mean L1 was 30.5 dB with the range of 11 to 53 dB and the Standard Deviation was 6.6. Mean L2 was 16 dB with the range of 3 to 40 dB and the Standard Deviation was

5.6. Mean L3 was 29.5 dB, the range was 21 to 44 dB and the Standard Deviation was 10.61. L4 mean value was 19.5 dB, the range was 12 to 31 dB and the Standard Deviation was 8.37

Mean L1 for [ā:] was 12.25 dB, the range was 10 to 16.1 dB and the Standard. Deviation was 2.98. L2 mean value was 36 dB the range was 30.2 to 39.1 dB and the Standard Deviation of 12.27. Mean L3 was 19.5 dB with the range of 12.5 to 22.9 and Standard Deviation 7.32. Mean L4 was 33.25 dB, the range being 29.1 to 35.3 dB and the Standard Deviation was 17.44.

For [ē] mean L1 was 32 dB with the range of 29.5 to 40.1 dB and the Standard Deviation 6.6. Mean L2 value was 57 dB, the range was 45.7 to 60.1 dB and the Standard Deviation was 7.07. L3 mean value was 69 dB the range was 63.2 to 73.1 dB and the Standard Deviation was 14.9. Mean L4 was 51 dB with the range of 45.1 to 57.2 dB and the Standard Deviation being 10.45.

Vowel [ū] revealed mean L1 as 35.75 dB with the range of 30.1 to 37.5 dB and Standard Deviation was 5.15. Mean L2 was 20.35 dB with the range of 15.1 to 22.7 dB and Standard Deviation being 6.84. Mean L3 was 23.25 dB with the range of 19.4 to 27.5 dB and the Standard Deviation of 6.44. L4 mean

value was 15.25 dB with the range of 13.5 to 21.8 dB and Standard Deviation was 9.53.

For [ā] mean L1 was 23 dB, the range was 19.5 to 25.9 dB and the Standard Deviation was 4.08. Mean L2 was 46.25 with the range of 38.9 to 49.5 dB and the Standard Deviation of 10.12. mean L3 was 22.25 dB, the range was 18.9 to 25.7 dB and the Standard Deviation was 3.7. L4 mean value was 27 dB, the range being 21.9 to 31.5 dB and Standard Deviation being 6.22.

Mean of LI for [ā] was 27.75 dB with the range of 24 to 31 dB and had 12.98 as the Standard Deviation. L2 mean was 19.0 dB with the range of 12 to 27 dB and the Standard Deviation was 6.37. Mean L3 value was 26 dB, the range was 22 to 32 dB and the Standard Deviation was 4.32. L4 mean value was 32.75 dB the range was 30 to 39 dB and Standard Deviation being 4.19.

For [õ] mean L1 was 22.5 dB, the range was 3 to 37 dB the Standard Deviation was 10.20. Mean L2 was 28.75 dB, the range was 22 to 39 dB, with the range of 60-69 and Standard Deviation 3.27.

On analysis of [ɐ] the mean L1 was 23.0 dB with the range of 14 to 27 dB and the Standard Deviation of 6.05. Mean L2 was 14.75 dB with the range of 13 to 16 dB and Standard Deviation was 1.5. L3 mean value was 13.25 dB, the range was 6 to 17 dB and the Standard Deviation of 4.92. Mean L4 was 21.25 dB with the range of 8 to 28 dB and Standard Deviation was 8.99.

Vowel [ē:] showed mean L1 as 27.75 dB with the range of 14 to 37 dB and the Standard Deviation was 10.90. Mean L2 was 38 dB, the range was 2 to 65 dB and had 0.49 as the Standard Deviation. L3 mean value was 49.75 dB with the range of 19 to 76 dB and Standard Deviation was 12.54. Mean of L4 was 32.5 dB with the range of 2 to 54 dB and Standard Deviation of 5.89.

VOWEL DURATION:

Results of the analysis gave the following mean vowel durations along with the range and the range and the Standard Deviation.

For [i] the mean vowel duration (VD) was 89.25 msec, with the range of 81 to 92 msec, and the Standard Deviation of 2.21.

[i:] had a mean duration of 165.5 msec. The range was 145 to 200 msec, and the Standard Deviation was 14.4.

Duration of [t̪] was 124.5 msec. The range was 100 to 186 msec, and the Standard Deviation was 11.3.

VD of [t̪:] was 182 msec, with the range of duration between 189 to 317 msec. and the Standard Deviation was 16.99.

For [] the duration was 195 msec. The range was between 149 to 244 msec, and the Standard Deviation was 19.08.

Vowel [] had a duration of 177 msec, the range being 150 to 198 msec, and the Standard Deviation being 19.96.

[e] had a duration of 143 msec. with the range of and the Standard Deviation 2.81.

For [e:] the duration was 204 msec. The range was 200 to 215 msec, and the Standard Deviation was 7.34.

Vowel [a] had a mean duration of 124.25 msec. The range was 114 to 148 msec, and the Standard Deviation was 16.04.

Mean VD of [a:] was 252 msec, the range was 222 to 317 msec, and the Standard Deviation of 14.41.

For [u] the mean VD was 87.75 msec, the range was 74 to 120 msec, and the Standard Deviation of 12.60.

[u:] had a mean VD of 252 msec, the range was 225 to 273 msec, and the Standard Deviation was 21.50.

Vowel [o] had a mean VD of 172.53 msec, the range was 122 to 156 msec, and the Standard Deviation was 23.18.

Similarly, for [o:] mean VD was 215 msec. The range was 184 to 258 msec, and the Standard Deviation was 11.09.

For [ɔ] the mean VD was 157.25 msec. The range was 148 to 173 msec, and the Standard Deviation was 10.87.

Vowel [ɔ:] had mean VD of 231.75 msec, the range was 224 to 240 msec, and the Standard Deviation was 8.42.

NASALIZED VOWELS:

For [T:] the mean VD was 274.5 msec, the range was 258 to 298 msec, and the Standard Deviation was 19.89.

Mean Standard Deviation for [t̃:] was 250.5 msec. The range was 200 to 282 msec, and the Standard Deviation was 25.26.

Vowel [ɜ̃:] had mean VD of 309 msec. The range was 282 to 321 and the Standard Deviation was 18.49.

For [ū:] mean VD was 180.25 msec, the range was 216 to 298 msec, and the Standard Deviation was 13.57.

Mean VD of [õ:] was 304.25 msec, the range was 251 to 377 msec, and the Standard Deviation was 12.84.

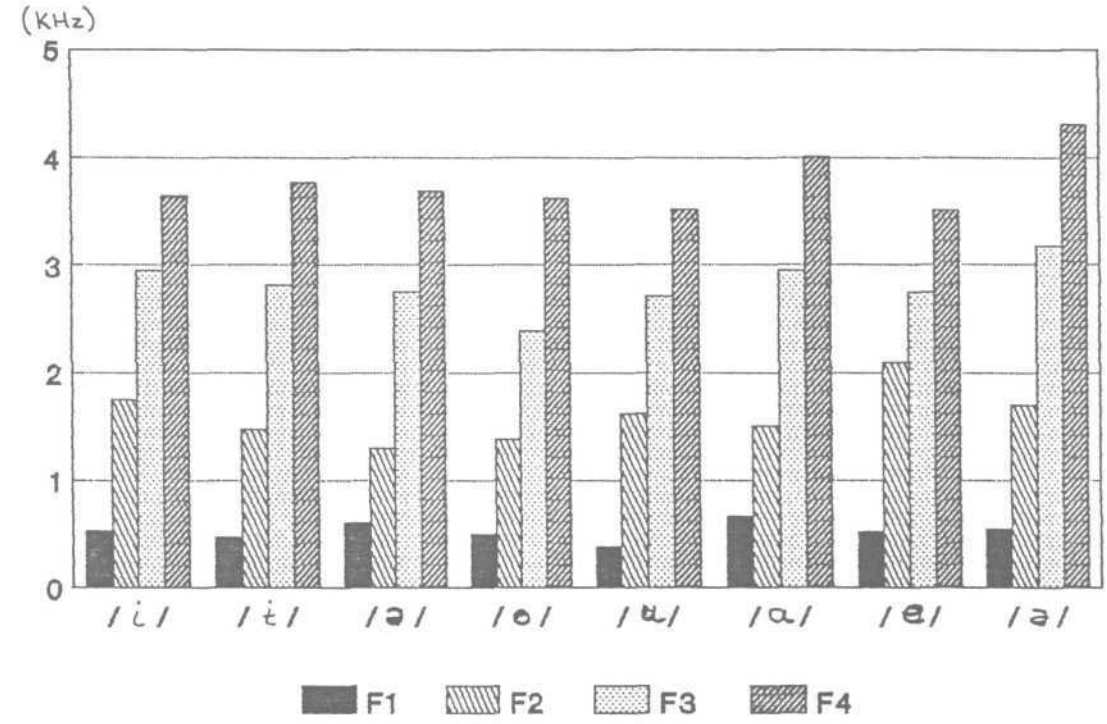
Vowel [ā:] had a mean duration of 213.75 msec. The range was 125 to 243 and the Standard Deviation was 37.90.

For [ē] mean VD was 119.75 msec, the range was 142 to 168 msec, and the Standard Deviation was 11.88.

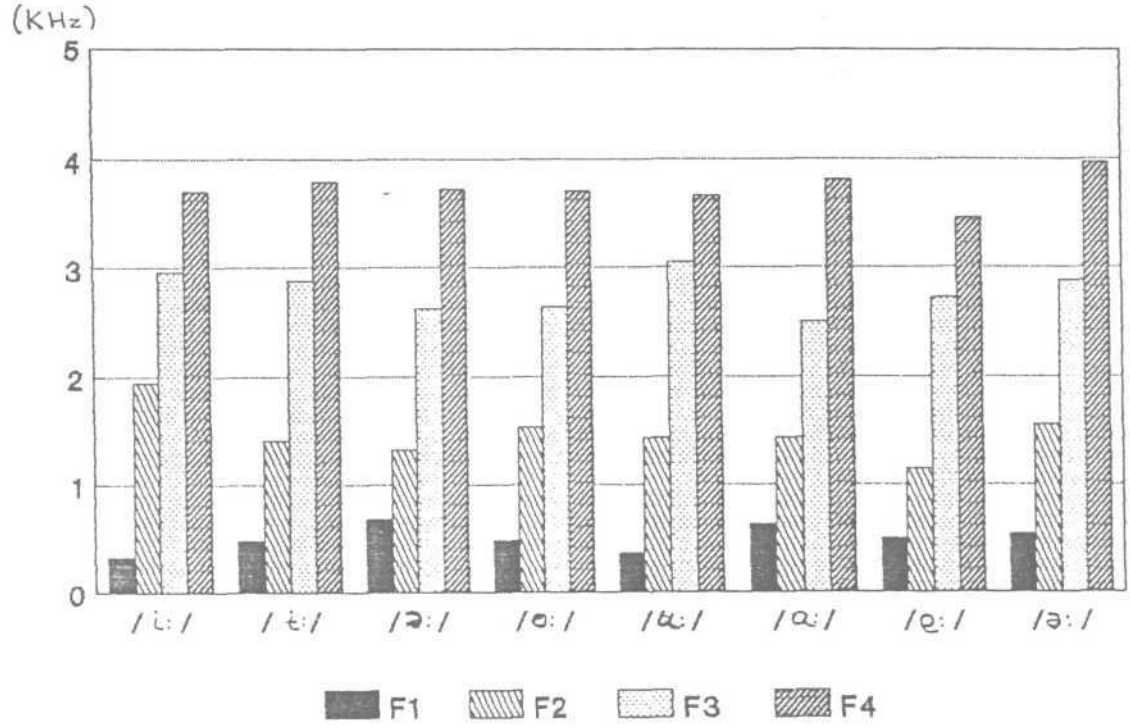
[ū] had mean VD of 261.5 msec, the range was 141 to 221 msec, and the Standard Deviation 14.50.

[ā] had mean VD of 145.25 msec, with the range of 136 to 151 msec, and Standard Deviation being 6.44.

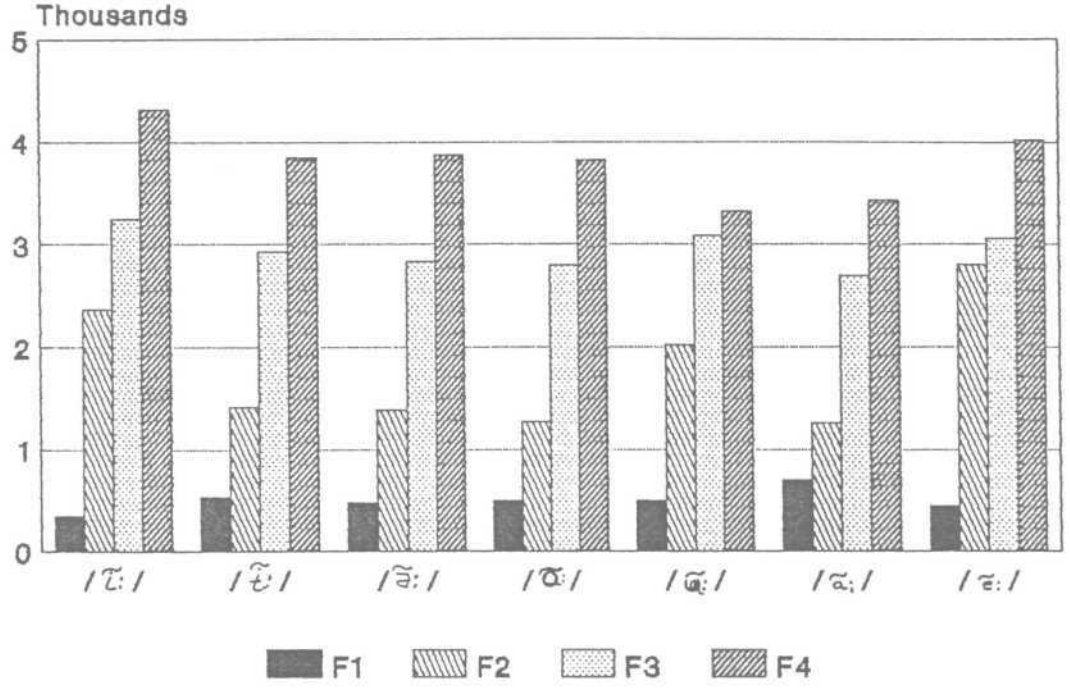
Formant frequencies of short oral vowels
(in females)



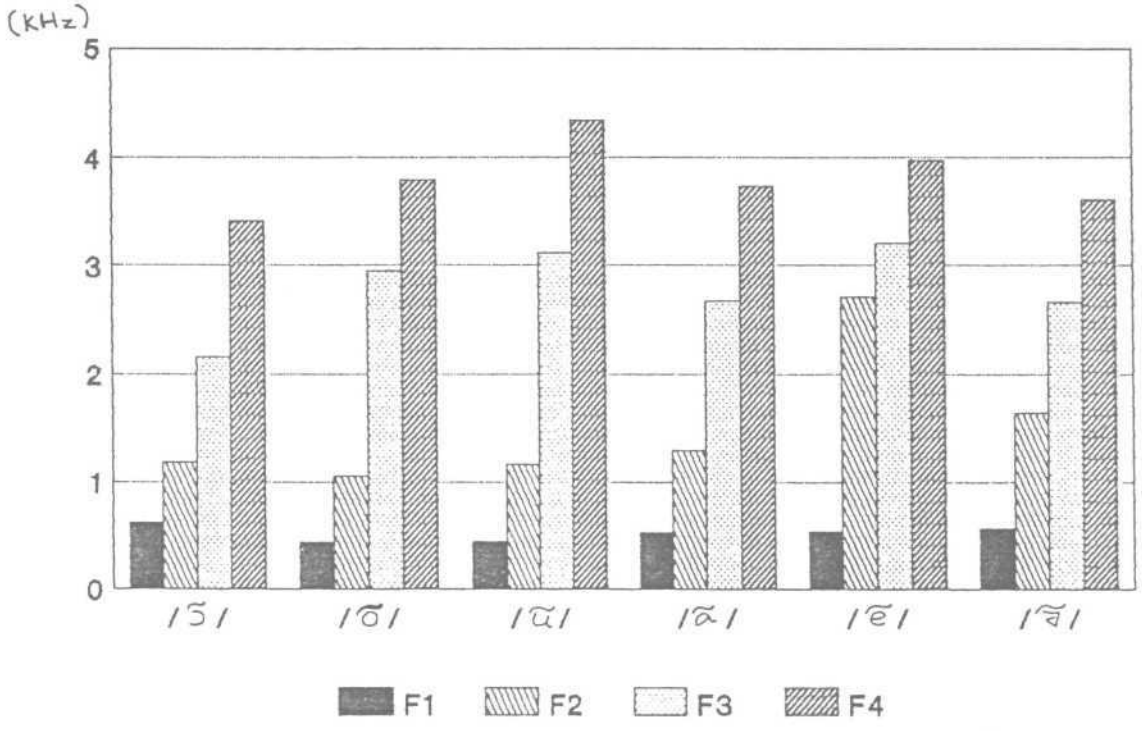
Formant frequencies of long oral vowels
(in females)



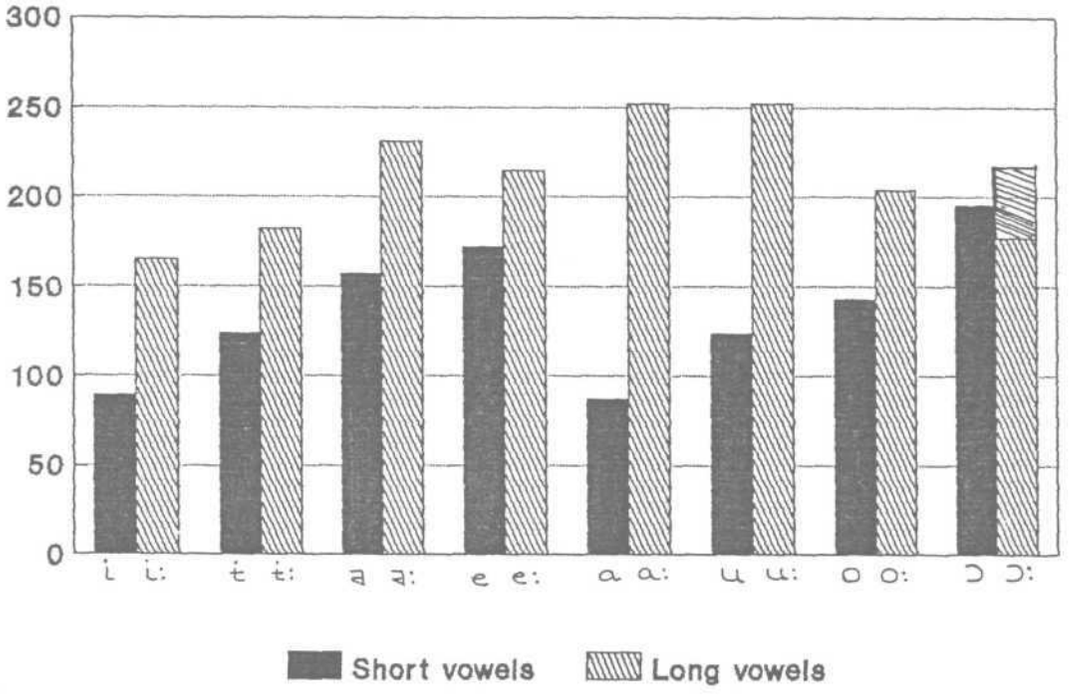
Formant frequencies of long nasal vowels
(in females)



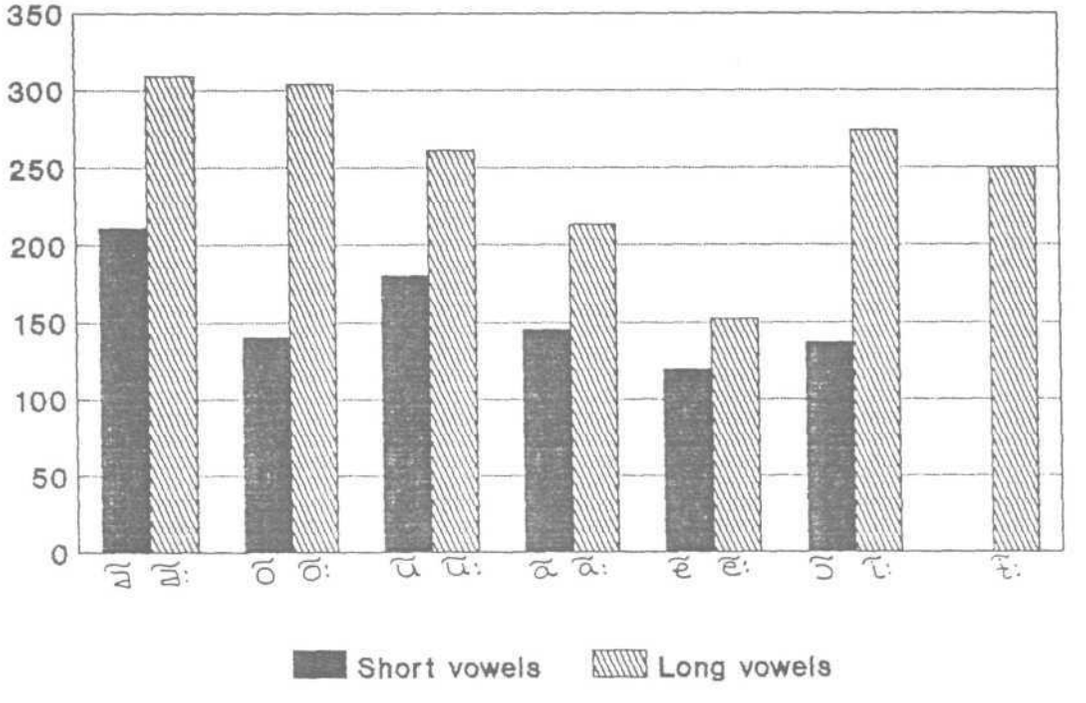
Fromant frquencies of short nasal vowels
(in females)



Vowel duration of oral vowels
(in females)



Vowel duration of nasal vowels
(in females)



For [ɔ̃] the mean VD was 137.25 msec, the range was 114 to 150 msec, and the Standard Deviation was 16.02.

Vowel [õ] had mean VD of 140.7 msec the range was 120 to 154 msec, and Standard Deviation was 14.6.

VD for [ā] was 211 msec, the range was 189 to 223 msec, and the Standard Deviation was 15.12.

Analyse of [ē] revealed the mean VD of 152 msec, the range was 75 to 157 msec, and the Standard Deviation was 7.77.

From Table-1 and Table-2 it is evident that the formant frequencies of the nasal vowel are lower as compared to the oral vowels. This is because of the effect of coupling the nasal resonant space to the vocal tract. Not only are the resonant frequencies altered bu antirsonances are also observed.

Comparing the mean of formant frequencies of Table No.1 and Table No.2, it is clear that the formant frequencies are higher for females (Table No.2) when compared to the males data (Table-1). The same results have been also reported by Mol (1963) and Kent (1976).

The formant frequencies of the vowels except [a] is generally low. This is because the frequency of first formant dependent more on the back cavity volume thanon the volume of other cavities. For [a], Fl is affected equally on a percentage basis by a change in the front cavity volume (Fant, 1960).

Thus, the null hypothesis stating that there is no difference between oral and nasal vowels in terms of formant frequencies is rejected. Also, the null hypothesis stating that there is no differnce between males and females in formant frequencies is rejected.

The results revealed that the bandwidths of the nasal vowels are larger when compared to the oral vowels. Between long and short vowels there is no significant differnce in terms of band width.

Thus, the null hypothesis stating that there is no significant difference in bandwidth between oral and nasal vowels is rejected.

From the tables 1 and 2 , it is evident that there is difference in formant untensities between male and female

data. This may be due to the recording procedure. The gain used might have been low.

Second possible reason might be that the female subject's might have spoken in a softer voice.

There is no significant difference between nasal and oral vowels in terms of formant intensities, thus the null hypothesis stating the there is a differance between oral and nasal vowels in terms of formant intensities if rejected.

The mean average value and the Standard Deviation of the duration of all the vowels in male and female subjects have been presented in Table 1 and Table-El.

As is evident from the Table-1 the duration of short vowels is less than that for the long vowel. Mean of short vowels is 134.8 (Standard Deviation 32.9) and mean of long vowels is 232 (Standard Deviation 27.45) . Again from Table-1, the difference between the mean of short nasal vowels and long nasal valuesis also evident. For short nasal vowels the mean duration is 158.76 msec.(Standard Deviation 26.73) and the mean duration of along nasal vowels is 237.14 (50.98 Standard Deviation;.

From Table-2 (female data) the same conclusion may be inferences drawn as in case of the male data presented in Table-1. The mean duration of short vowels is 136.72 msec. (Standard Deviation 44.94 and the mean duration long vowels is 186 msec (Standard Deviation 33.7).

For nasal short vowels the mean duration as evident from the table is 161 msec (Standard Deviation 33) and for long nasal vowels the mean duration is 248 .59 msec. (Standard Deviation 62).

Though the differenace between the long and short vowels in Kashmini language is present as is no significant difference between the oral vowels and nasal vowels in terms of durations.

The differences between the long and short vowels in Kashmiri Language is present is inAmerican English reported by House, 1961; House and Fairbanks, 1953; Klatt, 1973.

Thus, the null hypothesis stating that thre is significant difference in vowel duration between oral vowels and nasal vowels is rejected. Also, the null hypothesis stating that there is no differance between long and short vowels is also rejected.

5.1

SUMMARY AND CONCLUSION

The present study aimed at the acoustic analysis of 29 vowels in Kashmiri language.

Five male and four female subjects in the age range 18-25 years were stuidied. The subjects were asked toread the target word witha carrier phrase. The following parameters were obtained by analyzing the target vowel.

a) Formant frequencies (F1,F2,F3 and F4)
b) Formant intensities (L1 L2 L3 and L4)
c) Bandwidths (BW1, BWI2, BW3. and BW4)
d) Vowel durtion (VD).

The results of study indicated that :

1) The formant frequencies of nasal vowels are lower than oral vowels. Formant frequencies of females were higher than ma1es.
2) Bandwidths of the nasal vowels *are* large for the nasal vowels than for oral vowels.
3) There is no significant difference between vowel duration for nasal vowels and oral vowels. However, long vowels had longer durtion than short vowels.

Thus the null hypothesis are rejected. As the data analysis shows that -

a) There is a significant difference in the formant frequencies between oral and nasal vowels.
b) There is a significant difference in the formant frequencies of males and females.
c) There is no signiicant difference in vowel duration between nasal and oral vowels.
d) There is a significant differance between long and short vowels.
e) There is a significant differnce in bandwidths between nasal and oral vowels.
f) There is no significant difference between oral and nasal vowels in terms of formant intensities.

Implication of the study:

The study provides information regarding the formant frequencies, energy levels, band widths and vowel duration of all the vowels in Kashmiri.

The study provides information regarding the difference in formant frequencies, energy levels, band widths and vowel duration between males and females.

5.3

This being the first study in Kashmiri language has opened scope for further studies in acoustic characteristics of sounds in this language.

Limitations of the study:

1. Only 5 males and 4 females were considered for study.
2. The age group has been limited to 18-25 years.
3. Intra subject and intra group variations were not studied. As it is known that the physical dimensions of the oral cavity result in change in the acoustical parameters.

Recommendation:

The present study may be extended by

a) Selecting subjects of different age ranges.
b) Using the speech material in which the phonetic environment of the target vowel is constant. Also the voiced environment of the vowel may be avoided.
c) Controlling the intra subject and intra group variability.

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